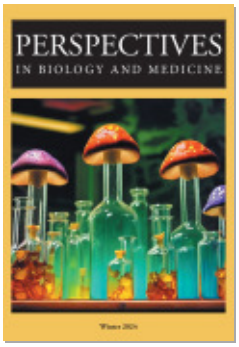
"Inherently Limited by Our Imaginations": Health Anxieties, Politics, and the History of the Climate Crisis



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David Shumway Jones

ABSTRACT As global warming became a cause of concern in the 1980s, researchers and climate activists initially paid little attention to the possible health effects of a warmer world. This changed quickly between 1985 and 1989, when scientists working on contracts with the US Department of Energy and the Environmental Protection Agency extrapolated from existing knowledge about the impact of weather on health to speculate about how global warming would impact health. However, they downplayed the impact of their contributions by highlighting the uncertainty in their models and the adaptability of human societies. Since that time, physicians and other health scientists have maintained a steady drumbeat of warnings about the health effects of global warming. They have published widely in the medical literature and participated actively in international scientific collaborations. Their research has significantly increased the breadth and depth of climate-health science and shown that measurable impacts of global warming have already begun. But as the many climate crises of 2023 show, action against global warming remains inadequate. Is it still reasonable to hope that health advocacy will incite communities and politicians to act? The history of climate and health advocacy reveals many obstacles that must be overcome.

As global warming became a serious concern in the 1980s, researchers and climate activists initially paid little attention to the possible health effects

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of a warmer world. When scientists first wrote in detail about health effects in 1985 and 1986, they believed that "no previous study has attempted to predict the impact of future weather changes on mortality" (Kalkstein et al. 1986, 276). However, within just four years the situation had changed dramatically. By 1989, scientists had produced detailed warnings of the possible health effects of global warming in both government reports and the medical literature (Leaf 1989). But even as they issued dire forecasts, scientists recognized the limits of their ability to predict what might go wrong: their analyses were "inherently limited by our imaginations" (Smith and Tirpak 1989b, xxix).

Physicians have kept up a constant drumbeat of research and advocacy since 1989. Although their writings have followed the basic outlines of the first generation of health-effects research, researchers have substantially improved the breadth, depth, and rigor of their knowledge. They have shown how measurable changes in climate have already had measurable impacts on human health. The adverse effects of climate change are no longer an imagined, speculative future: they are our empirically demonstrated reality. Despite this, decisive action against global warming remains elusive amid scientific caution and countless countervailing interests. Even though many individuals, institutions, and societies have taken steps against global warming, emissions continue to rise. Earth continues to warm.

The history of the role of health anxieties in climate-change prophesizing raises important questions. First, what were the origins of this new medical-environmental consciousness? James Dunk and Warwick Anderson have traced the emergence of planetary thinking to ancient traditions of Hippocratic medicine, the appearance of ecological thinking in post–World War I medicine, the environmental movement in the 1960s, and medical fears of nuclear war (Anderson and Dunk 2022; Dunk and Anderson 2020; Dunk et al. 2019). They situate this new consciousness at the interface of imperial metropoles and settler-colonist societies in England, Australia, and the United States, where capitalist excesses and environmental degradation were obvious for all to see. The rapid developments in climate-health research that took place between 1979 and 1989 add a new piece to the puzzle. Most of the work was not undertaken by academic physicians, epidemiologists, or public health experts, but by scientists working on research funded by the US government. Key work emerged from the Environmental Protection Agency (EPA) and the Department of Energy (DOE), two institutions that usually found themselves on opposite sides of environmental debates during the Reagan-Bush era.

Second, when physicians took up climate-health advocacy in 1989, they hoped—even expected—that their work would have impact. Their efforts, however, immediately faced challenging obstacles. The first Bush Administration quashed hopes that the US would take decisive action against global warming. There are countless reasons why the US failed to curb greenhouse gas emissions

in the early 1990s, but the early health reports demonstrate one: authors went to such lengths to acknowledge the uncertainties and limitations of their analyses that they undercut their own message. It is important to consider how this caution might have reflected both political meddling and the conscientiousness of cautious scientists.

Third, what more could be done to increase the impact of climate-health advocacy? For over 30 years, physician advocates have pursued research, public education, and political outreach. They have moved from speculation to evidence. They have gained increasing attention in national and international deliberations. But their efforts continue to meet stiff resistance. Is it possible that ongoing research and teaching will reach a tipping point and trigger public outcry and government action? It is worth wondering if something else is needed.

Initial Hopes for a More "Genial" Climate

Scientific interest in global warming has waxed and waned repeatedly. Enlightenment luminaries, including David Hume and Benjamin Franklin, thought that the Earth had warmed since antiquity. Nineteenth-century scientists found no evidence of such changes (Fleming 1998). Two Swedish scientists—Svante Arrhenius and Nils Eckholm—argued in the 1890s that fossil fuel combustion increased the concentration of carbon dioxide in the atmosphere and that this would increase global temperatures. Neither was concerned. Living as they did amid Scandinavia's post-glacial landscapes, they worried more about another ice age. During the last one, "the countries that now enjoy the highest civilization were covered with ice"—Sweden, northwestern Europe, and North America north of the Ohio River (Arrhenius 1896, 267). The "enormous combustion of coal by our industrial establishments" might stave off another ice age, and ensure a "genial" future climate, at least for certain humans (Arrhenius 1908, 61; 1896, 268).

Interest in carbon dioxide as a possible cause of climate change quickly fell out of fashion. British engineer Guy Stewart Callendar revived the hypothesis in 1938. He showed that between 1900 and 1940, CO_2 had increased by 10% and Earth's surface temperatures had increased by 0.5°C. But like Arrhenius and Ekholm, he thought warming was "likely to prove beneficial to mankind," whether because of better prospects for agriculture or because "the return of the deadly glaciers should be delayed indefinitely" (Callendar 1938, 236; see also Fleming 2007).

This research captured public attention. In 1950, the *Saturday Evening Post* relayed anecdotes of a warming climate—for example, that Penobscot Indians could no longer rely on frozen rivers during Maine's winters—and hoped that this foretold a "balmier" future: "if the moderation in world temperature continues for another decade or two, the retreat of the ice will become a rout" (Abar-

banel and McClusky 1950, 63). *Time* magazine was more pessimistic. It warned in 1956 that fossil fuel combustion "may have a violent effect on the climate," melting the icepacks and flooding coastal lands (*Time* 1956, 59). Gilbert Plass explained in *Scientific American* in 1959 that humans had become "a new geological force" (46). These fears reached both Lyndon Johnson and Richard Nixon (Freeman 2020; Macfarlane 2021; Oreskes and Conway 2010).

However, after rising from the 1880s into the 1940s, global temperatures began to fall. Some scientists feared that a 3.5°C drop, caused by increased atmospheric dust and aerosols, might bring about another ice age (Aronowsky 2021; Peterson, Connolley, and Fleck 2008). Writing in *Science* in 1970, climate scientist Helmut Landsberg entertained the idea of human-induced warming but remained unconvinced. Global warming had been discussed "with more zeal than insight": "There have been dire predictions of imminent catastrophe by heat death, by another ice age, or by acute oxygen deprivation. The events foreseen in these contradictory prophesies will obviously not all come to pass at the same time, if they come to pass at all" (1265). The basic problem was "the restlessness of the atmosphere" (1266). Earth's climate changed dramatically over geological time. Yes, rising carbon dioxide might cause 2°C warming over 400 years, but this "can hardly be called cataclysmic" (1267).

The Recognition of Global Warming, and Its Politics

Scientific "awakening" to the threat of global warming came slowly. The 1970s saw a flurry of activity, with university scientists, Nixon's Domestic Policy Council, the National Academy of Science (NAS), and Congressional hearings all considering the consequences of rising CO_2 (Fleming 1998; Freeman 2020; Nierenberg, Tschinkel, and Tschinkel 2010; Oreskes and Conway 2010; Pomerance 1986; Rich 2018). Natural disasters in the 1970s—droughts in Africa, India, and Europe, and cripplingly cold winters in North America—reminded humans that they remained vulnerable to the environment. The World Meteorological Organization (WMO) convened the first World Climate Conference in February 1979. As the NAS's Robert White explained in his keynote: "If natural climate disasters had not been enough to motivate governments and the scientific community to action, the ominous possibilities for man-induced climatic changes would have triggered our presence here" (WMO 1979, 4).

In April, prominent scientists warned the DOE that current trends in fossil fuel use could double atmospheric CO_2 by 2035. The possible consequences were not yet well understood: "The warming of climate will not necessarily lead to improved living conditions everywhere" (MacDonald 1979, iii). In July another group of concerned scientists warned President Jimmy Carter that CO_2-induced warming "will probably be conspicuous in twenty years" and would have "far reaching implications for human welfare" (Woodwell et al. 1979, 7). The DOE, committed to fossil fuel development, "reacted negatively" (Speth 2008, 1–2).

The Carter Administration commissioned a study from the National Research Council (NRC), which predicted that a doubling of CO_2 would produce 2 to 3.5°C of warming (NRC 1979). Experts continued to downplay the problem. An NAS committee in April 1980 emphasized human resilience: global warming could be managed through adaptation and migration (Oreskes and Conway 2010). President Carter signed the Energy Security Act in June; this requested the NAS to examine climate change more carefully.

In September 1983, a small group within the EPA, led by John Hoffman, quietly issued its own report, *Can We Delay a Greenhouse Warming?* It concluded that 2°C warming was likely and "may occur sooner than most of us would like to believe" (Seidel and Keyes 1983, ix; see also Freeman 2020). This would impact agriculture, water availability, and sea level, and these changes could disrupt economic systems and political institutions. The *New York Times* covered the report several weeks later, explaining that it was "the first warning by the Federal Government that the 'greenhouse effect' is not a theoretical problem but a threat whose first effects will be felt within a few years" (Shabecoff 1983a). President Reagan's science advisor criticized the report as "unwarranted and unnecessarily alarmist" (qtd. in Shabecoff 1983b).

The NAS released its report at a formal gala in October 1983. It acknowledged that rising carbon dioxide levels had begun to warm the Earth's atmosphere, but its overall message was reassuring. As William Nierenberg wrote in the preface, "Our stance is conservative: we believe there is reason for caution, not panic" (NRC 1983, xiii). The Executive Summary continued this tone. Social and economic impacts were "largely unpredictable" with even the best climate models. Humans, moreover, were versatile and mobile: Earth's climates ranged from tropical to arctic, and "large numbers of people now live in almost all climatic zones and move easily between them" (NRC 1983, 3; see also Nierenberg, Tschinkel, and Tschinkel 2010; Oreskes and Conway 2010). No one needed to fear 2°C of warming. The *New York Times* followed this lead and downplayed the threat. As Nierenberg explained there, "We feel we have 20 years to examine options before we have to make drastic plans" (Shabecoff 1983b). Global warming again faded from public concern.

A different problem pushed anxiety about anthropogenic changes to Earth's atmosphere back into the spotlight. Scientists in 1974 had recognized that chlorofluorocarbons (CFCs) broke down stratospheric ozone, a gas that shielded Earth's surface from ultraviolet radiation. The United Nations Environmental Programme (UNEP) convened a conference in Vienna in March 1985 to hammer out a framework to control CFCs. The meeting did not yield a specific agreement. However, in May British scientists reported that ozone levels had indeed fallen over Antarctica, a problem that came to be known as the "ozone hole." While a clear link between Antarctic ozone and CFCs had not yet been established, these concerns prompted action that led to the Vienna Convention for the Protection of the Ozone Layer (Oreskes and Conway 2010).

Inspired by this development, advocates renewed their push for action against global warming. In October 1985, the UNEP, WMO, and International Council of Scientific Unions (ICSU) hosted a conference in Villach, Austria, on climate and carbon dioxide. The assembled scientists affirmed the scientific consensus that doubling of CO_2 would lead to a 1.5° to 4.5°C increase in global temperatures. There was "little doubt" that this "could have profound effects on global ecosystems, agriculture, water resources and sea ice" (World Climate Programme 1986, 3; see also Pomerance 1986; Rich 2018).

In June 1986, the Senate Subcommittee on Environmental Pollution and the Public Works Committee held hearings about the risk of global warming (Subcommittee on Environmental Pollution, 1986). In his opening remarks, Senator John Chafee invoked the findings from Villach: "there is a very real possibility that man—through ignorance or indifference, or both—is irreversibly altering the ability of our atmosphere to perform basic life support functions for the planet" (2). Crucial testimony came from NASA's James Hansen. His climate models predicted a 1°C rise by the 1990s and, if no action were taken, a 5°C rise by 2050. To bring this home to the senators, he explained that Washington, which suffered less than one 100°F day each summer, could face 12 such days by 2050 (90°F days would jump from 35 to 85). Changes could be visible within a decade (18–26, 78–97). Chafee described the scientists' testimony as "powerful, graphic, and clearly disturbing" (155). When representatives from the Department of Commerce and DOE downplayed the need for decisive action, Michael Oppenheimer, from the Environmental Defense Fund, castigated their "massive underreaction" and "perplexing lethargy" (188).

Following through on prior discussions with climate advocates, Chafee and the committee requested that the EPA produce a report that explored policy options that might stabilize the atmosphere and stave off global warming (Freeman 2020). The Senate committee was explicitly interested in health: "One of the studies we are requesting should examine health and environmental effects of climate change" (letter from G. J. Mitchell and J. H. Chafee to L. Thomas, Sept. 12, 1986; qtd. in Smith and Tirpak 1989b, 411).

Health Effects of Global Warming, Part 1: Off to a Slow Start

For thousands of years, physicians had described how the environment affected human health. In the 1950s, such concerns consolidated as the field of biometeorology (Weihe 1979). Most experts saw weather as something that happened; humans simply had to adapt. A 1972 *JAMA* review, for instance, explained that while "pollution may be controlled, climate and weather cannot be": "we are truly at the mercy of the elements" (Burch and Giles 1972, 1051).

Rare voices invoked the specter of global warming. In April 1971, Frank Ellis, a British expert on tropical medicine, discussed the epidemiology of heat at the

National Institute of Environmental Health Sciences. He warned that the problem would get worse because Earth's atmosphere, "according to the latest consensus of informed opinion . . . may be expected to warm up even more during the next 30 years" (Ellis 1972, 50). Stephen Boyden, an Australian veterinarian turned ecologist, issued a similar warning that August. He described how human damage to the environment posed "a serious threat to the survival of civilization and mankind" (Boyden 1972, 1229). Although he did not name global warming directly, he noted that "the extraordinarily rapid development and spread of technology following the introduction of fossil fuels has very recently reached such proportions that the integrity of the biosphere as a whole is now considered by many ecologists to be in serious jeopardy" (1233).

As concern about climate change deepened in the 1970s, health concerns remained on the periphery. The report from the WMO's 1979 World Climate Conference contained 27 chapters, with six on agriculture but just one on health. The conference's formal declaration noted concern about water resources, soils, forests, and rangelands, but not health (WMO 1979, 716). The health chapter, by Swiss biometeorologist Wolf Weihe, spent 48 pages reviewing ways in which current weather and climate could impact health, but gave the future—"possible effects on man of a major climatic variation"—just three paragraphs (Weihe 1979, 314). He focused on two possible health hazards of CO_2-induced global warming: "firstly, the added heat with all its consequences in the ecosystem and, secondly, the larger carbon dioxide concentration" (360). He mentioned three other possible changes in passing: climate migrants, food systems, and shifts in disease vectors (361). Weihe's analyses were not based on studies of existing health effects of climate change, or on models of future climate and health, but on plausible extrapolation—in other words, speculation—about what might happen as the world warmed. He ended with a note of reassurance: "Man is highly adaptable to new or changing circumstances" (362).

Conference participants discussed Weihe's report briefly (the 14-page summary of the discussions devoted less than one page to health). They acknowledged the risks of changing patterns of disease, malnutrition, and migrations that might follow. But they again emphasized human adaptability: "To a great extent man controls his environment by wearing suitable clothing and constructing climate-controlled buildings. By such means he is able to survive a wide range of climatic conditions" (WMO 1979, 702).

When scientists warned the Carter Administration that summer, they highlighted a single health concern, malnutrition: "The displacement of agriculture in a world constantly threatened by hunger would alone constitute an extremely serious international disruption within the lifetimes of those now living" (Woodwell et al. 1979, 9). The NRC's assessment, released later that year, did not discuss health or other impacts of global warming (NRC 1979).

Deadly heat waves in the summer of 1980 prompted Senate hearings where senators and witnesses alike expressed outrage over deaths that ought to have

been easily prevented. Global warming was not discussed, except possibly in an ambiguous comment by an official from the Social Security Administration that "the climate has literally changed" (Special Committee on Aging 1981, 350). It is not clear whether this is a reference to Earth's climate or the political climate.

When the EPA issued its first report in 1983, it did not include any discussions of health effects of global warming, just one passing mention of deaths from flooding during a recent El Niño event, and another about industrial air pollution (Seidel and Keyes 1983). The NAS report that followed discussed three dangers of global warming: direct effects of heat, shifts in vector-borne disease, and toxic effects of CO_2. It dismissed the direct risks of CO_2: even the direst forecasts (for example, doubled CO_2) "will never be dangerous" (NRC 1983, 81; see also 471–72). The other threats—heat and vectors—did merit attention, but humans had long ago demonstrated their ability to thrive across a range of hot and cold climates.

The situation was little different at the international conference in Villach in 1985. The assembled scientists discussed many impacts on terrestrial ecosystems—soil degradation, acidification, ozone depletion—but said less about socioeconomic impacts, and nothing about health beyond a caution about threats to "health and well-being" of developing countries in tropical climates (World Climate Programme 1986, 70).

When the Senate held its hearings in June 1986, only one witness raised health concerns. Andrew Maguire, from the World Resources Institute, told Senators that ozone depletion could cause thousands of cases of skin cancer and increase heat-related deaths. Moreover, the "effects of much warmer weather on human health and lifestyles would surely be enormous" (Subcommittee on Environmental Pollution 1986, 114). Heat waves would become more frequent. Air pollution would worsen. Crops might fail.

In September 1986, WMO, UNEP, and the World Health Organization (WHO) hosted a symposium, *Climate and Human Health*, in Leningrad. Weihe, then at WHO, assisted with conference planning. The program focused on existing environmental problems—industrialization, environmental pollution, and deforestation—not the threat of global warming (WMO/UNEP/WHO 1987a). However, the conference did generate a brochure, written for a general audience (with colorful cartoons), which raised health concerns (WMO/UNEP/WHO 1987b). It warned that "thermal stress leads progressively to greater discomfort, then specific disorders and in extreme cases to death" (9; see Figure 1). Seemingly citing Hansen's June testimony about hotter days ahead for Washington, it acknowledged that while the effects of warming were "difficult to predict," "there is no question that increased urban heat stress could come to claim many lives" (10).

In June 1987, the World Commission on Environment and Development (WCED), established by the UN in 1983 and chaired by physician Gro Harlem

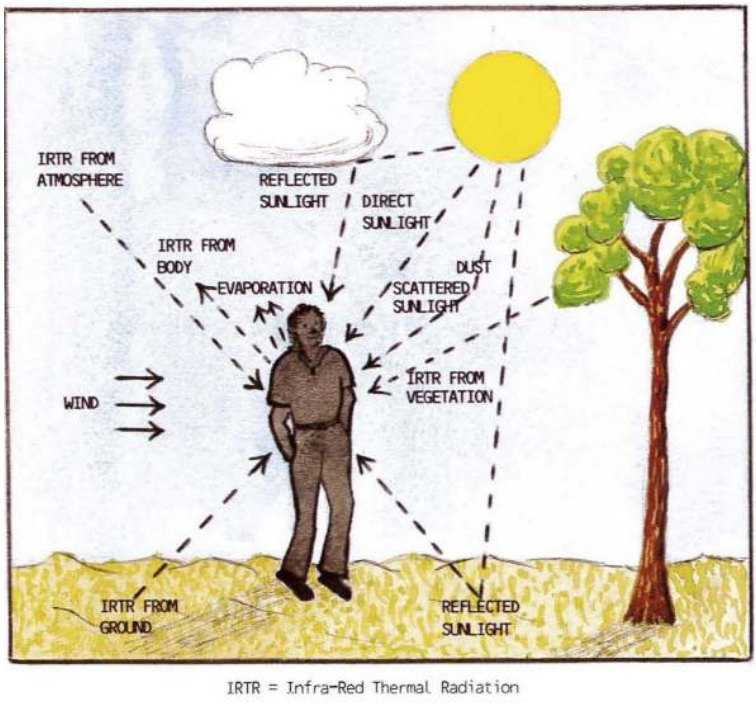

Figure 1

The impact of heat on humans

Source: WMO/UNEP/WHO 1987b.

Brundtland, delivered its report *Our Common Future*. Discussions again focused on current threats, especially desertification, deforestation, acid rain, air pollution, and industrial chemicals. What about health? Ozone depletion could increase human cancers. Global warming, meanwhile, could exacerbate hunger by disrupting agriculture and fisheries (WCED 1987, 2–3).

Health Effects of Global Warming, Part 2: The Pace Quickens

As debate about carbon dioxide intensified in the 1970s, the DOE established an Office of Carbon Dioxide Effects to study CO_2's potential impacts on Earth's climate and vegetation. After a near-death experience early in the Reagan Administration, the office commissioned a study to clarify the direct effects of rising CO_2 to facilitate subsequent studies of its indirect effects (White 1985). The DOE assigned the project to Margaret White, a scientist at Lawrence Berkeley Laboratory. She had begun her work there in the 1950s, conducting studies of the impact of radioactive fallout on thyroid function in humans and cattle. She went

on to study carcinogenesis in mice, air pollution and cancer, and the use satellites to gather solar energy in orbit and beam it to Earth below.

White's report, submitted in December 1985, included chapters on fisheries, forests, water resources, agriculture, and human health. The health chapter, coauthored with an epidemiology graduate student, Irva Hertz-Picciotto, highlighted two challenges. First, there were no prior studies of the health effects of climate change: "until the CO_2 issue arose, there was no particular reason to study the effects that regional climate change might have on human health because climate change was not expected to occur, except possibly extremely slowly, over hundreds of years" (White and Hertz-Picciotto 1985, 174). Second, since existing climate models could not predict changes on a regional scale, "it is currently impossible to predict the impacts of CO_2-induced climate change on human health" (173). They could only review known weather-health relationships and extrapolate what might happen (Figure 2). For instance, increased CO_2 would not have toxic effects: even if atmospheric CO_2 quadrupled, its concentration would still be lower than that in each breath humans exhale. Other effects could easily be imagined. Increased heat waves would be hard on elderly people and those with circulatory disease. Diseases that exhibited seasonal variations—heart disease, respiratory infections, infant mortality, and others—might exhibit new patterns. New weather patterns could concentrate (or disperse) air pollution. Changes in vegetation and pollen would impact allergies and asthma.

But while such changes could be imagined, there were many uncertainties. If warming increased temperatures but reduced variability, heat waves would have less impact. Agriculture would change, but whether "these changes are beneficial or detrimental will depend on the extent and type of regional and seasonal changes" (White and Hertz-Picciotto 1985, 195). It was even harder to predict the impact of acclimatization or socioeconomic factors. New technologies might "offset or prevent the detrimental health effects of CO_2 build-up" (White 1985, xvi). White and Hertz-Picciotto seemed nonplussed: "In some of these situations, climate change may intensify the problems, in others it may be beneficial" (197). Like Weihe and the authors of the 1983 NAS report, they were reassured by humans' ability to "live in extremely cold and extremely hot climates and survive by modifying their ways of life (clothing, shelter, food, etc.). They will, of course, probably continue to do so under a CO_2-induced climate change" (173).

The EPA soon embarked on a similar project. In June 1986, shortly after the Senate hearings, the UNEP and EPA hosted a conference on ozone depletion and climate change. The conference report, published in October, included seven chapters on forestry, agriculture, and endangered species, five on water resources, and one on health (Titus 1986). The health report was prepared by scientists at the University of Delaware led by Laurence Kalkstein (Kalkstein et al. 1986). Kalkstein, like White, followed a roundabout path to this project. A bioclimatologist, he had studied the impact of weather on southern pine beetles,

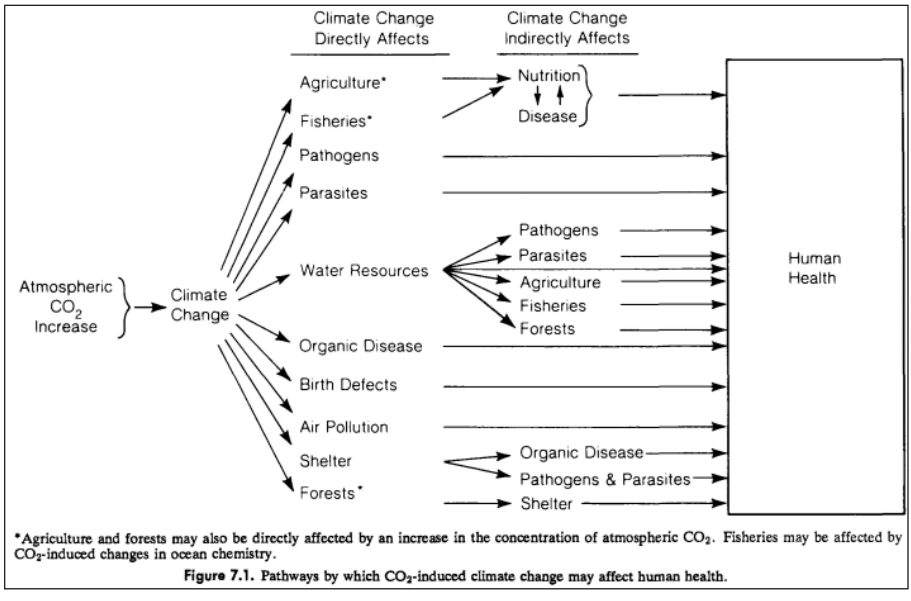

Figure 2

The possible impacts of rising CO_2 on health

Source: White and Hertz-Picciotto 1985.

a pest that threatened the timber industry. After doing some work on climate impact assessments with the National Oceanic and Atmospheric Administration, he received grants from the EPA to study climate and health (Kalkstein 2023).

Kalkstein and his team believed that they were breaking new ground: "no previous study has attempted to predict the impact of future weather changes on mortality" (Kalkstein et al. 1986, 276). Unlike Weihe, White, and Hertz-Picciotto, who relied on plausible extrapolations to imagine how warming might affect health, Kalkstein's team developed a quantitative model. They used existing climate-mortality data to analyze the impact of warming on cities (Figures 3 and 4). For instance, deaths in New York City rose "quite rapidly" when temperatures exceeded 92°F (275); thankfully only 5.7% of days hit that threshold. What would happen if Earth warmed by 1°, 2°, 4°, 5°, or even 7°F? In the 7°F scenario, nearly half of July days in New York would hit 92°F, and 1,300 people would die annually—if the population did not acclimatize to the heat. Was acclimatization likely? Heat did not increase mortality rates in Jacksonville, Florida. Might New York achieve a similar détente? Kalkstein's team was skeptical because of differences in urban infrastructure: "it is improbable that New Yorkers will become as totally insensitive to hot weather as Jacksonville residents are today" (287).

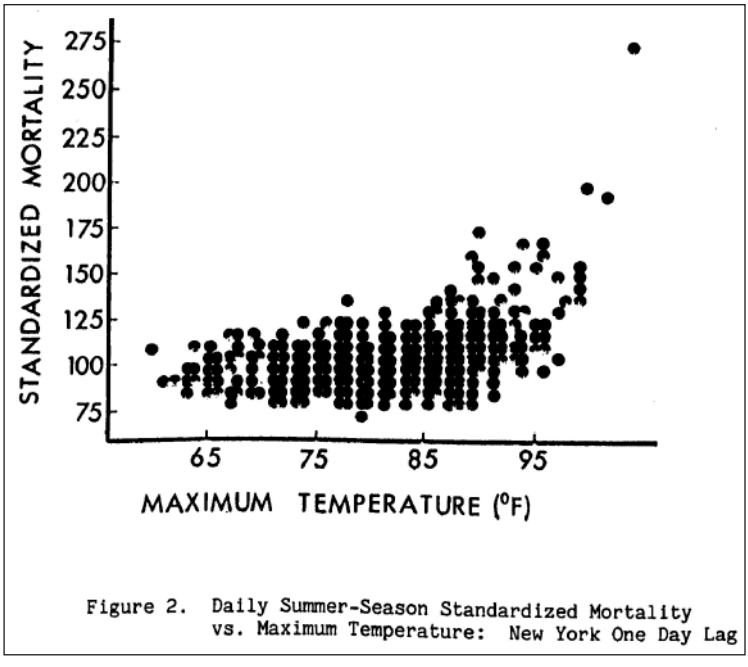

FIGURE 3

Increased mortality on hot days in New York City

SOURCE: KALKSTEIN ET AL. 1986.

That same October, the EPA drafted another report on ozone depletion (the final report was published, largely unchanged, in December 1987). This multivolume risk assessment aimed to guide policymakers in developing a US negotiating position in what would become the Montreal Protocol on Substances that Deplete the Ozone Layer. As the abstract explained, the report "examines the human health, environmental and atmospheric risks associated with a decrease in stratospheric ozone" (Hoffman 1987). However, John Hoffman, who led the project, broadened this mandate and considered a host of possible atmospheric changes, including global warming. The authors warned about mortality from rising temperatures (citing Kalkstein's work), extreme weather events, and the many effects of ozone depletion. In a separate volume, a team led by Dennis Tirpak, director of the EPA's Global Climate Change Policy Division, examined the potential effects of climate change on forests, vegetation, agriculture, water, and human health (Tirpak 1986, 1987). Kalkstein and one of his students, Kathleen Valimont, wrote the health chapter. This reviewed the NYC modeling study but reached much further. Citing the report by White and Hertz-Picciotto, it discussed heat waves, heart disease, asthma, and mood. Kalkstein and Valimont (1986) hoped that society would make the necessary investments to manage the threat.

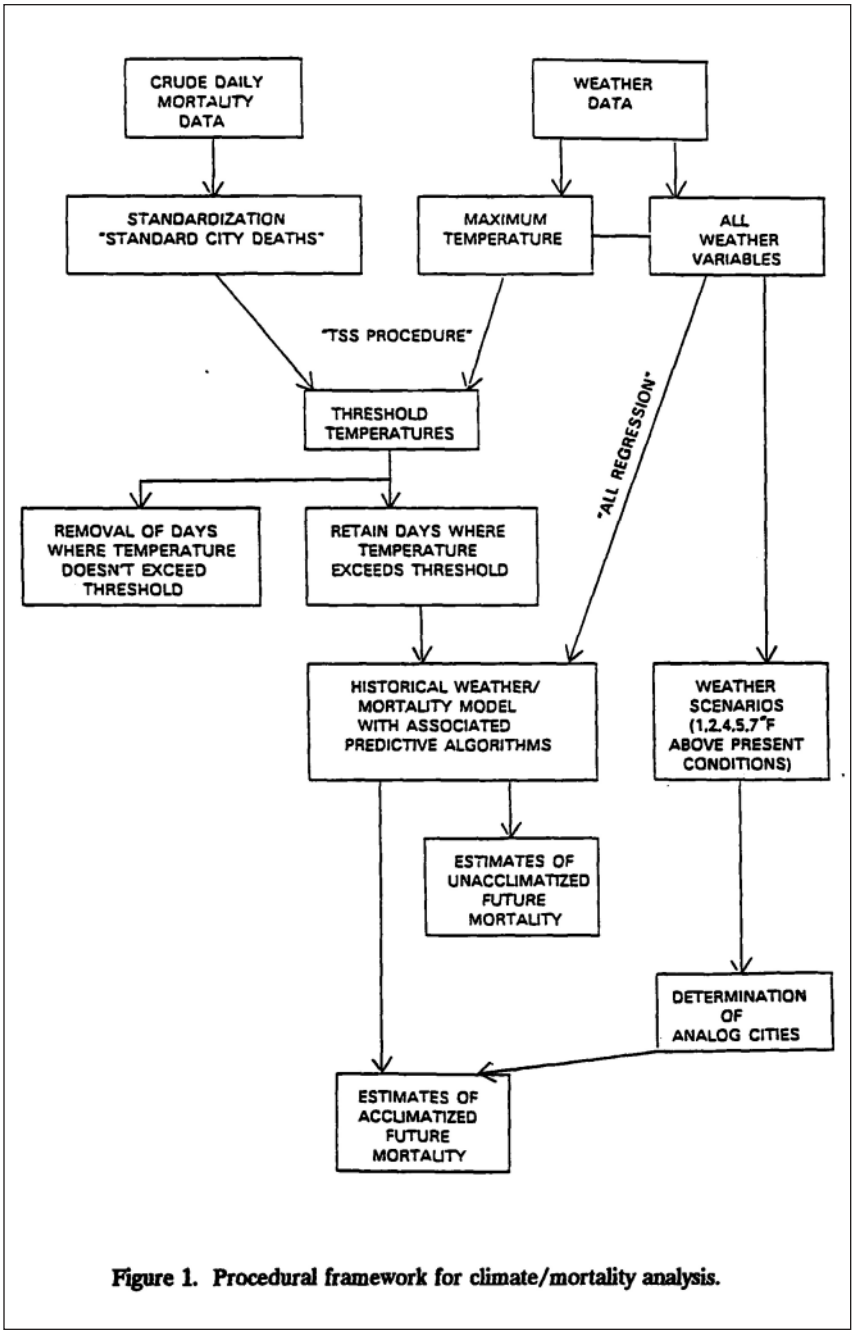

Figure 4

Modeling the impact of rising heat on health

Source: Kalkstein 1989.

When the Senate requested a report about atmospheric changes and possible policy responses at its hearing in 1986, the EPA commissioned 55 scientific studies of the potential effects of global warming. Three focused on health. Tirpak recruited a policy analyst, Joel Smith, to manage the project. Work was well underway in October 1988, when someone leaked the Executive Summary to the press. Journalists emphasized the impacts on forests, coastal wetlands, and air and water quality. The *New York Times* mentioned health effects as well: "Summer heat waves may lead to an increasing number of deaths, particularly among the elderly." Disease distributions could shift. Air pollution could become "increasingly troublesome" (Shabecoff 1988).

The 55 studies were submitted to the EPA in May 1989 (Smith and Tirpak 1989a). In the first of the three health studies, Kalkstein expanded his heat mortality analysis to 15 cities across the US. Without acclimatization, annual heat-related deaths would increase from 1,150 to 7,400: "predicted warming could have an enormous impact on human health" (Kalkstein 1989, 1:33). The other two studies, focused on infectious diseases, remained noncommittal. One noted that disease-carrying ticks and mosquitos might increase in some places but decrease in others (Haile 1989). Janice Longstreth and Joseph Wiseman (1989) catalogued possible direct and indirect effects of warming on infectious diseases but concluded that too much remained unknown to offer useful analyses.

Smith and Tirpak (1989b) submitted the EPA's *Report to Congress* in December 1989. Terry Davies, from the Office of Policy, Planning, and Evaluation, wrote the Foreword. He downplayed the findings. While "climate change could lead to significant changes," he urged "caution in interpreting the results" and emphasized the model's uncertainties. Climate scenarios were "indicative of what could occur in the future," but "cannot predict impacts" (xxi). In the Executive Summary, Smith and Tirpak expressed more concern. They acknowledged the uncertainty, but also noted that some possible outcomes had not even been considered: the analyses were "inherently limited by our imaginations. Until a severe event occurs, such as the drought of 1988, we fail to recognize the close links between our society, the environment, and climate" (xxix). They were confident that the "findings collectively suggest a world different from the world that exists today" (xxx).

Health featured prominently. Smith and Tirpak highlighted possible impacts on infectious diseases, allergies, and heat-related mortality. Details mattered: increased heat waves were "virtually certain" (33), but their impact would depend on whether weather variability increased or decreased. Other impacts could be mitigated by acclimatization and adaptation (such as increased air conditioning and changes to work habits or architecture) (xliii). The *Report* included a chapter on human health, written by Longstreth, that did not simply summarize the three commissioned health studies (Longstreth 1989). Instead, she reviewed the voluminous literature on health and the environment, going back to Hippocrates

and including the chapter by White and Hertz-Picciotto (Longstreth 1999). She described seven possible effects of global warming (see Figure 5). More people could die each summer from heat waves. Disease vectors could shift. Air pollution and resultant respiratory diseases could intensify. Allergies could flare as pollens shifted. Infant mortality, which peaked each summer, could get worse as summers warmed. Food and water supplies could be threatened. Crowding could cause further problems. However, following the lead of her predecessors, Longstreth found cause for reassurance: "Societies possess considerable ability to adapt to change" (Longstreth 1989, 232). She did admit that countries that lacked the resources required for adaptation would suffer.

After producing this report, the EPA established a program on health and global warming within its Climate Change division. President Bush called for "more vigorous research" at an April 1990 White House conference on science and climate change (Kalkstein and Giannini 1991, 728). However, plans for decisive action quickly derailed (Freeman 2020; Oreskes and Conway 2010; Rich 2018).

Several aspects of this narrative merit special attention. First, a new domain of climate-health analysis had emerged remarkably quickly. In 1985 and 1986, White, Hertz-Picciotto, and Kalkstein's team had found no prior studies of health and climate change (they did not cite the few paragraphs in Weihe's 1979 chapter). Working under contracts to the DOE and EPA, they scrutinized existing research on the relationship between weather and health, identified many distinct mechanisms of influence, and then imagined or modeled how warming could increase morbidity and mortality. The nature of this work allowed it to advance quickly: the scientists were thinking, not gathering data. This, however, opened a door to critique.

Second, this initial work on the health effects of global warming took place outside of the medical profession. White was a wide-ranging laboratory biologist, Hertz-Picciotto an epidemiologist-in-training, Kalkstein a bioclimatologist, and Longstreth a toxicologist and scientific writer. Kalkstein recalls that physicians were reluctant to engage with bioclimatologists (Kalkstein 2023). Additionally, three of these four researchers were women. There are many possible interpretations here, all speculative. One is that studies of climate and health in this period were low priority and delegated to lower-status researchers. Another is that these early climate researchers were trying to draw attention to a problem with few resources or institutional supports; this mission appealed to scrappy and resourceful researchers willing to stretch their expertise to tackle the possible health effects. Yet another possibility is that these people, working outside of medical institutions, were able to recognize a problem that conventional medical researchers had missed.

Third, while the work may have emerged on the margins, it did not occur in a vacuum. Leaders of the climate programs at the DOE and EPA, such as Fred

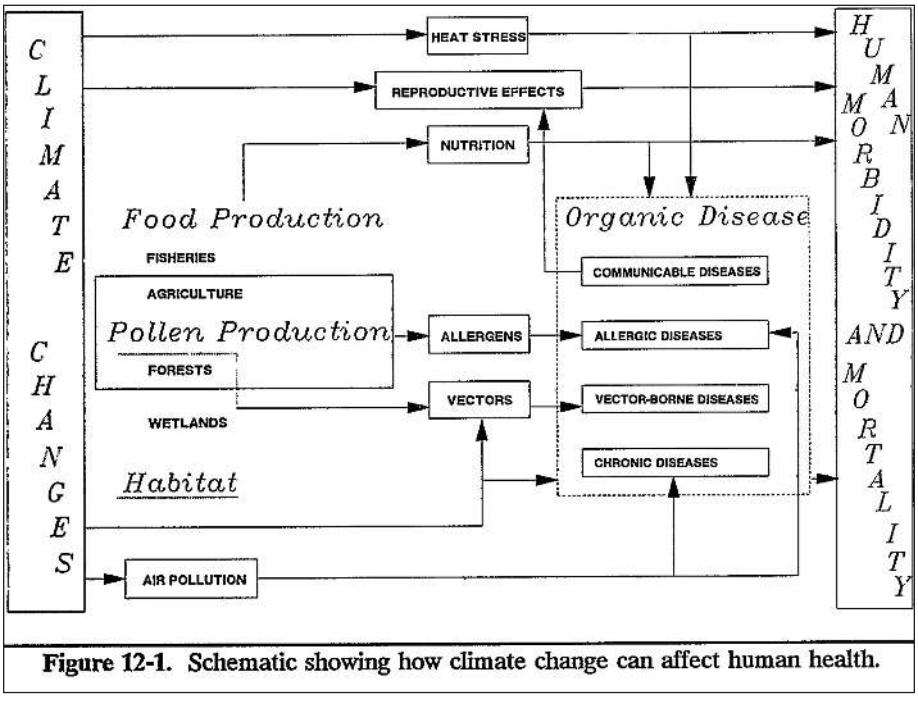

FIGURE 5

Another framework for health and climate change

SOURCE: LONGSTRETH 1989.

Koomanoff and Dennis Tirpak, attended the Villach conference. William Ruckelshaus, Administrator of the EPA, was one of the 22 members of the WCED that produced *Our Common Future*. The reports by White, Kalkstein, and the others presumably reflected ideas about climate change that circulated through informal dialogues.

Fourth, different participants have different judgments about the role of political considerations. In interviews with the author, Kalkstein and Smith did not recall any political interference (Kalkstein 2023; Smith 2023). This might seem surprising, given that the EPA had been repeatedly targeted by industry and Republican presidents since its creation in 1970. Reagan famously put Anne Gorsuch, "an anti-regulation zealot," in charge (Rich 2018). However, the politics of global warming were different in the 1980s than they are now. Hoffman had been drawn to climate change in the early 1980s because it was a low-profile problem that had not yet been politicized. Democrats and Republicans had not yet taken sides. John Chafee, a Republican, chaired key Senate hearings and was a strong proponent of action, while George H. W. Bush outflanked Michael Dukakis during the 1988 campaign and claimed to be the environmental candidate.

That said, other participants were aware of political pressures. Stephen Seidel, a coauthor of the 1983 EPA climate report, recalls that it was impossible to ignore political considerations when working in the EPA's policy office during the Reagan-Gorsuch years (Seidel 2023; see also Freeman 2020). Agencies like the EPA have limited power and cannot accomplish much without support from Congress or the White House. Staffers were aware of the political agendas of the president and congressional leaders, and they pursued deliberate strategies to bring attention and resources to their climate work.

These contrasting perspectives introduce ambiguity into historical interpretations. The initial DOE and EPA reports about the health effects of climate change echoed the minimizing tone of the 1983 NAS report and emphasized the inadequacy and uncertainty of their data, models, and predictions. They reiterated the claim that humans thrived across an enormous range of temperatures and environmental conditions. Kalkstein and Davis believed that this caution reflected good science and not nefarious politics: their findings simply were not conclusive enough to justify the massive social and economic changes that a shift away from fossil fuels would have required. That might be true, and it might also be true that political considerations and institutional expectations influenced this work. The fossil fuel industry, increasingly concerned about global warming, had begun to work to defend its interests (Oreskes and Conway 2010; Rich 2018; Supran and Oreskes 2021). It had many allies at the DOE and the White House. Industry leaders would certainly have welcomed the ways in which scientists' protestations of uncertainty undercut their warnings of the possible health effects of the climate crisis. As Naomi Oreskes and Erik Conway (2010) have shown, emphasizing uncertainty and adaptation had been a strategy of global warming denial throughout the 1980s.

The rhetoric of adaptation was especially interesting. Many authors had cavalierly noted that humans had learned to live in a wide range of climates and easily tolerated traveling from one climate to another. Invited to review a draft of the 1983 NAS report, Alvin Weinberg was furious: it was shockingly naive to think that millions of people would be able to move across political borders in search of more tolerable climates (Oreskes and Conway 2010). To make matters worse, the people most vulnerable to climate change would likely lack the resources migration requires. The blithe attitudes are especially surprising in light of centuries-long debates about acclimatization. History has countless examples of communities who suffered mightily from moving between climates. These researchers, however, were not alone in their fetishization of adaptation. James Lovelock's Gaia hypothesis, elaborated and debated in the 1970s and 1980s (at a time when Lovelock received funding from Royal Dutch Shell), initially argued that Earth itself had a limitless adaptive capacity and would find ways to restore itself despite the insults inflicted by human's industrial capitalism (Aronowsky 2021).

Finally, why did the health concerns emerge in the mid-1980s? Some of the interest was driven by the restless climate. After cooling from the 1940s into the 1970s, Earth began to warm again. Five of the hottest years to date had occurred in the 1980s, and 1988 was especially difficult: heat waves, drought, and failed harvests focused public attention on global warming. As the *Worldwatch Institute* reported, "earth's deteriorating condition moved into the limelight" (Brown, Flavin, and Postel 1989, 3). Scientists, senators, and oil executives all paid attention, as did DOE and EPA authors. The concerns about health effects may also have reflected broader shifts in public health thinking. Andrew Lakoff (2017) has shown how a discourse of "preparedness," developed by nuclear war and civil defense planners in the 1950s and 1960s, increasingly influenced how health officials thought about pandemics. Guillaume Lachenal and Gaëtan Thomas (2023) have described this as a shift from an emphasis on development and public health to a new "security-focused vision of global health" (56), designed to manage new, unpredictable threats, such as HIV or Ebola. Global warming posed such a threat and demanded preparation and action—or, for some, just more research.

Global Warming's Health Effects Go Mainstream

Between the leak of the EPA draft Executive Summary in October 1988 and the release of the full report in December 1989, the medical literature came alive. This first generation of medical writers lacked the caution of the DOE and EPA scientists. While they covered familiar ground, they advocated more aggressively.

Lancet may have led the way. In April 1989, it published an unsigned editorial, "Health in the Greenhouse," written by British dermatologist Robin Russell-Jones. It led by noting that while much had been written about the health effects of ozone depletion, "the implications for human health of global warming have received less attention." It reviewed the basics of industrial emissions, projected warming (1.5 to 4.5°C), and the disruptions that could follow, including temperature extremes, sanitation failures (from flooding), malnutrition (damage to crops), armed conflict (dwindling natural resources), and expanded tropical diseases. This was science, not politics: "there is an inevitability about global warming, which stems not from human behavior or human error but from the radiative properties of atmospheric releases and the fundamental laws of physical science" (819). The editorial acknowledged the many uncertainties but argued that they did not justify inaction: "Remedial measures are needed now." The "expense may be considerable," but "the cost of doing nothing is incalculable" (820).

The Centers for Disease Control (CDC) followed with a passing comment in June. Its nearly annual commentary about summer heat waves added a twist: "Growing scientific and public concern about the potential for global warming due to the 'greenhouse effect' has focused attention on the health effects of heat during the summer" (CDC 1989). It did not elaborate (Jones 2023).

In December 1989, the *New England Journal of Medicine* published the first extensive review of the problem. Its author, Boston physician Alexander Leaf, had worked with International Physicians for the Prevention of Nuclear War, which won the Nobel Peace Prize in 1985. Leaf had described how nuclear war would devastate global ecosystems, especially agriculture, leaving any survivors doomed to famine. He soon became concerned about other environmental issues, including air pollution, ozone depletion, and population growth. This led him to global warming. He learned what he could from colleagues at Harvard, from Worldwatch Institute reports, and from *Our Common Future*. When he proposed an essay about the health effects of global warming, his close friend Arnold Relman—editor of the journal—encouraged him to proceed (Dunk and Jones 2020).

Even though climate change "has been much in the news," Leaf saw that the "impact of environmental change on the health and survival of humans has received relatively little direct attention" (Leaf 1989, 1577). Leaf acknowledged that the "health consequences of global warming are potentially great but are currently speculative" (1580). That did not stop him. He reviewed how global warming would increase the number of hot days (echoing Hansen's 1986 testimony). While air conditioning could mitigate this, "air conditioning expends energy and increases the consumption of fossil fuels that create the greenhouse warming" (1580). Air pollution would worsen. Increased UV exposure would cause skin cancer, cataracts, and immune suppression. Immunosuppression, along with crowding, poor sanitation, malnutrition, food shortages, and contaminated water, could worsen infections. It was possible, but "unclear," if warming would influence the vectors of insect-borne diseases and introduce tropical infections into the US. Amid these many riders of the apocalypse, Leaf believed that "the most widespread and devastating consequences of global environmental changes" would be its impact on food supplies (1581).

Yes, adaptation was possible, but Leaf called on physicians to act. Society gave physicians a mandate "to be the guardians of health" (1583). Global warming, which could bring about "disastrous consequences to health," "becomes our special burden." They had to educate themselves, the public, and government officials: "Only an educated and aroused public is likely to force antiquated nationalistic political systems to cooperate in promoting family planning, energy conservation, and the protection of the global environment in time to prevent the direst possibilities from occurring."

Subsequent work followed these leads. In 1988, the WMO and UNEP created the Intergovernmental Panel on Climate Change (IPCC) and tasked it with assessing climate science and summarizing findings for the world's governments. It issued its first assessment in 1990. Working Group 2 (which included Longstreth), examined impacts, including health. The executive summary stated the obvious: "Major health impacts are possible," due to heat stress, spreading infec-

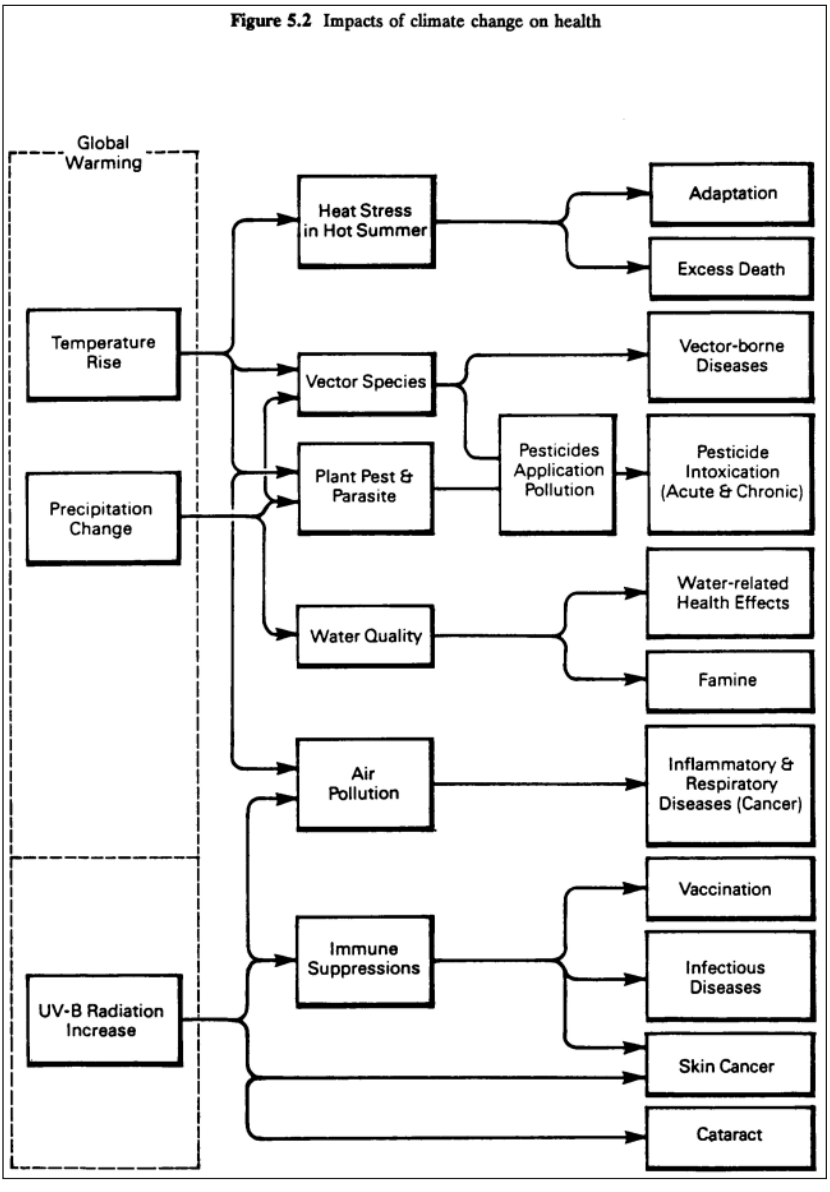

FIGURE 6

The IPCC's first climate-health framework

SOURCE: TEGART, SHELDON, AND GRIFFITHS 1990.

tious diseases, threats to food and water supplies, and resultant migrations (Tegart, Sheldon, and Griffiths 1990, 3). The chapter on human settlements offered more detail about the various possible mechanisms, from heat and UV radiation to famine, floods, epidemics, and changed patterns of heart disease and cancer (see Figure 6). But the IPCC report again downplayed the risk: it led—on its first page—with the usual caveats about uncertainty, adding that it had not considered prospects for human adaptation or technological innovation (1).

WHO prepared its own report in 1990. It noted that precise predictions "cannot be made," and that (citing Weihe) humans had "an extraordinarily high capacity for individual physiological, intellectual, and social adaptability" (WHO 1990, 3). Humans could live "in virtually every climate on earth" (16). The WHO report also downplayed specific threats. Predicted levels of warming would "exert a minor deleterious thermal stress on populations, but adaptation will readily occur with prolonged and gradual warming" (19). If ozone depletion increased UV exposure, skin pigmentation would increase to compensate (23).

Researchers and advocates kept the warnings coming (Haines 1991; Kalkstein and Giannini 1991). In November 1991, *BMJ* editor Fiona Godlee, with help from Andrew Haines, published a thorough review. As she explained, "Every age has its catastrophe theory. In the past decade alone scientists have threatened us with a new ice age and a nuclear winter. Now two new threats confront us, global warming and the destruction of the ozone layer, linked by their origin in man's pollution of the environment. Both have enormous implications for health" (Godlee 1991, 1254). She reviewed the many possible effects, acknowledged the uncertainty, and invoked an analogy to clinical medicine to justify action:

> with acute medical emergencies there is no time to wait for the return of the investigations which would confirm the diagnosis. It is necessary to act on the balance of probabilities rather than waiting, like criminal lawyers, for all reasonable doubt to be removed. Global warming may prove to be this decade's scary story, though the weight of scientific evidence makes that unlikely, but the risks of drastic climatic change are too great to ignore. (1256)

Lancet went further and published 11 articles and two commentaries in a series, "Health and Climate Change," from October to December 1993 (Epstein and Sharp 1993).

The advocates grappled with conceptual and methodological challenges. As physician and epidemiologist Anthony McMichael (1995) noted, while certain health effects seemed obvious—for example, heat waves and vector distribution—the connections to health "lack the mechanistic directness-of-effect that epidemiological research methods are best equipped to study" (195) (see Figure 7). Researchers had "to move beyond the traditional reliance on empirical data that describe the past into an 'anticipatory' mode that uses the predictive mathematical modelling of complex systems. This, in turn, will require new approaches

TABLE 1 *Types of possible adverse effects upon health due to global environmental change.*

Environmental change	Manifestation	Type (direct, indirect), timing[a] (early, late) of adverse health effect			
		Direct, early	Direct, late	Indirect, early	Indirect, late
Enhanced Greenhouse Effect	*Global warming and climate change*	Heatwave-related illness and deaths Natural disasters: cyclones, floods, landslides, fires		Altered distribution of vector-borne infectious diseases. Food shortages due to altered agricultural productivity	Reduced viability of edible fish in warmed oceans
	Sea-level rise	Increased risk of flash floods, surges	Inundation: social dislocation, sanitation breakdown, farm loss	Consequences of damage to foreshore facilities, roads, etc.	Destruction of wetlands—decline in fish stocks
Stratospheric ozone depletion	*Increased UV-B flux at Earth's surface*	Sunburn, photo keratoconjunctivitis Suppression of immune system—increased risk of infection, cancer	Skin cancer Ocular effects: cataracts pterygium		Impaired growth of food crops and of marine micro-organisms (base of aquatic food web)
Acid aerosols (from combustion of sulphurous fossil fuels)	*Acid rain (and other precipitation)*	Possible effects on respiratory system		Killing of aquatic life —reduced food Impaired crop growth	Impairment of forest growth—reduced ecosystem productivity
Land degradation: over-intensive agriculture and excessive grazing	*Erosion, sterility, nutrient loss, salinity chemicalization; desertification*	Decline in agricultural productivity	Rural depression—migration to fringes of cities (shanty towns) (see also bottom row)	Exposure to higher levels of pesticides and fertilizers; may also lead to toxic algal blooms in waterways	Consequences of silting up of dams and rivers
	Depletion of underground aquifers	Lack of well-water for drinking and hygiene	Decline in agricultural productivity		
Depletion of plants and animals; loss of biodiversity	*Destruction of habitat*	Deforestation: disruption of local culture and health	Shortage of edible species		Deforestation—greenhouse enhancement
	Loss of genetic diversity (species and strains); weakening of ecosystems			Loss of medicinal chemicals, and other health-supporting materials	Greater vulnerability of plants and livestock. Decline in vitality of ecosystems
Other effects of overpopulation, particularly in poor countries	*Proliferation of crowded urban slums and shanty towns (due to migration and high fertility)*	Infectious diseases Malnutrition Antisocial behaviours	Effects of breakdown of social organization.		Various consequences of overload of local ecosystems

[a] the designations 'early' and 'late' are notional only, indicating the relative time of occurrence

FIGURE 7

Effects of global environmental change on health

SOURCE: MCMICHAEL 1993.

to the handling of uncertainty, and its communication to policy-makers and the public at large" (200).

In fall 1995, the IPCC released its second assessment, far more detailed than the first. It drew on contributions from over 1,000 scientists from 50 countries to document impacts on physical and ecological systems, socioeconomic conditions, and health (Watson, Zinyowera, and Moss 1996). Distinguishing between direct

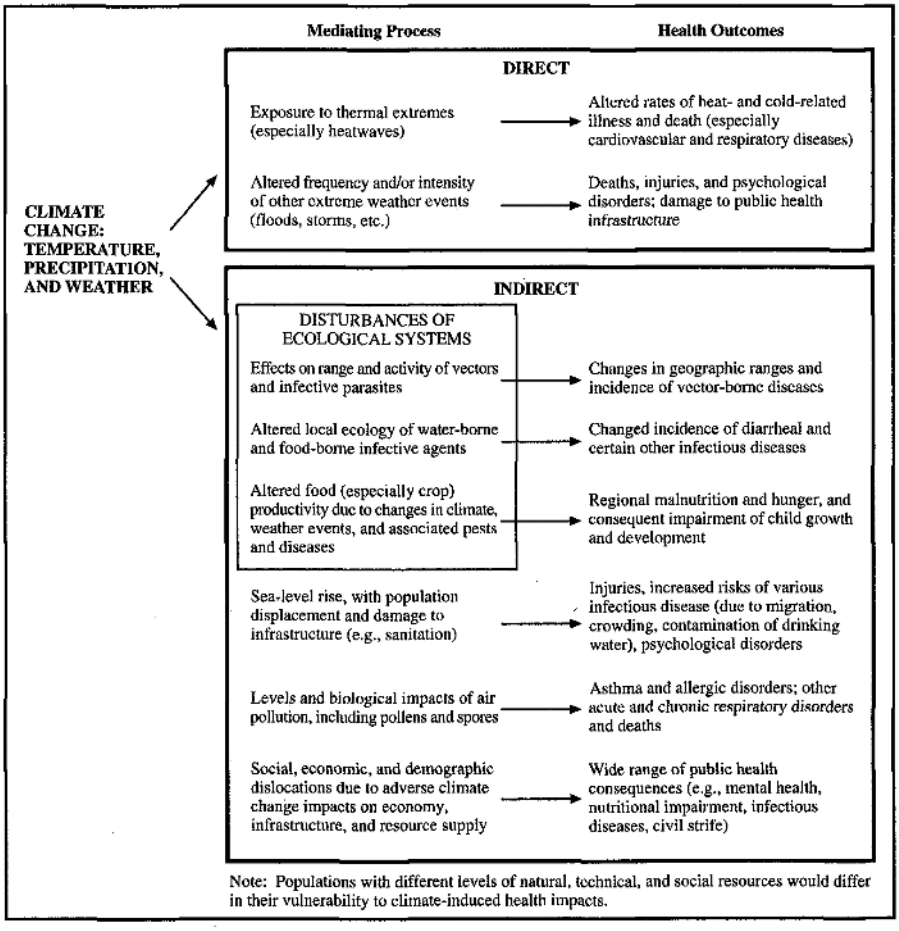

Figure 3: Ways in which climate change can affect human health.

Figure 8

The IPCC's second climate-health framework

Source: Watson, Zinyowera, and Moss 1996.

(heat) and indirect (vectors, food, flooding) pathways, it argued that in the long run the indirect effects would cause the most suffering (37) (see Figure 8). More significantly, the IPCC reported that adverse consequences had already begun: "There have, indeed, been various recent events that, plausibly, might be early signals of such change. The increased heat-related deaths in India in 1995; the changes in geographic range of some vector-borne diseases; the coastal spread of cholera: Could these be early indications of shifts in population health risk in response to aspects of climate change?" (580). While other causes could not be ruled out, global warming was the obvious suspect.

Legacies

Scientists and physicians have continued to document the ever-expanding health effects of global warming. In January 2019, nearly 30 years after Leaf's essay, the *New England Journal of Medicine* published another clarion call, "The Imperative for Climate Action to Protect Health" (Haines and Ebi 2019). The authors asserted that the changes predicted in the 1980s had begun: "Climate change is already adversely affecting human health and health systems" (263). Many of the specific mechanisms were familiar—heat, extreme weather, air pollution, food supply—but others received new emphasis, including wildfires, mental health, and climate change-induced poverty (see Figure 9). Unless actions were taken, "substantial increases in morbidity and mortality are expected" (263). Doctors had to act: "The pervasive threats to health posed by climate change demand decisive actions from health professionals and governments to protect the health of current and future generations" (272). Concerns with health equity and social justice have also become more prominent. One chapter notes that the "hostile consequences of climate change will disproportionately affect vulnerable and marginalized groups, particularly those whose ability to cope with climate hazards is curtailed by systemic racism, colonial legacies, illicit financial flows, and human rights failings" (Richardson, Burkett, and Farmer 2022; see also Balbus et al. 2022).

The IPCC released its sixth assessment in 2022, weighing in at 3,068 pages (Pörtner et al. 2022). The chapter on health had reached 130 pages (still just a small share of the total), with over 1,500 references (Cissé and McLeman 2022). The overall conclusions were starker and more confident than ever. The damage was not just a projection, but an observed, empirical, reality: "Climate change has adversely affected physical health of people globally (very high confidence) and mental health of people in the assessed regions (very high confidence)" (Pörtner et al. 2022, 11). Projected impacts remained even more dire: "An excess of 250,000 deaths per year by 2050 attributable to climate change are projected just due to heat, undernutrition, malaria, and diarrheal disease, with more than half of this excess mortality projected for Africa" (Cissé and McLeman 2022, 1046) (see Figure 10). Urgent action was required: "Any further delay in concerted anticipatory global action on adaptation and mitigation will miss a brief and rapidly closing window of opportunity to secure a liveable and sustainable future for all (very high confidence)" (Pörtner et al. 2022, 33).

Health activists remain hopeful. When *Lancet* released its seventh "Countdown on Health and Climate Change" installment in October 2022, its tone was dire, but the authors preserved their faith in action inspired by health advocacy: "putting human health at the centre of an aligned response to these concurrent crises could represent the last hope of securing a healthier, safer future for all" (Romanello et al. 2022, 1647). COP28 in December 2023 for the first time featured a "Day of Health" (Miller 2023).

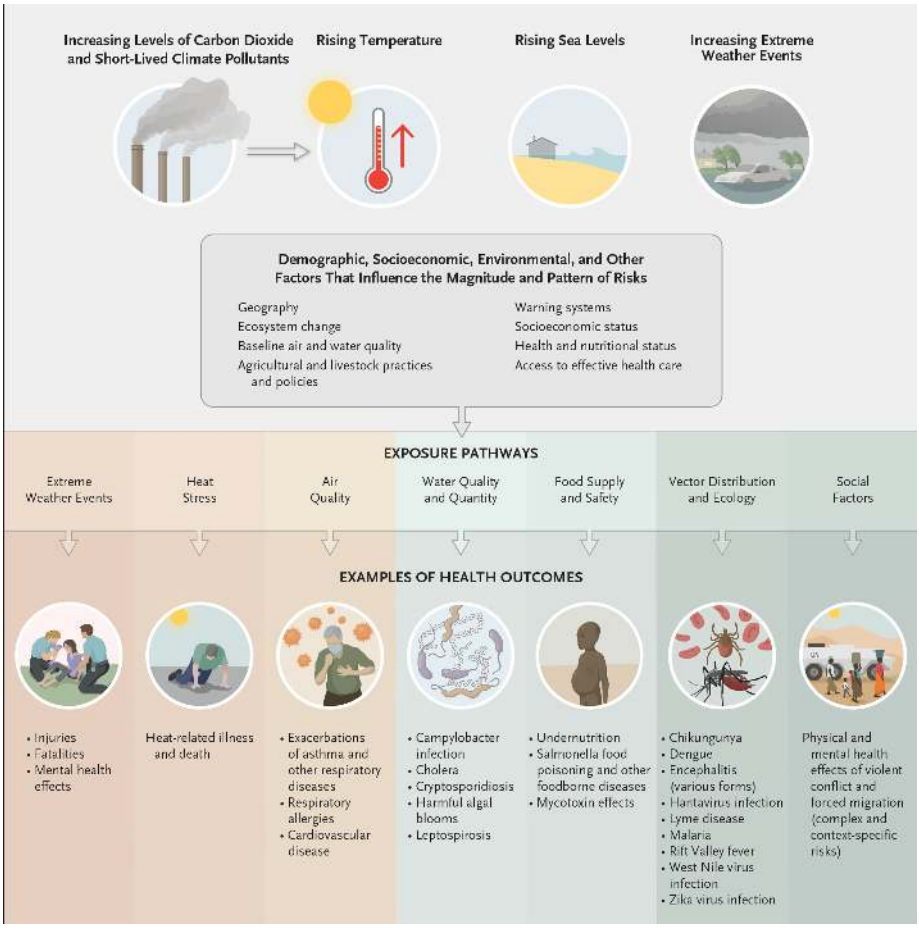

Figure 9

The current state-of-the-art representation

Source: Haines and Ebi 2019.

Is hope warranted? When scientists first imagined CO_2-induced global warming in the 19th century, they believed that humans (at least certain ones) would benefit. In the 1980s, however, researchers documented the many ways in which global warming threatened human health. Citing the precedent of their successful advocacy against nuclear war, physician advocates invoked their moral authority as guardians of health and demanded action against global warming.

As the heat waves, wildfires, and other climate calamities of summer 2023 showed, those hopes from the first era of climate-health advocacy remain unfulfilled. Leaf and others had assumed that an educated public would demand action. Countless obstacles emerged. Scientists emphasized the uncertainty of

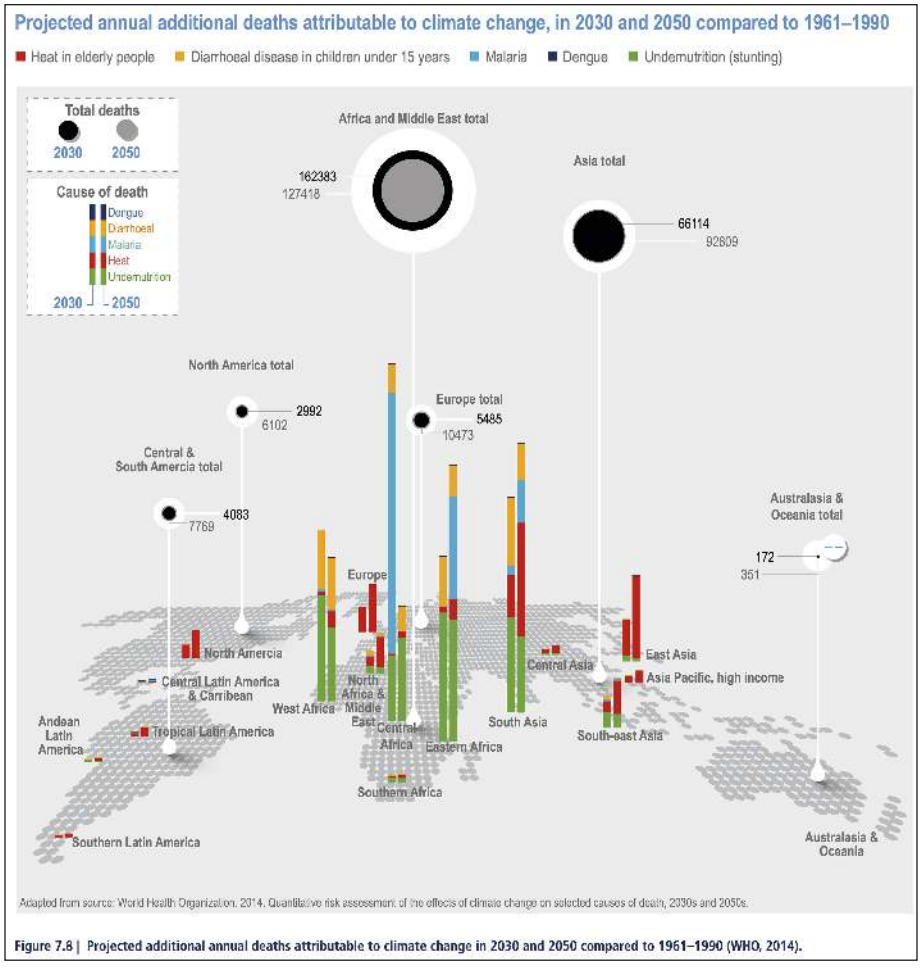

Figure 7.8 | Projected additional annual deaths attributable to climate change in 2030 and 2050 compared to 1961–1990 (WHO, 2014).

FIGURE 10

Projecting deaths

SOURCE: PÖRTNER ET AL. 2022.

their forecasts. Global warming deniers orchestrated sophisticated disinformation campaigns. Fossil fuel interests lobbied government officials. The Supreme Court imposed limits on environmental regulation. US voters prioritized other concerns. As James Speth, who encouraged Carter to take action in 1979, wrote in 2008, "we are all complicit in that failure" (4).

Just as activists in 1989 noted that five of the hottest years on record had occurred in that decade, activists now note that the past eight years have been the hottest on record. Is there something more physicians could do to educate and energize communities? Much has changed since the 1980s. Earth is now warmer

than it has ever been in recorded human history, and the adverse health consequences have begun. Decades of research have improved our understanding of climate-health relationships: what researchers once imagined or forecast through modeling, they now can demonstrate. This strengthens the predictions that the worst is yet to come. Physicians now, as then, have an obligation to speak out. Yet they must also understand that their decades of speaking out have not had the desired effect. Is it insanity to do the same thing and expect different results?

It might be reasonable to hope that climate-health science is now so robust that it will have more impact than it did in the 1990s. Certainly it receives more attention in the media. In summer 2023, a book about the health effects of heat waves became a bestseller amid record-breaking heat (Goodell 2023). Media attention extends researchers' reach. Doctors, now more strategic, have described specific approaches that can be taken: they can document changes in health patterns; they can work to green health care practices; they can communicate the best information about what steps individuals can take (such as changing their diet and modes of transportation); they can educate the next generation of clinicians; and they can work with others to build social movements to pressure industries and governments (Myers et al. 2022). Doctors can also reformulate bioethics to take ecology and environmental justice more seriously and to value other forms of knowing, such as indigenous approaches to the environment, thereby "campaigning not only for the health and dignity of the sick but also for the health and security of our plundered planet" (Anderson 2023).

Some have gone further. In 2019, physicians and nurses in England participated in blockades as part of the Extinction Rebellion. *Lancet* editor Richard Horton (2019) defended them: "Doctors and all health professionals have a responsibility and obligation to engage in all kinds of non-violent social protest to address the climate emergency. That is the duty of a doctor." Some might disagree, but all climate-health advocates need to think seriously about the limits of possible strategies and work to find new ways to incite action. Dramatic reductions in fossil fuel combustion and large-scale investments in adaptation could make a difference. Without that, we risk a climate catastrophe that kills so many people that continued inaction becomes impossible (as in Robinson's 2020 cli-fi thriller). It is getting late (and hot), but action is better late than never.

References

Abarbanel, A., and T. McClusky. 1950. "Is the World Getting Warmer?" *Saturday Evening Post,* July 1.

Anderson, W. 2023. "Toward Planetary Health Ethics? Refiguring Bios in Bioethcs." *Bioethical Inq,* Aug. 25. DOI: 10.1007/s11673-023-10285-0.

Anderson, W., and J. H. Dunk. 2022. "Planetary Health Histories: Toward New Ecologies of Epidemiology." *Isis* 113: 767–88.

Aronowsky, L. 2021. "Gas Guzzling Gaia, or: A Prehistory of Climate Change Denialism." *Crit Inq* 47: 306–27.

Arrhenius, S. 1896. "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground." *Philos Mag* 41: 237–76.

Arrhenius, S. 1908. *Worlds in the Making: The Evolution of the Universe*, trans. H. Borns. New York: Harper.

Balbus, J. M., et al. 2022. "After COP26: Putting Health and Equity at the Center of the Climate Movement." *N Engl J Med* 386: 1295–97.

Boyden, S. 1972. "The Environment and Human Health." *Med J Austral* 1: 1229–34.

Brown, L. R., C. Flavin, and S. Postel. 1989. "A World at Risk." In *State of the World 1989: A Worldwatch Institute Report on Progress Toward a Sustainable Society*. New York: Norton.

Burch, G. E., and T. D. Giles. 1972. "A Perspective on Climate and Man's Health." *JAMA* 221: 1050–51.

Callendar, G. S. 1938. "The Artificial Production of Carbon Dioxide and Its Influence on Temperature." *Q J R Meteorol Soc* 64: 223–40.

Centers for Disease Control (CDC). 1989. "Current Trends Heat-Related Deaths: Missouri, 1979–1988." *MMWR* 38: 437–39.

Cissé, G., and R. McLeman. 2022. "Health, Wellbeing and the Changing Structure of Communities." In *Climate Change 2022*, ed. H.-O. Pörtner, et al., 1041–1170. Cambridge: Cambridge University Press.

Dunk, J. H., and W. Anderson. 2020. "Assembling Planetary Health: Histories of the Future." In *Planetary Health: Protecting Nature to Protect Ourselves*, ed. S. Myers and H. Frumkin, 17–35. Washington, DC: Island Press.

Dunk, J. H., and D. S. Jones. 2020. "Sounding the Alarm on Climate Change, 1989 and 2019." *N Engl J Med* 382: 205–7.

Dunk, J. H., et al. 2019. "Human Health on an Ailing Planet: Historical Perspectives on Our Future." *N Engl J Med* 381: 778–82.

Ellis, F. P. 1972. "Mortality from Heat Illness and Heat-Aggravated Illness in the United States." *Environ Res* 5: 1–58.

Epstein, P. R., and D. Sharp. 1993. "Medicine in a Warmer World." *Lancet* 342: 1003–4.

Fleming, J. R. 1998. *Historical Perspectives on Climate Change*. New York: Oxford University Press.

Fleming, J. R. 2007. *The Callendar Effect: The Life and Work of Guy Stewart Callendar (1898–1964)*. Boston: American Meteorological Society.

Freeman, J. 2020. "The Environmental Protection Agency's Role in U.S. Climate Policy A Fifty Year Appraisal." *Duke Environ Law Policy Forum* 31: 1–79.

Godlee, F. 1991. "Health Implications of Climatic Change." *BMJ* 303: 1254–56.

Goodell, J. 2023. *The Heat Will Kill You First: Life and Death on a Scorched Planet*. New York: Little, Brown.

Haile, D. G. 1989. "Computer Simulation of the Effects of Changes in Weather Patterns on Vector-Borne Disease Transmission." In *The Potential Effects of Global Climate Change on the United States*, ed. J. B. Smith and D. A. Tirpak. Washington, DC: EPA.

Haines, A. 1991. "Global Security: A Role for Health Professionals." *PSR Q* 1: 89–95.

Haines, A., and K. Ebi. 2019. "The Imperative for Climate Action to Protect Health." *N Engl J Med* 380: 263–73.

Halvorson, C. 2021. *Valuing Clean Air: The EPA and the Economics of Environmental Protection*. New York: Oxford University Press.

Hoffman, J. S. 1987. *Assessing the Risks of Trace Gases That Can Modify the Stratosphere. Vol. 1: Executive Summary*. Washington, DC: EPA.

Horton, R. 2019. "Health and Climate." *RubberRepublic*, Oct. 24. https://www.youtube.com/watch?v=YEVGNeneYug.

Jones, D. S. 2023. "Killer Heat Waves Are Coming." *Boston Rev,* June 1. https://www.bostonreview.net/articles/heat-death/.

Kalkstein, L. S. 1989. "The Impact of CO_2 and Trace Gas-Induced Climate Changes upon Human Mortality." In *The Potential Effects of Global Climate Change on the United States*, ed. J. B. Smith and D. A. Tirpak. Washington, DC: EPA.

Kalkstein, L. S. 2023. Interview with author, July 11.

Kalkstein, L. S., and S. H. Giannini, 1991. "Global Warming and Human Health: Does a Real Threat Exist?" *New Biologist* 3 (Aug.): 727–28.

Kalkstein L. S., and K. M. Valimont. 1986. "Effects on Human Health." In *Potential Effects of Future Climate Changes on Forests and Vegetation, Agriculture, Water Resources, and Human Health, Appendix B*, *Draft Final*, ed. D. A. Tirpak, 122–52. Washington, DC: EPA.

Kalkstein, L. S., et al. 1986. "The Impact of Human-Induced Climatic Warming upon Human Mortality: A New York City Case Study." In *Effects of Changes in Stratospheric Ozone and Global Climate, Vol. 3: Climate Change*, ed. J. G. Titus, 275–93. Washington, DC: EPA.

Lachenal G., and G. Thomas. 2023. *Atlas historiuque des épidémies*. Paris: Autrement.

Lakoff, A. 2017. *Unprepared: Global Health in a Time of Emergency*. Berkeley: University of California Press.

Lancet. 1989. "Health in the Greenhouse." *Lancet* 333: 819–20.

Landsberg, H. E. 1970. "Man-Made Climatic Changes." *Science* 170: 1265–74.

Leaf, A. 1989. "Potential Health Effects of Global Climatic and Environmental Changes." *N Engl J Med* 321: 1577–83.

Longstreth, J. 1989. "Human Health." In *Report to Congress: The Potential Effects of Global Climate Change on the United States*, ed. J. B. Smith and D. A. Tirpak, 219–36. Washington, DC: EPA.

Longstreth, J. 1999. "Public Health Consequences of Global Climate Change in the United States." *Environ Health Perspect* 107 (Feb.): 169–79.

Longstreth J., and J. Wiseman. 1989. "The Potential Impact of Climate Change on Patterns of Infectious Diseases in the United States." In *The Potential Effects of Global Climate Change on the United States*, ed. J. B. Smith and D. A. Tirpak. Washington, DC: EPA.

MacDonald, G. 1979. *The Long Term Impact of Atmospheric Carbon Dioxide on Climate*. JASON Technical Report, US Department of Energy. Arlington, VA: SRI International.

Macfarlane, R. A. 2021. "Wild Laboratories of Climate Change: Plants, Phenology, and Global Warming, 1955–1980." *J Hist Biol* 54: 311–40.

McMichael, A. J. 1993. "Global Environmental Change and Human Population Health: A Conceptual and Scientific Challenge for Epidemiology." *Int J Epidemiol* 22: 1–8.

McMichael, A. J. 1995. "Conceptual and Methodological Challenges in Predicting the Health Impacts of Climate Change." *Med War* 11: 195–201.

Miller, J. 2023. "HMS Physician-Scientist Named WHO Special Envoy for Climate Change and Health." *Harvard Med News,* July 20.

Myers, S. S., et al. 2022. "Clinicians for Planetary Health." *One Earth* 5: 329–332.

National Research Council (NRC). 1979. *Carbon Dioxide and Climate: A Scientific Assessment*. Washington, DC: National Academies Press.

National Research Council (NRC). 1983. *Changing Climate: Report of the Carbon Dioxide Assessment Committee*. Washington, DC: National Academies Press.

Nierenberg, N., W. R. Tschinkel, and V. J. Tschinkel. 2010. "Early Climate Change Consensus at the National Academy: The Origins and Making of *Changing Climate*." *Hist Stud Nat Sci* 40: 318–49.

Oreskes N., and E. M. Conway. 2010. *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*. New York: Bloomsbury Press.

Peterson, T. C., W. M. Connolley, and J. Fleck. 2008. "The Myth of the 1970s Global Cooling Scientific Consensus" *BAMS* (Sept.): 1325–37.

Plass, G. N. 1959. "Carbon Dioxide and Climate." *Sci Am* 201 (July): 41–47.

Pomerance, R. 1986. "The Dangers from Climate Warming: A Public Awakening." *EPA J* 12 (10): 15–16.

Pörtner, H.-O., et al. 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

Rich, N. 2018. "Losing Earth: The Decade We Almost Stopped Climate Change." *NY Times Mag,* Aug. 1.

Richardson, E. T., M. A. Burkett, and P. E. Farmer. 2022. "Health Effects of Climate Change." In *Harrison's Principles of Internal Medicine*, 21st ed., ed. J. Loscalzo, et al. New York: McGraw Hill.

Robinson, K. S. 2020. *Ministry for the Future*. New York: Orbit.

Romanello, M., et al. 2022. "The 2022 Report of the *Lancet* Countdown on Health and Climate Change: Health at the Mercy of Fossil Fuels." *Lancet* 400: 1619–54.

Seidel, S. 2023. Interview with author, Sept. 15.

Seidel, S., and D. Keyes. 1983. *Can We Delay a Greenhouse Warming? The Effectiveness and Feasibility of Options to Slow a Build-Up of Carbon Dioxide in the Atmosphere*. Washington, DC: EPA.

Shabecoff, P. 1983a. "E.P.A. Report Says Earth Will Heat Up Beginning in 1990s." *NY Times,* Oct. 18.

Shabecoff, P. 1983b. "Haste of Global Warming Trend Opposed." *NY Times,* Oct. 21.

Shabecoff, P. 1988. "Draft Report on Global Warming Foresees Environmental Havoc in U.S." *NY Times,* Oct. 20.

Smith, J. B. 2023. Interview with author, July 17.

Smith, J. B., and D. A. Tirpak. 1989a. *The Potential Effects of Global Climate Change on the United States*, document no. 230-05-89-057, Appendix G. Washington, DC: EPA.

Smith, J. B., and D. A. Tirpak. 1989b. *Report to Congress: The Potential Effects of Global Climate Change on the United States*. Washington, DC: EPA.

Special Committee on Aging and Subcommittee on Aging of the Committee on Labor and Human Relations, US Senate, 1981. "Energy Assistance for the Elderly: Impact of the 1980 Heat Wave," 25 July 1980, 96th Congress, 2nd Session. Washington, DC: GPO.

Speth, J. G. 2008. "Foreword." In *The Carbon Dioxide Problem,* ed. G. M. Woodwell. Woods Hole: Woods Hole Research Center.

Subcommittee on Environmental Pollution, Committee on Environment and Public Works, US Senate, 1986. "Ozone Depletion, the Greenhouse Effect, and Climate Change," 10–11 June 1986, 99th Congress, 2nd Session. Washington, DC: GPO.

Supran, G., and N. Oreskes. 2021. "Rhetoric and Frame Analysis of ExxonMobil's Climate Change Communications." *One Earth* 4: 696–719.

Tegart, W. J. McG., G. W. Sheldon, and D. C. Griffiths. 1990. *Climate Change: The IPCC Impacts Assessment*. WMO/UNEP/Intergovernmental Panel on Climate Change Working Group II. Canberra: Australian Government Publishing Service.

Time. 1956. "One Big Greenhouse." *Time* (May 28): 59.

Tirpak, D. A. 1986. *Potential Effects of Future Climate Changes on Forests and Vegetation, Agriculture, Water Resources, and Human Health,* Appendix B, final draft. Washington, DC: EPA.

Tirpak, D. A. 1987. "Assessing the Risks of Trace Gases That Can Modify the Stratosphere." In *Potential Effects of Future Climate Changes on Forest and Vegetation, Agriculture, Water Resources, and Human Health,* vol. 5, Appendix B. Washington, DC: EPA.

Titus, J. G. 1986. *Effects of Changes in Stratospheric Ozone and Global Climate, Vol. 3: Climate Change*. Washington, DC: EPA.

Watson, R. T., M. C. Zinyowera, and R. H. Moss. 1996. *Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses*. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

Weihe, W. H. 1979. "Climate, Health and Disease." In *Proceedings of the World Climate Conference: A Conference of Experts on Climate and Mankind, Geneva, 12–23 February 1979*, 313–68. Geneva: World Meteorological Organization.

White, M. R. 1985. *Characterization of Information Requirements for Studies of CO_2 Effects: Water Resources, Agriculture, Fisheries, Forests and Human Health*. Washington, DC: DOE.

White, M. R., and I. Hertz-Picciotto, 1985. "Human Health: Analysis of Climate Related to Health." In *Characterization of Information*, ed. M. R. White, 171–206. Washington, DC: DOE.

Woodwell, G.M., et al. 1979. *The Carbon Dioxide Problem: Implications for Policy in the Management of Energy and Other Resources*, Report to the Council of Environmental Quality; reprinted 2008, Woods Hole: Woods Hole Research Center.

World Climate Programme (WCP). 1986. *Report of the International Conferences on the Assessment of the Role of Carbon Dioxide and of Other Greenhouse Gases in Climate Variations and Associated Impacts*. Geneva: World Meteorological Organization.

World Commission on Environment and Development (WCED). 1987. *Our Common Future*. New York: Oxford University Press.

World Health Organization (WHO). 1990. *Potential Health Effects of Climatic Change*. Geneva: WHO.

World Meteorological Organization (WMO). 1979. *Proceedings of the World Climate Conference: A Conference of Experts on Climate and Mankind, Geneva, 12–23 February 1979*. Geneva: WMO.

World Meteorological Organization (WMO), UN Environmental Programme (UNEP), and World Health Organization (WHO). 1987a. *Climate and Human Health: Proceedings of the Symposium in Leningrad, Vol. 1*, 22–26 September 1986. Geneva: WMO.

World Meteorological Organization (WMO), UN Environmental Programme (UNEP), and World Health Organization (WHO). 1987b. *Climate and Human Health: World Climate Programme Applications*. Geneva: World Meteorological Organization.