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Advancing a Social Determinants Approach to Climate Change and Health

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Advancing a Social Determinants Approach to Climate Change and Health

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Abstract

Advancing a Social Determinants Approach to Climate Change and Health

Naomi Beyeler

Climate change is a global crisis harming the health of communities around the world. We have known about the causes and risks of climate change since at least the 1960s, and about the health harms of climate change since the 1990s. Yet our collective inability to envision and enact alternative energy and economic systems has locked in a level of global temperature rise with devastating consequences. At current levels of warming, communities around the world are already experiencing a wide range of harmful impacts to mental and physical health and wellbeing; impacts which will grow as climate change continues unabated. As a result of systemic forms of social injustice – including those of economics, race, and gender – climate change is deepening health inequities within and between countries.

Gaps in the literature hinder our ability to comprehend and effectively communicate the scale of the challenge, to identify and implement effective programs and policies to protect health in the face of climate change, and to overcome deeply entrenched political barriers to action. In this dissertation, I focus on one gap in particular: the paucity of research at the global level exploring the intersection of climate change and the social determinants of health. Using Nancy Krieger's Ecosocial Theory of Disease Distribution as a conceptual guide, I develop three empirical case studies, each of which focuses on a distinct pathway through which climate change and the social determinants of health intersect to drive adverse health outcomes.

Chapter One offers a brief overview of the current state of the climate change and health literature and describes how a social determinants approach can respond to existing research gaps. Chapter Two utilizes a historical case study to document the engagement of the fossil fuel industry in the science of climate change and health, newly emergent in the 1990s. It identifies how the industry sought to influence the public health narrative on climate change and opens a critical new area of research for understanding and navigating political barriers to climate action. Chapter Three quantitatively assesses the relationship between drought – an environmental phenomenon becoming increasingly common and severe because of climate change – and women's empowerment – a social determinant of women's and children's health. Drawing on analysis of household surveys in twenty-four countries in sub-Saharan Africa, this paper finds that drought is associated with a small but significant decline in women's empowerment, and thus expands a currently understudied area in the literature on climate change and women's health. Chapter Four presents qualitative analysis of how climate change impacts mental health in a uniquely vulnerable population of smallholder farmers living with HIV in western Kenya. This chapter finds that mental health is predominantly mediated by profound changes in economic and social systems, and thus proposes a new conceptual framework for understanding the social determinants pathways through which climate change shapes emotional health.

Finally, Chapter Five draws conclusions from these three studies: proposing directions for future research and highlighting how a social determinants approach to global health sciences research on climate change can inform more effective community and policy interventions to reduce climate change's health harms.

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List of Abbreviations

ACSH	American Council on Science and Health
CEI	Competitive Enterprise Institute
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station
DHS	Demographic Health Survey
EA	Enumeration Area
GCC	Global Climate Coalition
HIV	Human Immunodeficiency Virus
IPCC	Intergovernmental Panel on Climate Change
PAR	Population Attributable Risk
STAC	Science and Technology Assessment Committee
UCSF	University of California San Francisco
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
WFA	Western Fuels Association
WHO	World Health Organization

Chapter One

Introduction

Introduction

Climate change is a global crisis harming the health and wellbeing of communities around the world – and disproportionately impacting those communities and populations that are vulnerable. We have known about the causes and risks of climate change since at least the 1960s, and about the health harms of climate change since the 1990s. Yet through our collective inability to envision and enact alternative energy and economic systems, we have likely locked in at least 2°C of global temperature rise, with devastating consequences for health. A recent explosion of health research on climate change has contributed to the creation of dozens of health organizations that strive to address this emergency. However, significant roadblocks to this work still exist: funding for climate and health research and programs is sparse, climate change has not been widely integrated into the health policy conversations, and the health voice is largely absent in climate policy discussions.

Critical gaps in the literature hinder our ability to comprehend and effectively communicate the scale of the challenge, to identify and implement effective programs and policies to protect health in the face of climate change, and to overcome deeply entrenched political barriers to action. In this dissertation, I focus on one gap in particular: the paucity of research at the global level exploring the underlying causes of the climate health inequities that

are a focus of interest within the health community. However, though several social determinants of health frameworks underpin a broad body of research that addresses the social, economic, and political drivers of health, commonly referenced climate and health frameworks do not fully integrate these same drivers. This dissertation explores how the explicit incorporation of a social determinants approach into global climate and health sciences research can expand our understanding of the complex pathways through which climate change impacts health, and thus increase the number of potential opportunities to protect health from climate change. Furthermore, this social determinants approach offers an important perspective on advancing new avenues of health sciences research that could support policy engagement at the intersection of climate and health.

I begin Chapter One with a brief overview of the current state of climate change, and of current health impacts and research, and describe how a social determinants approach could respond to existing research gaps. I then present three empirical case studies, each of which focuses on a distinct pathway through which climate change and the social determinants of health intersect to drive adverse health outcomes. Chapter Two examines the commercial determinants of health, using analysis of fossil fuel industry documents to understand how health fits into the industry's broader efforts to prolong climate inaction. In the subsequent chapters, I address the consequences of this inaction. Chapter Three probes the intersection of climate and gender through analysis of the impact of drought on women's empowerment in sub-Saharan Africa. Chapter Four explores the social and economic pathways through which climate change affects mental health in a vulnerable community in Kenya. Chapter Five draws

on the findings from this dissertation, illustrating how a research approach explicitly grounded in the social determinants of health may open new arenas for health sciences research, as well as recommending future research directions that can inform community and policy interventions to reduce the health harms of climate change. I conclude with brief thoughts on the role of global health sciences research in translating evidence into policy in the context of the emerging climate change and health movement.

Current state of climate change and health

The impacts of climate change are apparent in every corner of the world. Our continued collective dependence on fossil fuels has led to accelerating climate change – what scientists call the greatest threat to health of the 21st century (1,2). At current levels of warming – roughly 1.1°C above pre-industrial levels (3) – communities around the world are already experiencing a wide range of significant impacts, including those connected to mental and physical health and wellbeing (4,5). Rising temperatures, more extreme heat waves, worsening storms, more severe droughts, accelerating sea level rise, and worsening air quality all cause direct and immediate harms – including heat-related illnesses, cardiovascular and respiratory diseases, adverse maternal and child health outcomes, some cancers, infectious diseases, food insecurity, poor mental health outcomes, and premature death (5–14).

In the 2015 Paris Climate Agreement, the global community committed to limit temperature rise to well below 2°C, with the ultimate goal of remaining below 1.5°C above pre-industrial levels (15). Those commitments were in line with scientific estimates of temperature

thresholds that, if not exceeded, will preclude the most severe health and social impacts of climate change. Though scientific models outline pathways through which achieving the 1.5°C target may technically be feasible (16,17), inertia in our political and economic systems and a lack of political will for transformative action has realistically foreclosed this possibility. Indicators in nearly every sector show we are off track to reach the goals of the Paris Agreement (18–23) and that even if all countries were to meet their emissions targets, the planet would still warm by an estimated 2.4°C to 2.8°C (18,19). This level of warming will fundamentally remake our ecological systems, resulting in cascading impacts on our health. At these temperatures we will experience increasingly common and severe heatwaves, droughts, extreme precipitation events, and sea level rise (16) and likely pass irreversible tipping points, such as the collapse of the Greenland ice sheet (24). These changes may render uninhabitable the places where millions of people live and may thus bring to pass a tremendous increase in climate-related illness and death. For instance, one study suggests that without significant reductions in greenhouse gas emissions, temperature-related deaths alone could surpass 80 million by 2100 (25).

Climate health impacts are intertwined with the social determinants of health. As a result of systemic forms of social injustice – those of economics, race, and gender, to name but a few – climate change and fossil fuel-related air pollution disproportionately impact certain regions and communities, deepening health inequities within and between countries (26–29). Within countries, communities of color, low-wealth communities, and marginalized peoples are the most exposed to climate risks and the least able to adapt to climate impacts, thus bearing

the heaviest climate-related health burdens (30). At a global level, the impacts of climate change – and thus its health effects – are greatest in the low- and middle-income countries least responsible for historic greenhouse gas emissions (31,32). Climate change is also causing widespread economic, social, ecological, and health system disruptions, in turn driving increases in poverty, migration, conflict, and violence, each of which in their turn increase a wide range of adverse health outcomes (4,33–36). One example of this chain effect is that of economic growth. Climate change is slowing economic growth most acutely in lower-income countries, resulting in growing economic inequity (37). The African Development Bank estimates that climate change could reduce regional GDP by as much as 15% by 2050 (38). Globally, climate change could return tens of millions of people to extreme poverty by 2030 (39). The health impacts of these widespread disruptions, though mostly unquantified, are likely to be severe.

The shape and magnitude of future risks and impacts remain open to change by our action. The available evidence paints a dire picture of what the future holds for communities around the world, and a daunting one of the scale of effort needed to protect human wellbeing as the climate continues to change. As the result of decades during which we knew the risks yet failed to act, we are now left with an imperative: simultaneously advance transformative adaptation, that continues to expand people's ability to withstand climate threats, and transformative mitigation, that gives us the best possible chance of maintaining our climate within livable bounds and avoiding the most severe health consequences.

The causes of climate change are well-established. Our energy, transportation, land use, food and agriculture, industry, and building systems produce greenhouse gas emissions that trap heat in the earth's atmosphere, leading to not only global temperature rise but also a wide range of climatic changes affecting the biosphere – from ocean acidification to biodiversity loss. The solutions to climate change are also well-known. They include, most fundamentally, the reduction of greenhouse gas emissions: transitioning from burning fossil fuels to using clean energy across all systems that contribute to climate change (18). Fossil fuel-driven growth over the past centuries has underpinned the tremendous global health gains made in recent history and expanding energy access remains critical to enable the achievement of the health, economic, and other goals of the global community. Thus, as we undertake this transition we must look seriously at pathways to a just energy transition in low- and middle-income countries that enable energy access, development, and good health.

Our likelihood of failing to meet the 1.5°C goal of the Paris Agreement also cannot be an excuse for abandoning the most strenuous efforts to reduce greenhouse gas emissions and to mitigate global temperature rise and accompanying climatic changes. Rather, limiting climate change as much as possible is imperative. Every dimension of health and wellbeing is projected to decline as temperatures rise (40,41); thus, every marginal increase in warming is meaningful from a health perspective. The locking in of increasingly severe future health and climate risks (4) demands that we devote much greater attention to bolstering the health and climate resilience of the most impacted communities. Current adaptation efforts fall far short of what is needed to manage current levels of climate change (1,42,43). Yet mitigation remains essential,

because as climate change accelerates, the effectiveness of known adaptation strategies declines (44). Indeed, there are levels of climate change beyond which adaptation will likely become impossible (45).

While there remain unanswered questions about what the future will look like, from both a climate and a health perspective, the timeline on which action must be taken to avoid catastrophic impacts requires that we move much more quickly to develop and implement climate solutions that can protect health. The choices we make in the coming few years will determine our health for many years to come.

Research gaps

Critical research gaps exist in this field of study, hindering our ability to take effective action. Research on climate and health began to emerge in the mid-1990s, and has exploded in the past decade (5). By one estimate, over 15,000 articles were published on the topic from 2013 to 2019 (46). Yet the growth of research on climate change and health has featured inequitable attention paid to disease areas and regions of the world. In addition, the methodological approaches used have been limited. Recent reviews have identified gaps in the literature, including but not limited to:

- **Health areas**: Research focuses on a narrow subset of health outcomes, such as heat-related and infectious diseases and illnesses linked to air pollution (46). A recent review found that over one quarter of studies focused on heat, while only

around two percent of studies examined mental health, or maternal and child health (47).

- **Regions**: Research is located predominantly in high- and upper-middle-income countries (46,48,49), and not in those countries experiencing the greatest impacts of climate change on health.
- **Risk factors**: Research focuses mainly on isolating the impact of climate change on health, instead of analyzing climate-health impacts in the context of other drivers of ill health. One review found that a large majority of articles published in the academic literature focused on discrete health impacts while less than ten percent of articles examined social vulnerability as a mediating factor of climate-related health outcomes (46).

Critically, across all domains of health research on climate change, relatively little is currently known about climate mitigation, adaptation, and health sector solutions, at all levels of action, that would best protect health and health equity. We have done much more to catalogue the extent of the problem than to expand the evidence base on health-protective strategies. Cataloguing the extent of the problem is certainly a critical first step in climate and health research. Given the scale and urgency of the problem, however, we must move quickly towards a focus on solutions. The necessity of this shift in focus presents a dilemma: namely, that gaps in our current approach to this area of research may hinder our ability to develop solution-focused evidence. I identify three constraints in the current approach – constraints which could be remedied by an expanded thinking about research integrating the social

determinants of health. This expansion, in turn, could help build the case for action and provide the evidence base to allow more effective engagement of health scientists in shaping healthy climate policy.

First, current efforts focus predominantly on discrete rather than cumulative impacts. Though the impacts of climate change are varied and broad, much of the literature looks at single outcomes or exposures and does not capture aggregate health risks for communities vulnerable to multiple and intersecting climate health risks. Examining one climate exposure, such as heat, or one health endpoint, such as birth outcomes, risks not only obscuring the magnitude of the impact, but also failing to understand how risks compound and what solutions are available in response to them. Global health endeavors, such as the Global Burden of Disease, which seek to attribute population health outcomes to different causal risk factors, may also underplay the importance of climate change in their approach: breaking climate-related risk factors into many different categories (e.g., air pollution, high temperatures), and not including climate in measures of other leading health risk factors (e.g., malnutrition) despite well-documented impacts of climate change on these health risks (5,50).

Second, present efforts focus more on health outcomes (the “what”) than on the pathways through which climate change drives poor health and on how these pathways vary across populations (the “how and why”). Understanding impact without understanding how and why health outcomes occur may be insufficient to guide effective intervention. Particularly in the global health literature, there exists a comparative lack of focus on how climate change

intersects with the social determinants of health to amplify existing health inequities and create new health risks. One example of this underdeveloped aspect of the literature is gender (51,52). Thus, despite evidence on the increased risks of negative health outcomes faced by women (4,53,54), comparatively little is known about the pathways through which climate impacts gender inequity or by which gender inequity shapes climate vulnerability. Even in studies that acknowledge social determinants as important, the focus remains on counts rather than mechanisms. For example, though a recent World Health Organization (WHO) review of the climate and health literature noted the lack of research on gender, it concluded there was a need for more gender-disaggregated data rather than for increased investigation into how climate change and climate-related health risks and responses operate within, and are shaped by, systems of gender and gender inequity (47). Expanding our understanding of how multiple social determinants pathways interact – for instance gender and economic inequity – is also critical, given that these factors intersect to create unique challenges for different populations.

A third, and related, gap in the literature is the lack of attention paid to the structural drivers of climate exposure and vulnerability. This approach largely takes the social and economic contexts as a given – a background reality within which to improve health – rather than meaningfully exploring them as drivers of climate-health vulnerability and as locations for intervention. One significant example is the sparse analysis of the political drivers of climate inaction. A lack of political will, greatly fostered by the fossil fuel industry, is a major barrier to climate action globally (18,55,56). A large body of research documents the fossil fuel industry's decades-long strategy of scientific influence, denial, political lobbying, and public relations

efforts to successfully delay and block national and international climate policy (57–65). Global health researchers have produced a significant literature on the commercial determinants of health (66–69), turning attention to the role of the tobacco and sugar industries – among others – in shaping health policy and producing ill health. This research has opened new avenues for health action and policy change. However, no research to date has evaluated the fossil fuel industry's practices in relation to health. This gap is meaningful, as understanding how industry engages with the science of climate change and health, and with the health narrative around climate change, could help shape opportunities and strategies for health engagement in climate policymaking.

Collectively, prevailing research approaches may inhibit the efforts of the climate and health research community both to identify effective solutions and to communicate the problem in ways that will generate the necessary level of investment and attention. These research gaps are of concern because they limit our ability to adequately measure and convey the magnitude of the impact climate change has on health. For example, a widely cited WHO report estimates that climate-sensitive diseases will result in an additional 250,000 deaths each year from 2030 to 2050 (70). This is a very small number in relation to other leading causes of ill health. However, since it captures only a small slice of climate-related health endpoints, it is thus likely a significant undercounting of the true health costs. More recent quantification efforts, such as the Lancet Countdown, similarly offer a partial accounting of indicators on a relatively narrow set of health endpoints (5). These efforts and others like them may have

important implications for generating, or constraining, the level of political and financial attention granted to the topic of climate change.

These approaches also limit our understanding of how best to intervene in the context of complex and compounding social, economic, and climate risks. This is a critical gap because much of the work in the years ahead will need to focus on implementation. Tremendous innovation in recent years means that we have available a much wider range of mitigation technologies, yet lack evidence needed to spur their widespread adoption and use. Understanding pathways can help to bridge such implementation gaps. Focusing on discrete health endpoints, without greater consideration of the social, economic, political, and commercial determinants of health, also elevates individual clinical and organizational health systems solutions because it suggests that treating health outcomes is sufficient. However, these approaches risk being overwhelmed as climate change accelerates. Further, they fail to address the underlying causes of vulnerability. This approach also contributes to an emphasis on relatively narrow adaptation measures over greater attention to protecting health through efforts to reduce climate pollution and slow climate change. For instance, a significant focus in the discussion of heat health harms is on cooling centers – despite limited evidence of effectiveness and concerns about equity – rather than on more structural factors like urban greening or mitigation measures that will slow temperature rise. Similarly, while air conditioning can be a lifesaving adaptation, it is not accessible for many of the most vulnerable, and contributes to localized air pollution, heat islands, and climate change (71). It should be noted that adaptive capacity is shaped by the strength of social, economic, and health systems,

and that incremental measures can contribute to maladaptation (44). A broader research approach might help to identify more transformative adaptation strategies that overcome existing inequities in and constraints to community adaptive capacity.

A social determinants approach to climate change and health

A social determinants perspective can help to address these research limitations. Over the past three decades, public health scientists have theorized a number of frameworks on the social determinants of health (72–77). These are useful for guiding health research that explores the effects of structural factors and systemic inequities on health, and thus can help extend climate change and health research beyond its current focus. These frameworks vary in their attention to different social factors (78). Some leading social determinants models do not explicitly include the environmental determinants of health (77). Furthermore, the commercial determinants of health, and the role of industry in shaping health outcomes and inequities, are also missing from many common social determinants models (79). Since these environmental and commercial determinants are critical dimensions for the study of climate and health, their absence poses limitations. Nancy Krieger's "ecosocial theory of disease distribution" is thus one particularly useful social determinants framework, because it explicitly addresses the intersection of environmental and social factors and because it includes a focus on the role of institutional forces in shaping health.

Ecosocial theory centers the processes and pathways through which people embody the social, political, and environmental contexts in which they live, and how these in turn shape

population health inequities (78,80,81). In reference to the environmental context, Krieger specifically focuses on the "ecosystems that enable life to exist on our planet"; thus, while not developed in relation to climate change, ecosocial theory is relevant for its study (81). The interdependence of ecological and social systems forms the core of ecosocial theory: how systems of social power and inequity generate health outcomes through shaping vulnerability and response to intersecting health risk factors over the course of a person's life, across historical generations, and at levels ranging from the individual to the global (82). Figure 1.1 shows Krieger's conceptual model of ecosocial theory (81).

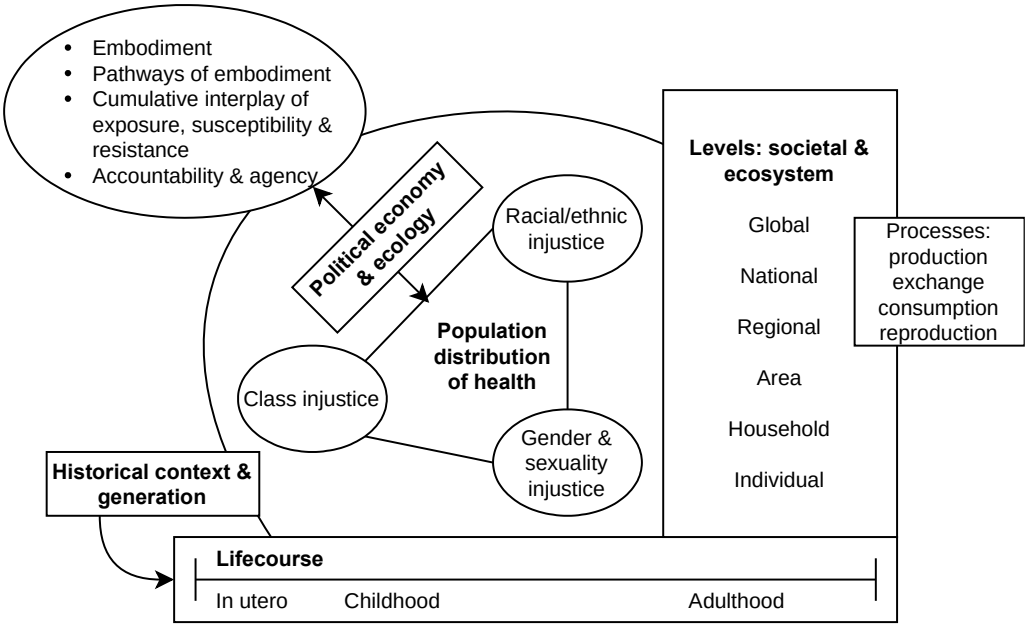

Figure 1.1. Nancy Krieger's Ecosocial Theory of Disease Distribution (81).

Ecosocial theory includes four main conceptual elements each of which can advance research in the above-mentioned gaps (78,81):

- *Embodiment*: The ways in which our social and environmental is expressed biologically in our bodies.

- *Pathways of embodiment:* The processes by which our social and environmental context shapes our health.
- *Cumulative interplay of exposure, susceptibility, and resistance:* How structural factors shape our vulnerability and response to different risks, and how these compound to impact health.
- *Agency and accountability:* How institutions create and preserve systems of inequity.

Applying these concepts is useful for understanding the multi-dimensional relationships between climate change and the social determinants of health, the ways in which these elements interact to drive exposure, vulnerability, and adaptation to multiple health risks, and the systems that drive climate change, perpetuate health inequity, and constrain political action. Thus, Krieger's ecosocial theory can help respond to existing gaps in the literature.

Selection of papers and structure of the dissertation

Each of the papers in this dissertation focuses on a critical gap in the literature and applies an ecosocial perspective to analyze the distinct pathways through which climate change and social determinants of health work together to drive adverse health outcomes. Drawing on the theory's attention to how social and political systems of power operate at multiple levels to shape health, this dissertation uses different methodological approaches to explore the relationship between climate change and health as it is shaped by social determinants.

Ecosocial theory aims to explore the nature of health inequities across the spectrum, from the biological to the social. The papers in this dissertation are not designed to provide a full exploration of one climate-related health outcome across this full range. I have not, for example, explored the complex way climate affects health over the life course, nor have I explored the expression of climate health risks at the biological level. Rather, each of my three papers addresses a topical gap in the current literature and explores that gap through one of Krieger's conceptual domains. Given the complexity of the topic at hand, and for the efficacy of future work in the field, a diversity of methodological approaches will be necessary to fully understand climate health impacts and to develop effective responses to them. Thus, in selecting papers for this dissertation, I additionally identified topics and data sets that would provide me opportunities to gain experience in several different research methodologies.

Chapter Two utilizes a historical case study, developed through analysis of internal- and external-facing industry documents, to examine the engagement of the fossil fuel industry in the science of climate change and health, newly emergent in the 1990s. This chapter applies document analysis methods widely utilized in the commercial determinants of health literature to explore how health fits into the fossil fuel industry's broader efforts to delay climate action. Focusing on ecosocial theory's concept of "agency and accountability", this analysis turns attention to the institutional and political factors driving climate decision making – factors which shape the nature of climate risk and the availability of opportunities for response. Topically, this chapter addresses a particular gap in the extant literature regarding the fossil fuel industry's strategies relating to health and health sciences. It additionally responds to a gap in

the climate change and health literature specifically regarding the institutional and political drivers of climate health outcomes. It brings together two strands of literature – on the fossil fuel industry and on the commercial determinants of health – to open new avenues of research with particular relevance for understanding and navigating political barriers to climate action.

Chapters Three and Four then explore the health consequences of delayed climate action. These chapters offer case studies from sub-Saharan Africa, addressing a regional gap in the literature. Chapter Three quantitatively assesses the relationship between drought – an environmental phenomenon becoming increasingly common and severe because of climate change (33) – and women's empowerment – a social determinant of women's and children's health. This chapter addresses the gap in the literature on how gender operates to shape women's differential vulnerability to climate change. In terms of the ecosocial concept of "pathways of embodiment": the availability of data on drought and women's empowerment offered the opportunity to explore one specific feasible pathway. Drawing on statistical analysis of cross-sectional, nationally-representative, household surveys of over 147,000 women in twenty-four countries in sub-Saharan Africa, this chapter identifies women's empowerment as a potentially important but understudied determinant of climate impacts on women's and children's health. This paper elevates the importance of studying the pathways through which climate impacts health in order to target efforts to the most relevant pathways.

Chapter Four explores how climate change impacts mental health in a uniquely vulnerable population of smallholder farmers living with HIV in western Kenya. The chapter

applies qualitative methods to explore the ecosocial concept of "cumulative interplay" between multiple climate and social risks – and how people respond and adapt to them – to understand the complex pathways and structural drivers of emotional wellbeing. A rapidly expanding literature documenting the mental health outcomes associated with climate change (4,14) has been accompanied by new concepts of eco-anxiety and ecological grief (83–85). Yet, despite extensive knowledge of the social determinants of mental health (86) there is comparatively little exploration within the climate change and mental health literature that integrates this systems perspective (87). This chapter puts these two bodies of literature in dialogue to explore the social and economic determinants of mental health and to investigate how these determinants are shaped by climate change. Conceptually, it advances the emergent literature on climate change and mental health by developing the social determinants and policy pathways relevant for mental health and considering the limitations of adaptation from a mental health perspective. It also points to the critical need to study multiple social determinants in concert, by highlighting the intersection of gender and economic determinants.

Chapter Five draws from these three cases to advance understanding of the social, economic, and political determinants pathways through which climate change impacts health. It also offers recommendations utilizing an ecosocial perspective in order to open new areas of interest for future global health sciences research – with the overarching goal of developing community and policy interventions that, by addressing the social determinants of health and climate change, can work to reduce climate change's health harms.

Conclusion

Climate change is a rapidly evolving challenge to the health and wellbeing of people around the world. An expansion of current research approaches is required to advance an evidence base that can most effectively enable the scale and speed of action necessitated by climate change. One domain for this expansion of research is the fuller integration of the social determinants of health, which can deepen understanding of barriers and pathways to action.

As evidence of the health harms of climate change and health benefits of climate action has grown, health sector involvement in climate has increased. A recent survey of health professionals found that nearly 70% reported it was extremely or very important to them that their organization take action on climate change (88). Every part of the health sector has a role to play in promoting health in the era of climate change. Public health systems can advance surveillance and early warning systems and work with communities to implement resilience measures. Clinical health systems can reduce their own emissions and enhance their ability to treat those facing climate-related health impacts. Health professionals can educate their patients and communities and can use their role as trusted messengers to advocate for health-protective climate policies. Indeed, emerging evidence indicates that a health message, coupled with continued trust of the U.S. public in health professionals, has the power to break through public and policy debates and catalyze climate action (89–93).

Health sciences research can provide foundational support for each of these endeavors, advancing the evidence base needed to inform effective climate action across all sectors and at

all levels. However, current gaps in the literature serve as a barrier to developing such policy-oriented research. This dissertation describes how a social determinants approach to climate change and health research can address present research gaps, and uses three studies to document the social and economic pathways by which climate change affects health.

On a personal level, as the mother of three young children, I am frightened by the science of climate change and its implications for the health and wellbeing of today's young people and future generations. Children born today will experience more extreme climate events and associated climate harm than children born in prior generations, with the greatest increases in lifetime exposure to climate threats in low-wealth countries (94). Prior to beginning my work in the area of climate change, my experience in global health science largely pertained to the translation of research evidence to global health policy in the areas of health systems and finance. Moving forward, it is critical that climate and health researchers consider how they can best support communities and decision makers in advocating for and implementing the ambitious mitigation measures needed in the face of the climate emergency. It is my sincere hope that this dissertation – by encouraging consideration of a climate and health research approach rooted in the social determinants of health – can help guide the development of the evidence needed to accelerate this work.

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Chapter Two

The Role of the Fossil Fuel Industry in Shaping the Narrative on Climate Change and Health: A Case Study of the Global Climate Coalition, 1995 to 1998

Introduction

Climate change is causing wide-ranging health harms (1): increasing incidence of chronic and infectious disease (2–4), worsening mental health (5,6), disrupting health systems (7), and deepening poverty, migration, and other social determinants of health (8,9). While known and feasible solutions exist to reduce greenhouse gas emissions and protect human health (10,11), political and social barriers have so far hindered the necessary urgent action (11–13). Key among these barriers is the power of the fossil fuel industry (14).

Industry influence in political, regulatory, and scientific activities is well-known as a shaper of public health policies and outcomes (15–19), with evidence documenting the role of the tobacco, food (20), beverage (21,22), sugar (23,24), lead (25), chemical (26), and other industries in promoting health-harming products and policies (27). These industries employ parallel strategies to shape policymaking, including, for instance, lobbying and making political contributions, engaging in scientific debates, funding public relations campaigns, and building alliances with public health organizations (28–30). A primary tactic used across industries is "information management" – producing research that supports industry positions, spreading

disinformation, suppressing public health evidence, and challenging the credibility of public health science and scientists (29).

Like other industries, the fossil fuel industry has successfully contributed to the obstruction of policy action on climate change domestically (31–33) and internationally (14), through direct lobbying and political engagement (34–36), by countering climate science (37,38), and by conducting misinformation campaigns (39–47). Yet, while there is extensive evidence of the fossil fuel industry's efforts to shape the climate change debate more broadly, no studies to date have explored the industry's efforts to influence health sciences research or public health narratives on climate change. This is an important perspective from which to study the fossil fuel industry given the potential for health evidence to affect public and policymaker views on climate change regulations.

The fossil fuel industry was aware of the climate impacts of fossil fuel combustion as early as the 1950s (48,49), and, by the 1970s, had largely accepted prevailing scientific consensus on climate change – while publicly denying it (50,51). It was not until the late 1980s, however, that climate change rose to prominence on the policy agenda, spurring a well-organized (52,53) countermovement (33,37,54) of corporations, trade associations, conservative foundations and think tanks, industry front groups, and lobbying and public relations firms (55,56).

For this study, we analyzed internal industry documents in the UCSF Fossil Fuel Industry Documents Archive (57) to trace how a leading industry organization of the time, the Global Climate Coalition (GCC), engaged with the emergent evidence on the health impacts of climate change during the years from 1995 to 1998. In 1995, a set of high-profile international reports established for the first time the link between climate change and health (58,59). That same year, international negotiations were launched under the United Nations Framework Convention on Climate Change (UNFCCC), towards the establishment of mandatory carbon emissions reduction targets. This critical period culminated in the U.S. failure to ratify the international climate treaty known as the Kyoto Protocol (60,61), which established for the first time legally-binding emissions reduction targets for industrialized countries. Ratification failure marked the start of a decade of climate inaction within the U.S. This paper explores why, how, and with what messages industry engaged in the science of climate change and health, during that science's initial emergence in climate policy discussions in the mid-1990s, and finds that the fossil fuel industry sought to advance a narrative that used pro-public health arguments. The findings of this study reflect a small part of larger efforts undertaken by the fossil fuel industry at the time to counter the Kyoto Protocol.

Methods

This study draws on an analysis of publicly available internal and external-facing industry documents housed in the University of California San Francisco (UCSF) Fossil Fuel Industry Documents Archive, itself part of the UCSF Industry Documents Library (57). The archive includes 1,161 documents, collected largely through lawsuits and freedom of information

requests. These documents comprise internal memos, meeting notes, emails and other personal communication, and financial reports, as well as policy briefs, reports, and public relations materials published by fossil fuel companies and industry trade associations.

Industry document analysis has become a key methodology for studying many health-harming industries (62–64); we thus utilized search and qualitative analytic methods standard in the literature (65). We first conducted a complete review of all the documents within the fossil fuel archive, examining these documents in their entirety to assess the scope of thematic topics and industry actors present. Through this analysis, we identified the Global Climate Coalition as the principal industry actor engaged in responding to the emergence of health science on climate change in the period under study. We then conducted broad searches across all industry documents archives housed at UCSF, including those specific to fossil fuels, food, tobacco, and chemicals. These cross-industry searches were necessary because many industry-affiliated actors were involved in efforts across multiple industries; thus, relevant documentation of those efforts existed in multiple archives. We initiated searches for organizations identified as significant to the fossil fuel industry's involvement in health science and communication, limiting our searches to the period 1994 to 1999. Our initial search terms included: Global Climate Coalition, Science and Technology Assessment Committee, American Council on Science and Health, Exxon Biomedical Sciences, American Institute of Automobile Manufacturers, Western Fuels Association, Competitive Enterprise Institute, and Edison Electric Institute. These searches generated over 8,000 documents, which were in turn screened to identify documents that discussed specifically the timeline of events and GCC activities related

to health, or that discussed health sciences research and communication. These documents were reviewed in detail.

We used Bates numbers to identify additional related materials, and snowball techniques (65) to search for other relevant individuals, organizations, events, and reports as references to them emerged through document review. We triangulated the archived documents through online searches for publicly available documents, including newspaper articles, industry newsletters, congressional testimony, grey literature, conference proceedings, and government reports using NexisUni, ProQuest, and Google. We additionally searched the webpages of the GCC, its members, and affiliated organizations from that period using the Wayback Machine (archive.org). This paper cites 35 industry documents. Searches were conducted from January to September 2022.

In our analysis, we first constructed a timeline, organizing the GCC's activities chronologically and comparing its internal activities and communications to events happening in the climate science and policy arenas. We used GCC meeting notes, memos, and reports to categorize the types of strategies the GCC sought to deploy in relation to health. Subsequently, we conducted a thematic analysis of newsletters and briefs published by the GCC and its member organizations, reports commissioned by the GCC and its members, slide presentations made by GCC members, and publications and congressional testimony by GCC members and affiliated organizations to assess the narrative frames used by multiple industry stakeholders when discussing health as connected to climate change, during the period of the case study.

Results

The Global Climate Coalition

The Global Climate Coalition (GCC) was a principal industry organization leading coordination and engagement in climate policy in the mid-1990s (33,34,54,55,66). The GCC was founded in 1989 by the National Association of Manufacturers to organize industry participation in climate science and policy discussions, following U.S. Senate hearings on climate change and the creation of the Intergovernmental Panel on Climate Change (IPCC) (34,66). The GCC described itself as "the leading voice for industry on the global climate change issue" with the mission to "contribute to a balanced debate on global climate change by sponsoring independent research and studies that examine the potential impact of proposed global climate change policies on the economy" (67). Founded with 16 members in 1989, the GCC's annual membership ranged from 50 to 70 members throughout the mid-1990s, predominantly industry trade associations and companies from the oil and gas, utility, coal, steel, rail, chemical, and automobile sectors (34). At one point, the GCC reported that its members represented over 230,000 companies (68).

Although oil and gas companies did not make up a majority of GCC members, the largest of these companies in the U.S. were members of the GCC. Furthermore, the majority of U.S. oil and gas companies were represented in the GCC through the participation of trade associations, such as the American Petroleum Institute on the GCC's Board of Directors (34). Fossil fuel industry members in this period included ARCO, BP, Chevron, Exxon, Mobil, Shell,

Texaco, as well as the American Petroleum Institute, the U.S. Chamber of Commerce, and numerous chemical, automobile, mining, and utility companies (Table S1.1).

With an annual operating budget of over $1 million in the mid and late 1990s (34,69,70) the GCC participated in domestic and international climate science and policy debates (34) in numerous ways, including: leading and commissioning research on climate science and the economic impacts of climate policy (71), undertaking direct political lobbying (34,66), participating in scientific dialogues such as the IPCC processes (66,72,73), undertaking campaigns questioning the legitimacy of the IPCC and affiliated scientists (34,38), funding public relations campaigns to reduce public support for climate policy (66,74,75), and coordinating with other industry coalitions (34,54). These strategies are similar to those widely adopted by other industries to block regulatory efforts (29).

Opposition to mandatory emissions reductions formed a principal policy position of the GCC. After lobbying to block the passage of a proposed U.S. carbon tax, and to influence the 1993 U.S. Climate Action Plan to rely solely on voluntary emissions reductions (76), the GCC turned its focus in 1995 towards the emergent negotiations under the UNFCCC to establish legally binding carbon emissions reduction targets for industrialized countries – and the Clinton Administration's support for these efforts. In the summer of 1995, GCC's Executive Director John Shlaes responded to these international negotiations, saying, "it is now apparent…that climate change will be…a major initiative for the Clinton Administration" (77).

The emergence of health in climate dialogues

In September 1995 the National Academy of Sciences held a national conference on climate change and health at the request of Vice President Al Gore. Participants noted "significant risks to human health" and that "the lack of complete data should not be used as an excuse for inaction" (78). In December 1995 the IPCC published a report establishing, for the first time, that "climate change is likely to have wide-ranging and mostly adverse impacts on human health, with significant loss of life" (58). GCC member Edison Electric Institute referred to the IPCC report as "a watershed event" and "a reason to argue for a protocol" under the UNFCCC (79).

GCC meeting notes from February 1996 include discussion of meetings held between GCC representatives and Clinton Administration officials, in which they noted "a more concentrated focus" on climate by the Administration "due to extreme events and the IPCC findings" (80). These meeting minutes reported Administration officials saying, "the U.S. needs an insurance policy approach" and "should adopt preventive measures per Cold War" including "non-voluntary programs" – concluding that this reflected "a shift in the Administration" and "that the Administration will become aggressive" (80). GCC members also noted that federal officials would "push publicly the likelihood of vector-borne disease increases with small changes in temperature and other health related issues" (80).

In July 1996, the U.S. publicly announced support for legally binding emissions reductions under the UNFCCC (81). GCC Chairman of the Board William O'Keefe responded with

a fundraising appeal, noting that this announcement made "it imperative that the GCC increase the scope of its activities" (82). In September 1996, Exxon scientists presented to the GCC that while the health impacts of climate change "remain speculative," those impacts "[provide] a potentially emotional issue", and that "advocates state…lack of scientific certainty can't justify postponing preventive action" (83). The GCC also circulated federal and WHO reports on climate and health to STAC committee members, highlighting a British Medical Journal editorial which "showed that this prominent medical journal viewed climate change impacts on health as a major concern" (72).

In a November 1996 document outlining its 1997 strategy, the GCC raised concerns that federal efforts to pass climate policy could "go beyond the beltway" to generate public support for climate action at the state and local level (84). The strategy perceived the Clinton Administration as willing to pursue climate policy "ahead of" analysis on the economic impacts of these policies and to "drop caveats" about scientific uncertainty in its public communication (84). The document noted that the Clinton Administration was "likely to play the health card – an unfounded argument that climate change will cause an increase in diseases and will otherwise effect the health of US citizens," and that this could "garner support for ratification of a treaty or protocol that includes legally binding targets (and associated costs and lifestyle changes)" (84).

In January 1997 GCC Executive Director John Shlaes stated "*the health issue* is increasing in importance with the climate change issue...The GCC has got to be prepared to respond to the

issue this year" (73, emphasis added). During this period, the health community was also beginning to engage publicly in calls for climate action. An industry-led communication plan from this period reported it would be difficult "to oppose the [Kyoto] treaty solely on economic grounds" (85), while a report from affiliated think tank Competitive Enterprise Institute (CEI) stated that "to sink the Kyoto Protocol, opponents must be prepared…to explain why curbing energy use will harm the health and safety of U.S. citizens" (86).

The GCC's Science and Technology Assessment Committee

The GCC's Science and Technology Assessment Committee (STAC) was one of the GCC's operating committees and based on the documents reviewed appears to be the committee that led the organization's efforts on health. The STAC tracked emergent science on the health impacts of climate change as early as 1995 (87,88). Based on analysis of available GCC STAC meeting notes from 1996 and 1997, we identified several strategies pursued by the STAC in response to this health science. One such strategy proposed the recruitment of health experts to serve as spokespeople on the health impacts of climate change. Based on meeting minutes, we found that in early 1996, the STAC looked to identify "a medical person or persons that could assist the GCC with the health effects issue", ideally "someone with a medical degree and some reputation (e.g., C. Everett Koop)" (88). The STAC sought experts who could "serve as a [sic] outside third-party spokesman for the GCC" and GCC members "volunteered medical experts" (80). However, based on available documents we are unable to confirm if such experts were identified or if they were engaged by the GCC.

The STAC also tracked health science. For example, GCC meeting minutes from February 1996 note that Exxon scientists were developing a white paper on climate change and health to understand "strengths, weaknesses and data gaps; and key players and universities in [the] health science arena world-wide" (80). (We were unable to locate this paper). In September 1996, the STAC discussed how to "increase involvement" in health science topics (72). Exxon representatives present at this meeting "advocated critical evaluation of models and ongoing studies to put climate change health hazards in perspective" and "promoted encouragement of scientific work in this area" (72). At the close of this meeting, the STAC decided on a statement noting that the STAC "is concerned with the lack of balance in the peer reviewed literature on the health effects of climate change" (72).

Finally, the STAC commissioned research on the health impacts of climate change. In 1997, the committee funded the American Council on Science and Health (ACSH) to produce a report on climate and health (73,89). (Please see the following section for discussion of key messages in this report). The ACSH was a pro-industry research organization that worked for multiple industries. Its funders in 1997 included the American Petroleum Institute, the Global Climate Coalition, Exxon Corporation, Mobil Oil Corporation, and the Shell Oil Company Foundation, alongside food, beverage, chemical, and pharmaceutical companies (90). An earlier funding report from Mobile Foundation, Inc., in 1993, described ACSH as having "an effective public outreach program in understandable lay terms" and "high credibility and recognition in the media and the scientific community, as evidenced by wide publication of their positions in the press and in scientific journals" (91).

Scientific narratives about climate and health

Through analysis of meeting notes from the GCC STAC, we determined that, in addition to the overarching role of the GCC, the work of the following organizations was central to the fossil fuel industry's efforts concerning health science on climate change: American Council on Science and Health, Competitive Enterprise Institute, Edison Electric Institute, Exxon, Mobil, and Western Fuels Association. During the mid-1990s, these organizations published newsletters, briefs, and reports on the health impacts of climate change, and additionally discussed the science of climate change and health in internal communications, presentations, and congressional testimony. Our analysis of these materials identified four main messages regarding the connection between climate change and health. Each of these messages drew on, and aligned with, the GCC's and the industry's more general communications on climate change during this period. Furthermore, these four main messages aligned with the public health community's own active debates on the most effective strategies to improve population health.

First, the materials reviewed included a common theme of scientific uncertainty. Uncertainty was a primary message utilized by the GCC, as well as industry broadly, to counter belief in the existence and severity of climate change (39,40,51,92,93). The GCC extended this message of uncertainty to studies on climate and health. A 1996 GCC brief on climate change and health stated, "according to the IPCC, confidence in regional climate forecasts 'remains low'. Therefore, confidence in health impact projections based on these models must also be low". The brief concluded that "attempting to link global climate change and adverse health impacts requires a long and very tenuous stretch" and that "concern" about climate health

impacts “rests on a number of unproved assumptions” (94). A 1996 presentation made to the GCC by GCC STAC member Exxon likewise outlined modeling uncertainties, noting “climate-induced changes in public health [are] extremely difficult to quantify” (83). A 1996 presentation by GCC member Edison Electric Institute stated that “quantifying the potential impacts is difficult due to varying circumstances such as nutrition, wealth, access to quality health services” (79).

In this period, there remained debate among health scientists about the potential impact of climate change. The GCC highlighted this debate, quoting prominent health organizations and scientists in its newsletters to focus attention on uncertainty in this nascent area of research. For example, articles from the GCC’s newsletter Climate Watch in 1995 and 1996 stated, “a recent warning that ‘global warming’ may be the cause of a resurgence in infectious diseases has been questioned by many parts of the scientific community” and quoted “skeptical” scientists from the U.S. CDC and NIH (87,95). Exxon scientists in their 1996 presentation commented that there were “few ‘experts’” and “many ‘advocates’ with a consistent message” and concluded that a “balanced view [is] not evident in peer-reviewed journals, [or] public media” (83). A main recommendation of the GCC at the time – the need for more research on climate change (96) – extended to calling for more research on health impacts. For example, in September 1996, the STAC at its meeting developed a statement on climate and health research, noting that “a strong need exists to encourage balanced quality studies in this area” (72) and the 1997 ACSH report recommended “increased investment…in research concerning the potential health effects of projected climate change” (97).

Second, the materials evaluated included a focus on the health impacts of economic disruption that might be caused by climate action. This message connected health to one of the GCC's and industry's primary arguments against climate action: namely, that it would result in significant costs to individual consumers and national economies (71). A 1997 memo by the CEI – a conservative think tank funded by GCC members – cautioned: "economic assessments can be useful, but only if advanced in the context of 'wealthier is healthier, richer is safer' arguments emphasizing the connection between livelihoods, living standards, and lives" (86). Drawing on public health research on the connection between wealth and health, the GCC and other industry-funded organizations extended this messaging to raise concerns about the adverse health consequences of these economic impacts. A 1996 article written by an industry-affiliated researcher at Stanford in the newsletter of GCC member Western Fuels Association (WFA) stated: "as any economist will tell you, being richer is healthier; being poor shortens a person's life", and estimated that "12,000 Americans would die prematurely each year" due to proposed climate policies (98). A CEI report stated that "the most serious concern about a global warming policy is that actions to restrain CO_2 emissions could cause thousands of deaths per year" (99). Similar messages were used by CEI representatives in Congressional briefings on the Kyoto Protocol during this period (100,101).

This framing included attention to the indirect impacts of economic disruption on health systems. The ACSH report concluded that "policies that weaken economies tend to weaken public health programs" and thus "implementation of such policies would (a) increase the risk of premature death and (b) exacerbate any adverse health effects of future climate change"

(97). The 1996 GCC brief stated: “Economic growth and development generate resources that enable societies to improve living standards, which include better access to health care facilities and disease prevention” (94).

A third message we identified was that climate change was less significant than other factors in causing ill health. In their 1996 presentation to the STAC, Exxon scientists recommended that the industry “promote [the] concept of relative risk…significance of climate impacts vs. other disease factors” (83). Reports by major global health institutions in the mid-1990s, such as the World Health Organization’s World Health Reports and the Global Burden of Disease studies, made passing reference, or no reference at all, to climate change – and did not identify climate as of major concern to the global health agenda (102–105). The GCC and ACSH cited these reports and studies in statements turning attention to other causes of poor health. The GCC’s 1996 brief on health called climate change a “marginal” factor in shaping health and suggested that “more critical issues exist” such as “inadequate public health” care (94). Likewise, in its 1997 report, the ACSH noted: “nearly all of the potential adverse health effects of projected climate change are significant, real-life problems that have long persisted under stable climatic conditions” and suggested that factors such as poverty, malnutrition, and conflict were more significant factors for health (97). A related theme reflected in the public relations materials of GCC member WFA was that climate change could benefit health. However, this was not as prevalent as other messages and was found only in documents associated with WFA. WFA funded a communications organization, called the Greening Earth Society, which produced films on the benefits of climate change to agriculture and food

production (106,107). Thomas Gale Moore, a researcher at Stanford's Hoover Institution – affiliated with WFA and CEI – published academic work showing that rising temperatures would reduce mortality (108,109).

Finally, the fourth message we identified was that efforts to mitigate climate change would not be the preferred response to climate change from a health perspective. The 1997 ACSH report concluded that "from the standpoint of public health, stringently limiting such emissions at present would not be prudent"; rather, "the optimal approach to dealing with the prospect of adverse climate-change-related health effects would be largely adaptational" (97). This message highlighted tradeoffs in the allocation of limited resources, concluding that direct health investments would be a better use of resources than investing in climate mitigation. A 1995 article in the GCC's newsletter stated: "scarce human and capital resources should be directed toward preventing and mitigating the effects of current and potential health crises rather than focusing on the marginal impact (if any) resulting from man-made greenhouse gas emissions" (95). Another GCC newsletter article noted that investments in health "would yield substantially higher benefits than investments in emission reductions" (110); similarly an article in a 1996 newsletter of GCC member WFA stated that "just a fraction" of the costs "to slow the production of greenhouse gases" if "spent to improve health conditions – would do more to eliminate sickness in poor countries than any amount of industry restriction could" (111). On this note, the 1997 ACSH report asked: "Should we invest now in efforts to decrease atmospheric GHG concentrations in the hope of limiting the future incidence of malaria? Or should we invest in efforts to control the mosquito population, prevent malarial infection, and

eliminate the disease?" (97). The 1996 GCC brief concluded that "the most prudent and effective course of action to protect public health is to improve basic health services" (94).

The GCC's dissolution

The GCC's activities and messaging on climate change and health formed one small part of a much larger campaign of lobbying, scientific engagement, and public relations: all undertaken by the GCC and its member organizations, in concert with efforts by other stakeholders – including, for example, the conservative movement and labor organizations – in order to block U.S. ratification of the Kyoto Protocol (33,34,112).

The 1997 Kyoto Protocol established the first legally binding greenhouse gas emissions reductions targets for industrialized countries. Throughout the period leading up to Kyoto, the GCC lobbied U.S. and international policymakers: in ways that ranged from weekly meetings with Congressional representatives (34) to sending delegations to each of the international negotiations under the UNFCCC (66). In July 1997, the U.S. Senate unanimously passed Senate Resolution 98 – the Byrd-Hagel Amendment – which stated that the U.S. would not sign any international climate treaty that included mandatory reductions in greenhouse gas emissions, or that would harm the U.S. economy. The GCC worked to generate support for the Amendment, which effectively precluded U.S. participation in the Kyoto Protocol (34). The Clinton Administration signed the Protocol in 1998 but never submitted it to the U.S. Senate for ratification. In 2001, President George W. Bush withdrew the U.S. signature to Kyoto, and indicated the U.S. would not pursue any emissions reductions.

There are many stakeholders and many factors that contributed to the ultimate failure of the Kyoto Protocol in the U.S. Likewise, the health messages used by industry stakeholders at the time were a comparatively small focus of much broader communications campaigns. Nonetheless, the fossil fuel industry and the conservative movement with which industry was affiliated are considered to have played critical roles in this policy decision (54,113), and the specific health messages used aligned with the broader themes adopted by the fossil fuel industry. Talking points from a June 2001 meeting between the GCC and representatives of the U.S. State Department noted that President Bush "rejected Kyoto, in part, based on input from you" (114). The GCC was dissolved in 2001 (34).

Discussion

The fossil fuel industry is one actor involved in shaping energy policy in the U.S. and globally – an actor working alongside many other stakeholders, including local and national governments, consumers, media, and advocacy organizations. The passage or failure of any climate policy is multi-causal. Reviews of stalled efforts to pass meaningful climate legislation point to numerous factors including ineffective governance regimes, consumer demand for fossil fuels, public opinion and polarization of climate politics, and the fragmentation of the pro-climate movement (11,14,31). However, the power and tactics of the fossil fuel industry have played a meaningful and critical role in delaying and countering climate policy action through the present day. Thus, greater understanding of the strategies employed by the fossil fuel industry can advance understanding of how best to engage industry and to overcome inaction.

There is a significant literature on the strategies and messaging used by the fossil fuel industry to delay and counter climate policy (37,40,48,54,115–117), yet, to our knowledge, no prior study has examined how the fossil fuel industry engaged the evidence on climate change and health. In this study, we analyzed one collection of industry documents discussing its response, in the mid-to-late 1990s, to emerging evidence on the health impacts of climate change as well as to the rise of climate change on the policy agenda. This response was led by the Global Climate Coalition (GCC) and the Coalition's Science and Technology Assessment Committee (STAC). The GCC was the largest industry coalition at the time, with dozens of members from the oil and gas, utility, coal, chemical, automobile, and other sectors collectively reported by the GCC to represent over 230,000 companies. Leading fossil fuel companies, trade associations, and sponsored think tanks, were involved in the GCC's efforts to track and respond to the rising inclusion of health science in climate policy dialogues.

The GCC, along with other organizations, used a range of strategies to challenge the Administration's climate efforts during this period (34), consistent with the tactics used by other industries to avoid regulation (17,28). Our analysis shows that as connections to health rose in importance on the climate policy agenda, the GCC extended many of these same strategies to include those connections. This suggests that health was perceived by industry and policymakers as an effective frame for discussing climate change. We found that the Clinton Administration's commitment to addressing climate change occurred at a time when the health impacts of climate change were becoming increasingly well known. In 1995 the IPCC warned of "wide-ranging…adverse impacts" of climate change on health (58); likewise, in this period a

number of reports, articles, and editorials making similar arguments were published by leading health organizations and medical journals. At this time, the GCC perceived that climate would be a "major initiative" for the Clinton Administration, which was signaling increasingly "aggressive" action on climate through the international Kyoto Protocol process. Exxon scientists recognized health was a "potentially emotional issue" (83) and the GCC noted that the Administration would "play the health card" to "garner support" for legally binding emissions reductions targets (84). The GCC and affiliated industry organizations commissioned research on climate change and health and sought to identify medical and health experts not affiliated with industry to serve as trusted messengers on the topic of climate and health.

Our study identified four main messages adopted by the fossil fuel industry regarding health. Each of these mirrored the fossil fuel industry's broader narratives on climate change – namely that the science was uncertain and lacked consensus, that economic costs of climate action would be high, that urgent action was not needed, and that non-regulatory solutions would be more effective (39,43,92) – and linked them to discussions happening within the global public health community. For instance, publications by the GCC and its partners questioned the certainty of emergent climate and health science, focused on the health and equity implications of economic disruption, minimized the comparative importance of climate to overall health outcomes, and recommended that investing in public health systems would protect health more effectively than investing in climate mitigation strategies.

These messages are particularly powerful because they draw on legitimate questions that were, and still are, actively researched and debated within the global health community – including, but not limited to: what are the leading drivers of health, how should we allocate limited health resources to maximize human wellbeing, and what should be the balance of attention to strengthening health care delivery compared to primary prevention? In the 1990s the broader health community had not yet recognized climate change as a major global health concern, which buttressed the uncertainty message adopted by industry, even though there was emerging consensus within the still-small health community engaged in climate research that climate impacts on health would be very significant.

By making the case for public health investments in public health systems, industry communications worked to shift attention away from the question of whether the global community should take seriously the issue of climate change, directing it instead to the question of how scarce public health resources should be spent. Global health efforts like the Global Burden of Disease were emerging, at the time, to rank leading causes of ill health and compare the cost-effectiveness of health solutions (104). These efforts measured cost-effectiveness in terms that valued near- over long-term health gains (as reflected, for example, in the choice of discount rates), prioritizing investment in public health interventions with immediate health returns such as infectious disease control and vaccination campaigns, rather than solutions with longer-run benefits such as chronic disease prevention. In this prevailing approach to the prioritization in health resource allocation, climate change would not rank as

important, given the perceived long-term nature of its impacts at that time.[1] While valuing intertemporal tradeoffs in health investment resource allocation is an important area of inquiry, industry messaging regarding health sought to deflect attention from the broader debates about climate change. In this way, industry was able to ground their arguments in legitimate, leading global health science, to strengthen their case for solutions that would not threaten their business model.

Additionally, industry's arguments about potential economic costs of mitigation and the importance of poverty and economic insecurity for health have validity. However, their arguments did not address the huge economic implications of unmitigated climate change. While the modeling of those costs was not as fully developed as today, the potential scale of those costs was appreciated. The same IPCC that first addressed the health concerns of climate change identified its potential economic impacts (119). Yet broadly, these costs were not included in the industry discussion of the costs of mitigation.

[1] The relative value of investments in health programs and in climate programs with short- or long-run benefits is determined by the discount rate used. The higher the discount rate, the less value will be given to interventions that primarily benefit health in the future versus interventions that result in immediate health returns. Thus, industry's stated preferences to prioritize adaptation over mitigation and to prioritize public health over climate change aligned with the prevailing thinking within the global health sciences community at the time that assigned greater value to interventions with more near-term health returns (i.e., applying higher discount rates). In the current policy environment, discount rates continue to matter both in health and climate decision making. For instance, discount rates affect the social cost of carbon that is a common metric applied in cost effectiveness analysis of proposed climate policies. A full discussion of discount rates and the social cost of carbon is beyond the scope of this paper; however several points may be of interest: (1) Recent updates to social cost of carbon calculations and applications of these to climate policymaking suggest the use of a discount rate of 2%, which contributes (alongside other updates to the economic and climate projections) to a significant increase in the assessed social cost of carbon (118). (2) These efforts may still significantly underestimate the health costs associated with climate change and the health benefits of climate mitigation. For example, updated estimates on the social cost of carbon include only heat-related mortality in their accounting for health costs, do not account for the direct costs of fossil fuel production on near-term health outcomes such as air pollution related mortality, and do not account for the avoided health care costs that would be achieved through climate mitigation.

This study suggests several avenues for future research. First, further analysis is needed of the role of industry in producing and disseminating health science research related to climate change, including both industry-led science and industry funding for, or engagement in, outside research. As early as the 1950s and 1960s, industry stakeholders including the American Petroleum Institute were funding scientific and public opinion research on air pollution (49,120). Recent research on the fossil fuel industry has found that industry-led research on climate change offered largely accurate predictions of the climate impacts we are currently experiencing (121), and that industry science on, and understanding of, climate change ran ahead of their communications on the issue. A deeper understanding of what the fossil fuel industry knew regarding climate change and health – and when – could contribute to the growing literature on scientific influence and misinformation. Second, additional research could explore how the fossil fuel industry uses health narratives in its communications, and how these narratives have evolved over time as the science on climate and health has grown – including how industry is currently responding to renewed scientific and policy attention to climate and health. Finally, public and policymaker opinion on climate change is shaped by a broad range of actors beyond industry. Additional research into the health-related research and communications activities of other stakeholders within the climate countermovement as well as research into if – and if so, how – industry narratives influence media and policy narratives on climate change could begin to elucidate the impact of industry's engagement on health.

Limitations

This study draws principally from the documents housed in the UCSF Fossil Fuel Industry Documents Archive. The documents publicly available at the present time, from the GCC and its member and affiliated organizations during the study period, are limited, and represent only a small fraction of the materials regarding industry actions. They therefore provide an incomplete view into the research, lobbying, and communications strategies undertaken by industry in relation to the science on the health impacts of climate change. For instance, while we know based on meeting agendas that the 1997 ACSH health study and other health communications activities were discussed in additional GCC STAC meetings (122), the notes and materials from these meetings are not currently available for public review. We similarly found references to the desired or proposed activities the STAC sought to undertake, such as the recruitment of health professional spokespersons, but, based on the current archive, we cannot ascertain if these strategies were implemented, or what their results may have been. We were additionally unable to locate all industry-produced reports on the health impacts of climate change referenced in the available documents. To compensate for the limited availability of industry documents from this period, we used other materials from internet and literature searches to supplement key findings; however, our set of documents for analysis remains partial. Finally, we did not conduct key informant interviews with industry or health actors to gain a first-hand account of activities undertaken in this period. Thus, while we were able to assess the narratives used by some industry stakeholders to discuss health and climate in the public sphere, we were unable to draw a clear line from these health messages to any specific policy

outcome, or to evaluate the relative contribution of these health messages to the broader successes of the GCC's and industry's overall communications campaigns.

Public health implications

This study shows that the fossil fuel industry monitored evidence on climate change and health from its early emergence. We show that industry sought not only to influence the evidence on climate change and health, but also to shape the narrative around this evidence, during this same time period. To do so, the GCC leveraged inherent tensions within the public health community about the relative importance of climate change and other fundamental causes of poor health, and of the value of climate change mitigation in protecting health. This history remains relevant today because it provides insight into how industry can use health evidence and pro-public health language not only to draw attention away from the need for mitigation but also to justify delayed climate action. While adaptation and investments in public health remain essential tools for protecting health from climate change, it is also critical to understand how these narratives can be adopted by industry, and to ensure that this use does not detract from the pressing need to reduce greenhouse gas emissions rapidly and substantially (11,123).

In the 1990s there was an opportunity for policy action to limit greenhouse gas emissions. This opportunity was not realized in part due to industry opposition. Health is once again rising on the global climate change agenda and there is growing health sector advocacy and engagement on issues of climate change policy (124–127). However, the fossil fuel industry

continues to actively engage in both domestic (31) and international (128) climate policy dialogues. A reflection on the missed opportunity of attention to the health impacts of climate change in the 1990s provides useful lessons for today's growing climate and health movement: lessons that may offer ways to effectively counter industry opposition to climate action.

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Chapter Three

The Association between Drought and Women's Empowerment: An Analysis of National Survey Data from 24 Countries in sub-Saharan Africa from 2011 – 2020.

Introduction

Climate change and climate-related extreme weather events adversely impact human health (1). Climate change has already increased drought in sub-Saharan Africa, and across many parts of the region climate change is projected to further increase the frequency and duration of drought (2). Drought impacts health through many pathways (3,4), including, but not limited to, malnutrition (5,6), and poor child health (7–11), HIV health (12–15), and mental health (16) outcomes. Drought impacts the drivers of poor health: increasing the risk of conflict and migration, and increasing water, food, economic, and energy insecurity (2,17,18). Nearly half of all deaths from natural disasters in Africa are directly due to drought (2).

Gender shapes vulnerability to climate risks, as well as the ability to respond to and mitigate the risks of climate events (19–21). Women are more vulnerable to climate change than men and as a result face unique and greater health impacts from climate risks such as drought, including higher rates of mortality from extreme weather events (17,22–25). Drought impacts women's health directly: Extreme heat and reduced precipitation, two climatic factors associated with drought, are associated with poor reproductive and maternal health outcomes (26,27). Drought is associated with intimate partner violence towards women (28) and with early marriage (29). Drought also affects health indirectly by increasing economic and food

insecurity. Women have less access to resources that can buffer against these economic impacts and support climate adaptation, such as land ownership, access to climate information and adaptation programs, economic security, and mobility. Therefore, women may be less able to adapt to climate change, furthering their vulnerability (29–32).

There remain gaps in the understanding of the pathways through which drought impacts health – particularly women's health. One possible and unexplored pathway is women's empowerment. Empowerment is the process through which people gain fuller control and power over their life. Greater women's empowerment is associated with improved health outcomes for both women and their children (33), including for example increased food security (34), higher contraceptive use (35), improved maternal (36) and child health outcomes (37–39), reduced infant and under-five mortality (40), and improved early childhood cognitive development and learning (41).

The factors that shape women's empowerment can vary across the life course of an individual, and across country and cultural contexts (42). However, empowerment is broadly conceptualized to include: the real and perceived ability to define one's life goals and to make decisions regarding them, the real and perceived availability of decision options and access to social and economic resources to fulfill these decisions made, and the extent to which one is able to achieve both one's self-determined goals and, more broadly, realize achievements in the political, social, and economic arenas (43–46). Educational attainment, economic independence and security, employment, and political and social representation and

participation are known determinants of women's empowerment (47–51) that could be adversely impacted by drought. Thus, drought may reduce women's empowerment and in turn affect women's and children's health.

In the context of climate change, women's empowerment is often discussed as a climate solution that can, for instance, increase utilization of family planning and therefore reduce population growth (52). However, to our knowledge, no literature explores the influence of climate impacts such as drought on women's empowerment. Indeed, gender remains an underdeveloped focus of the climate change literature (53,54). In this study, given the known relationship of women's empowerment to health, we analyzed cross-sectional survey data from twenty-four sub-Saharan African countries to explore the relationship between drought and measures of women's empowerment.

Methods

Data sources and measures

Drought. Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) data was used to measure drought. CHIRPS consists of 0.05-decimal-degree resolution raster rainfall estimates in millimeters, developed through a combination of weather station and satellite imagery data. For each survey date and enumeration area, cumulative precipitation was calculated for the twelve months prior to the survey date. This measure of cumulative precipitation was ranked in relation to the annual precipitation of the prior 29 years and this ranking converted into a percentile. We then created a binary drought indicator, in which

drought was defined as cumulative precipitation for the twelve months prior to the survey being less than the 15th percentile of historical rainfall. The classification of drought as the deviation of rainfall from long-term trends is a common methodology in the literature on drought and health. The 15th percentile threshold for drought was derived from a 2014 study by Burke et. al., which found that annual rainfall below the 15th percentile of historical rainfall was a significant threshold correlated with declines in agricultural and economic productivity, and thus an effective measure of a significant shock (15). Subsequently, this binary categorization of drought and the 15th percentile cut-off has been used in studies on the relationship between drought and various health outcomes including HIV, intimate partner violence, and immunization (9,10,13,28).

Women's empowerment. Women's empowerment was assessed using the women's empowerment indicators within the Demographic and Health Surveys (DHS). DHS are cross-sectional household-based surveys that are nationally representative. The surveys utilize a two-stage stratified cluster sampling method, by which country enumeration areas (EA) are first randomly sampled and subsequently households within each selected EA are randomly sampled. Within the sampled households, all women ages 15 to 49 years are invited to complete a questionnaire, including a module on women's empowerment. Our analysis included all DHS surveys in sub-Saharan Africa that included geolocated information on each EA and which occurred during or after 2011, the year in which drought exposure data begins, through 2020 (Table S2.1 lists included countries and survey years).

We defined women's empowerment using standard definitions that were pre-specified by the DHS program. The DHS women's empowerment module includes two binary outcomes representing different dimensions of empowerment at the individual level: an indicator of women's decision-making role within the household and an indicator of women's attitude towards wife-beating. Empowerment in decision-making is defined as a woman making decisions alone or jointly with her husband for all of three specific decision domains: women's health care, large household purchases, and visits to family or relatives. Empowerment in attitudes towards wife-beating is defined as a woman disagreeing with all of five specific justifications for wife-beating: burning food, arguing with husband, going out without telling husband, neglecting the children, and refusing sex with husband.

Empowerment is multidimensional, complex to measure, and can be measured at multiple levels from the individual to the societal (36,55,56). The DHS indicators are limited and do not capture the full range of domains conceptualized in the theoretical literature as relevant for empowerment. Definitions of empowerment can also vary widely by cultural context (46); and universal empowerment measures such as the DHS, for example, may embody the cultural norms and preferences of those who developed the indicators in a way that does not reflect the definitions and expressions of empowerment appropriate to each country context. Despite these limitations, the DHS offers the advantage of enabling cross-country analysis. In addition, the DHS indicators reflect domains widely considered critical elements of empowerment (46) and, in the case of household decision-making, that have been found relevant for making international comparisons (57). The DHS is widely used in the study of empowerment and the

empowerment measures are widely used in the health literature. Systematic reviews of the relationship between empowerment and contraceptive use, fertility, and various maternal and child health outcomes found DHS indicators of empowerment to be commonly applied (36,38,39,58,59). These measures have also been widely applied in sub-Saharan Africa: to study the relationship between empowerment and fertility preferences (60,61), contraceptive use (62), women's health (33), use of maternal and child health services (63–66), and various child health outcomes (41,67,68).

Covariates. We included the following sociodemographic variables demonstrated to be associated with women's empowerment (44,47,48,69), as controls in our regression models: respondent's age (categorical indicator with age groups 15 – 19, 20 – 29, 30 – 39, and 40 – 49 years), respondent's literacy (binary indicator of literate or not literate), respondent's employment status (binary indicator of employment in the twelve months prior to the survey), rural residence, number of children (categorical indicator with groups 0, 1 – 2, 3 – 5, and more than 5), and wealth quintile (defined by DHS and estimated through principal component analysis) (70).

Statistical analysis

We estimated a series of multivariable logistic regression models to assess the association between drought and women's empowerment outcomes, in which the binary empowerment outcome variable was regressed on the binary drought explanatory variable. We ran the model both without the covariates (unadjusted models) and with the covariates

described above (adjusted models). We included survey-level fixed effects in both the adjusted and unadjusted models to control for country-level factors that may shape empowerment such as economic factors and social and cultural norms. We included robust standard errors clustered at the EA level. We reported main results as marginal risk differences, calculated used Stata's *margins* command.

We assessed effect modification by respondents' employment, economic status, and rural residence, to examine if the association between drought and empowerment varied by population. Effect modifications were estimated in separate regressions by interacting the binary modifier variables (rural/urban, employed/not employed, and poor/not poor, where poor is defined as the lowest wealth quintile) with the binary drought variable. Results are reported as marginal risk differences for the interactions and were derived using the *dydx* option in Stata's *margins* command. We assessed statistical comparison of the margins for the modifiers using the *pwcompare* option. Analyses were conducted in Stata version 13.

Results

The participant sample included 147,502 currently married women ages 15 – 49 in 28 surveys across 24 countries in sub-Saharan Africa (Table 3.1). All respondents were married. The large majority (94%) had at least one child. The majority of respondents (69%) lived in rural areas. Nearly three quarters of respondents (72%) were employed at the time of the survey, while less than half of respondents (42%) were literate. Roughly half of the women were empowered: 44% of women made all three specific types of household decisions alone or

together with their husband, and 50% of women disagreed with all five specific reasons justifying wife-beating. The experience of drought varied widely in each country, as shown in Figure 3.1. Over three quarters of respondents in Namibia (78%) experienced drought conditions, while fewer than 1% of respondents in Burundi, Côte D'Ivoire, and Uganda experienced drought conditions in the twelve months prior to the survey.

Table 3.1. Descriptive statistics of currently married women ages 15 - 49 years (n = 147,502)	
Covariate or Outcome	**Number (percent)**
Wealth category	
Poorest	31,158 (21.12)
Poorer	29,839 (20.23)
Middle	29,122 (19.74)
Richer	29,433 (19.95)
Richest	27,950 (18.95)
Age category (years)	
15-19	9,408 (6.38)
20-29	58,207 (39.46)
30-39	59,405 (40.27)
40-49	20,480 (13.89)
Literate	60,124 (42.12)
Employed	106,194 (71.99)
Number of births	
0	8,382 (5.68)
1-2	46,505 (31.53)
3-4	44,538 (30.19)
5+	48,077 (32.59)
Rural	101,736 (68.97)
Empowerment outcomes	
Make all three specific decisions alone or with husband	65,277 (44.25)
Decisions about own health care	86,333 (58.53)
Decisions about large household purchases	86,169 (58.42)
Decisions about visits to family or relatives	95,790 (64.94)
Disagree with all specific reasons justifying wife-beating	73,641 (49.93)
Going out without telling husband	95,746 (64.92)
Neglecting the children	91,575 (62.08)
Arguing with husband	96,083 (65.14)
Refusing sex with husband	106,027 (71.88)
Burning food	120,860 (81.94)

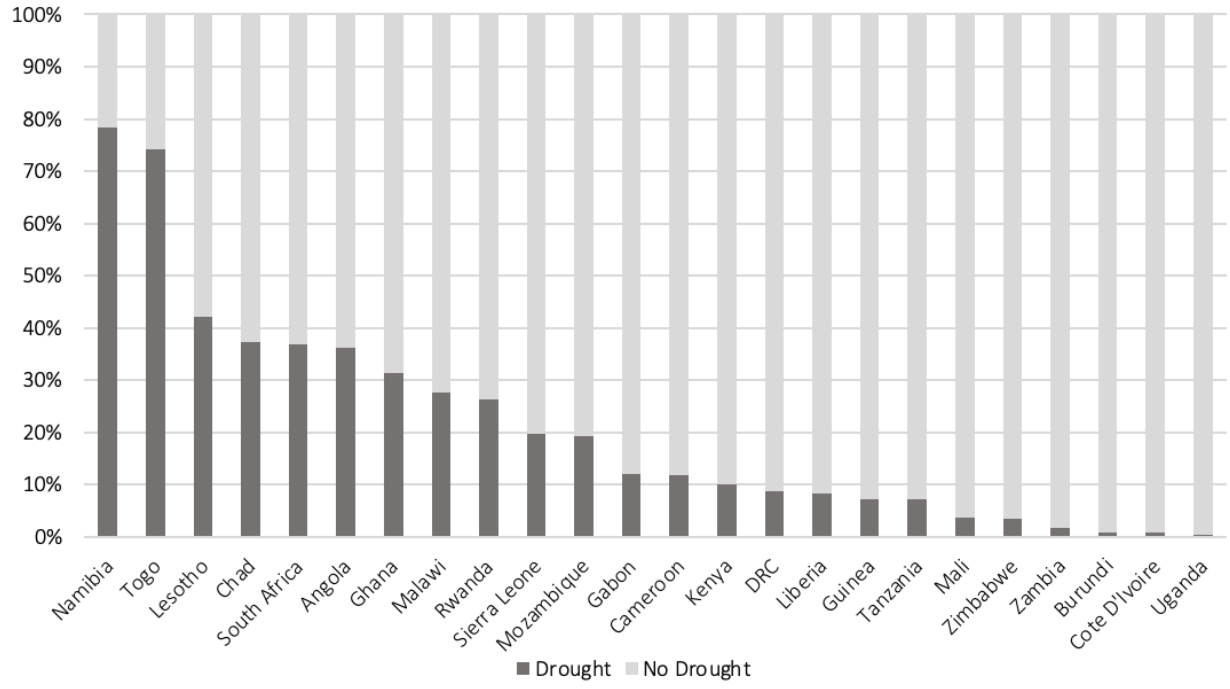

Figure 3.1. Percent of respondents experiencing drought in prior twelve months.

Association between drought and empowerment

The associations between drought and women's empowerment are shown in Table 3.2. Overall, women experiencing drought conditions were less empowered than those women not experiencing drought. In analyses adjusting for respondent's age, literacy, employment status, rural residence, number of children, and wealth, women who were living in drought reported less control over household decision-making by two percentage points as compared to women who did not experience drought (marginal risk difference –2.01; 95% CI –3.2, –0.97; p<0.001). Assessing the association between drought and women's control over specific domains of decision-making, we found that women experiencing drought reported less control over decisions about healthcare (marginal risk difference –2.1; 95% CI –3.2, –0.99; p<0.001) and large household purchases (marginal risk difference –3.2; 95% CI –4.4, –1.97; p<0.001), while

we found no significant association between drought and decisions about visiting family or relatives (marginal risk difference 0.3; 95% CI –0.95, 1.47; *p*=0.67).

Table 3.2. Associations between drought and women's empowerment among married women ages 15 - 49 (n = 147,502)

Outcome	**Unadjusted**	**Adjusted**
Woman has a say in decision-making	-2.5*** (-3.7, -1.3)	-2.0*** (-3.2, -0.97)
Healthcare decisions	-2.1*** (-3.2, -0.91)	-2.1*** (-3.2, -0.99)
Large household purchases	-3.1*** (-4.4, -1.87)	-3.2*** (-4.4, -1.97)
Visit family or relatives	0.3 (-0.96, 1.57)	0.3 (-0.95, 1.47)
Woman disagrees with reasons for wife-beating	-2.9*** (-4.2, -1.6)	-2.9*** (-4.2, -1.7)
Burning food, not justified	-2.0** (-3.3, -0.7)	-2.1*** (-3.4, -0.9)
Arguing with husband, not justified	-2.2*** (-3.4, -1.0)	-2.2*** (-3.4, -1.0)
Going out without notifying husband, not justified	-2.3*** (-3.6, -1.0)	-2.6*** (-3.9, -1.3)
Neglecting the children, not justified	-3.2*** (-4.5, -1.9)	-3.3*** (-4.6, -2.0)
Refusing sex with husband, not justified	2.3*** (1.0, 3.5)	2.5*** (1.2, 3.7)

Marginal risk differences are estimated in percentage points from logistic regression models with 95% confidence intervals. The unadjusted model includes survey-level fixed effects. The adjusted model includes calendar month, wealth quintile, age category, literacy, parity, household size, rural residence, and employment status. Standard errors are clustered at the EA level. Level of significance: ***p<0.001; **p<0.01; *p<0.05.

Drought was negatively associated with women's empowerment in terms of the reported attitude towards wife-beating, with women experiencing drought conditions reporting higher agreement with reasons justifying wife-beating as compared to women not living in drought. In the adjusted analysis, women experiencing drought had a nearly three-percentage-point lower disagreement with all specific justifications of wife-beating (marginal risk difference –2.9; 95% CI –4.2, –1.7; *p*<0.001). We assessed the association between drought and each of the specific justifications for wife-beating that make up the empowerment variable on attitudes towards violence. We found that women living in drought expressed greater agreement with

four of the five specific justifications: burning food (marginal risk difference –2.1; 95% CI –3.4, –0.9; p<0.001), arguing with husband (marginal risk difference –2.2; 95% CI –3.4, –1.0; p<0.001), going out without notifying husband (marginal risk difference –2.6; 95% CI –3.9, –1.3; p<0.001), and neglecting the children (marginal risk difference –3.3; 95% CI –4.6, –2.0; p<0.001). We found a reverse association for one justification, refusing sex with husband, such that women living in drought conditions were less likely to report agreement with that justification for wife-beating than women not experiencing drought (marginal risk difference 2.5; 95% CI 1.2, 3.7; p<0.001). The adjusted and unadjusted results were comparable for both empowerment outcomes. Odds ratios for all results are reported in Table S3.2. We additionally assessed the association between drought and women's empowerment in each of the 24 countries individually and found a high degree of heterogeneity across countries, shown in Figure 3.2.

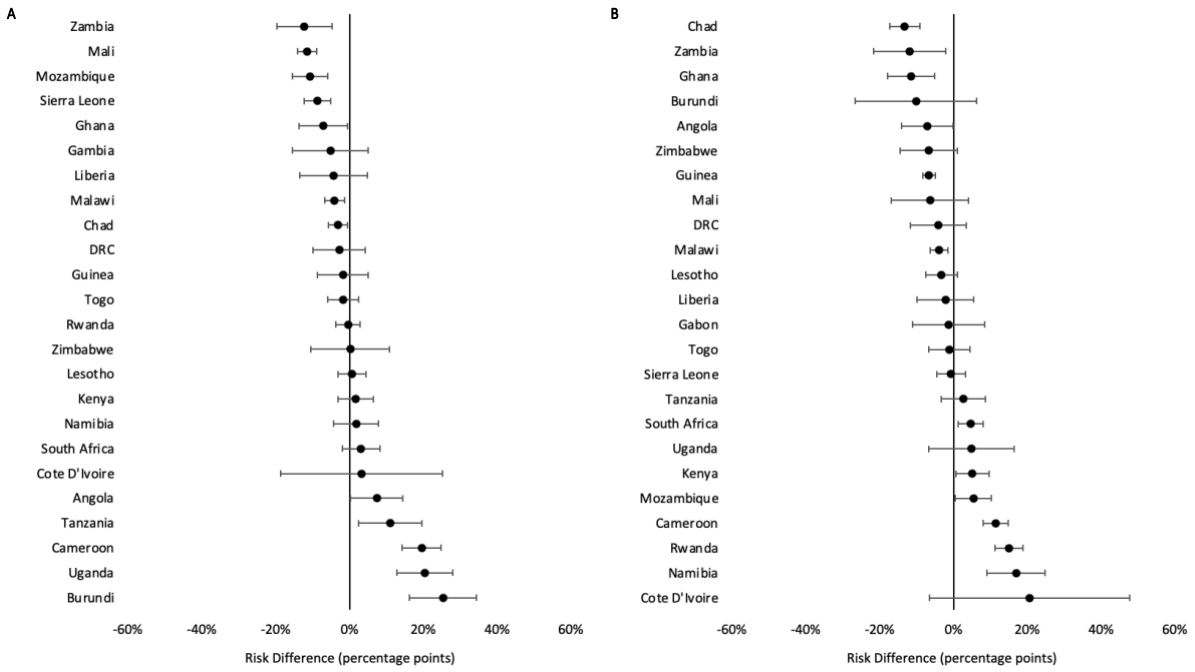

Figure 3.2. Country-specific associations between drought and women's empowerment.
Adjusted associations between drought and (A) women's reported control over decision making and (B) women's reported disagreement with justifications for wife-beating. Models control for respondent age, wealth, literacy, rural residence, employment status, household size, and parity. Associations are presented as marginal risk differences (percentage points) and 95% confidence intervals. Standard errors are clustered at EA level.

In order to assess the association between drought and empowerment at the population level, we also calculated the population attributable risk (PAR). This measure captures to what extent disempowerment can be attributable to drought among the women in our study population. Looking at the drought and empowerment relationship from this perspective, we found that for the indicator of empowerment in women's decision-making, the PAR is –0.34% (95% CI –0.57%, --0.17%; p<0.001). For the indicator of empowerment in attitude towards wife-beating, the PAR is –0.51% (95% CI –0.73%, --0.29%; p<0.001). Thus, at a population level, drought plays a marginal role in determining women's empowerment compared to other factors.

Effect modification

We assessed effect modification of the association between drought and women's employment status, rural residence, and socioeconomic status. Findings on effect modification are presented in Figure 3.3. For both indicators of women's empowerment, we found evidence of effect modification of the association between employment status and women's empowerment, such that drought has a stronger negative impact on empowerment among women who are not currently employed. Women currently employed reported greater control over household decision-making and reported less agreement with reasons justifying wife-beating. We additionally found evidence of effect modification of the association between economic status and women's empowerment for the indicator of disagreement with justifications for wife-beating. Among women experiencing drought, women classified as poor (defined as being in the lowest wealth quintile) experienced a greater negative impact on empowerment as measured by disagreement with wife-beating than women classified as not poor. We found no evidence for effect modification of the association between rural residence and either measure of women's empowerment.

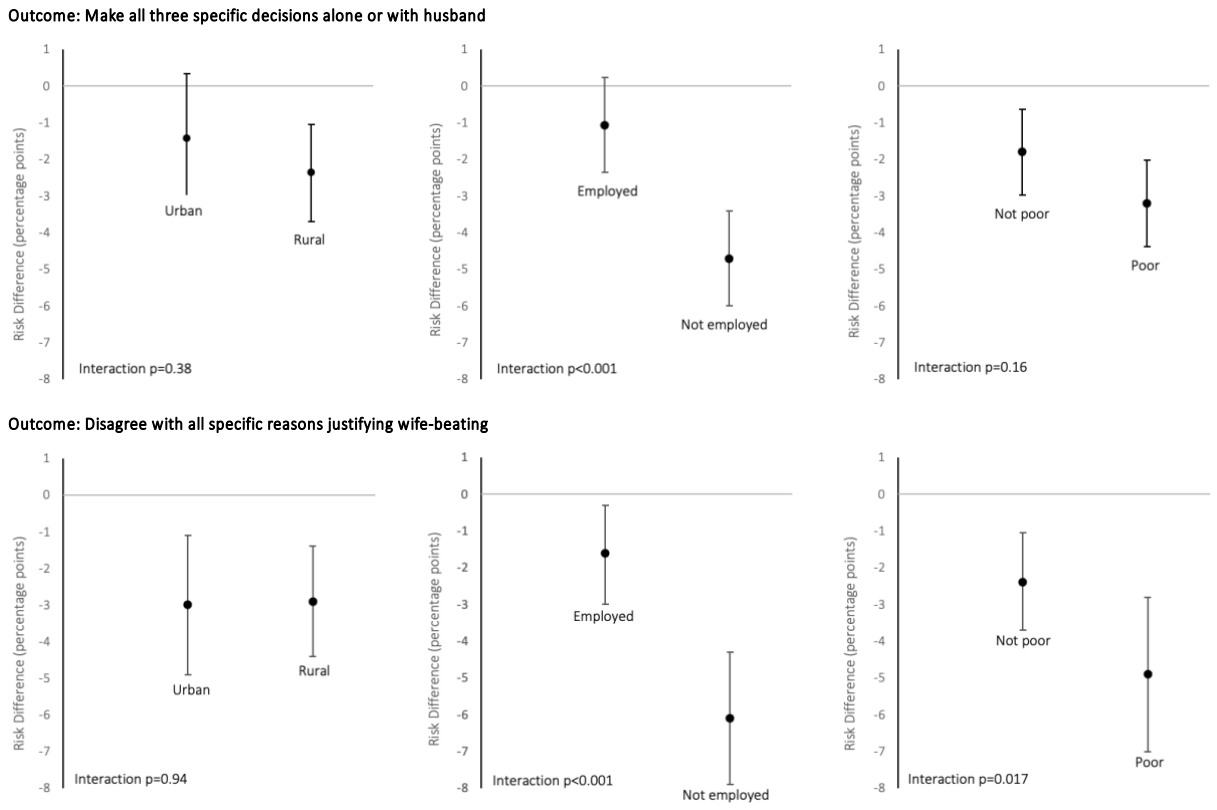

Figure 3.3. Effect modification of the relationship between drought and women's empowerment by rural residence, employment status, and economic status.

Discussion and conclusion

The findings from our analysis indicate that drought may have a small negative effect on women's empowerment. Using nationally representative survey data from 147,502 women in twenty-four countries in sub-Saharan Africa, we found that women who lived in drought conditions had lower household decision-making and were more likely to endorse a view that wife-beating was acceptable. Our findings align with the broader literature on the particularly harmful impacts of climate change on women's health (19,21,22,24) by demonstrating an association between drought, which is a major climate risk, and women's empowerment, which is a critical social determinant of women's and children's health. The risk differences suggest

drought can play a small but significant role for women's empowerment at the individual level, while at the population level, because few women in our study population are currently exposed to drought, the contribution of drought to overall women's empowerment is very small. Thus, this paper, while contributing methodologically to the study of pathways through which climate risk factors shape women's health, is likely more relevant for advancing a conceptual understanding of climate change and women's health than for informing policy.

There are a number of potential pathways through which drought could shape women's empowerment. Drought reduces household economic and food security and can increase both transient and persistent poverty such as by disrupting labor, agricultural, and food markets (71). Such environmentally mediated increases in poverty can reduce women's agency (72). As households experience greater economic stress, this may shift household decision-making dynamics to reduce women's power and may also increase women's economic dependence on their partner thus further reducing empowerment in household decision making. Drought and economic insecurity can increase women's labor time in household and caretaking responsibilities and can lead women to take on lower-paid and less safe work (72–74), further reducing economic empowerment, bargaining power within the household, and ability to pursue education and other activities that enhance empowerment. Women often have less access to adaptive resources to cope with drought, including less access to financial, informational, and social services (30) which can deepen their vulnerability during and after environmental shocks.

Drought also increases migration and displacement (75–77), but the relationship between migration and empowerment is complex (78). Migration and displacement could impact empowerment both for women who migrate and those who do not. Women who are displaced face economic, educational, health, and security disruptions (71,79,80). Women who migrate may have greater access to economic opportunities that increase empowerment or may experience further economic and social risks that reduce empowerment. Women often have more limited ability to migrate (72) and such immobility can increase risk to climate, economic and other threats (17,81) which could reduce empowerment. The health impacts of drought may additionally affect empowerment. For instance, mental health outcomes experienced by women, or their husbands, could affect attitudes towards violence. Women are more vulnerable to the adverse health harms of drought, and this could additionally undermine their status in the household.

While the documented direct impacts of drought on agriculture would suggest that the impact of drought on women's empowerment might be higher among rural women (71), we found no evidence of differential impact of drought on women's empowerment among urban and rural women. We likewise found only marginal evidence of interaction between economic status and drought on women's empowerment. Both findings were unexpected, given prior research suggesting that climate change can have profound health, social, and economic impacts among rural and poor communities (71) and deepen gender inequities for rural women (24). The lack of evidence for effect modification by economic status could be the result of the poverty cut off used, which compared women in the lowest wealth quintile to all other women.

Thus, a significant number of women in the comparator group could be experiencing a significant level of economic stress. The pathways and mechanisms through which drought impacts women's empowerment, and consequently health, across different domains of socioeconomic vulnerability is an important area for future research.

There are several limitations in this study. The first, and perhaps most important, are the limitations of the indicators available to measure empowerment in this cross-country study. Measuring women's empowerment is challenging (42,46) and the DHS empowerment module offers a limited set of indicators that capture a small number of empowerment domains (82) that may not fully capture women's empowerment (43). Empowerment is a multi-dimensional concept, and there is a wide range of indicators, measures, and frameworks used to measure empowerment (83), with different measures finding different associations between empowerment and health (59,84). Our analysis looked at only two measures of individual empowerment, and thus is not a comprehensive view of women's empowerment and does not consider the broader economic, political, cultural, and social arenas in which empowerment is shaped and expressed (47). Incomplete or inaccurate measures of empowerment could hinder our ability to identify drivers of empowerment and appropriate responses to these. Future research could explore the relationship between drought and additional dimensions of women's empowerment, including considering measures of empowerment tailored to different cultural contexts, and integrating qualitative data to understand the relationship between empowerment and climate change in drought-affected communities. An additional limitation regarding the measurement of empowerment is the potential for misclassification through

women's self-reported level of empowerment. However, we believe it is unlikely that reporting bias would vary based on exposure to drought.

Second, the DHS surveys are cross-sectional, which can make it difficult to assign the directionality of causality. However, in this case it is implausible that a lack of women's empowerment causes drought, and there are plausible mechanisms through which drought could lead to disempowerment. Third, our study was able to measure only the contemporaneous effects of short-term drought and does not capture the potential long-term and cumulative outcomes of sustained or repeated drought exposure. These long-term outcomes could be significant due to further strains on economic and social resilience over time, and it is therefore possible that the impacts of drought on empowerment could worsen over time (17,71). Prior research shows that the impacts of drought exposure can last across the life course (85,86). Alternatively, communities facing persistent drought may adopt better coping strategies, minimizing the long-term impacts on empowerment. Thus, future research should seek to understand the ways in which exposure to drought and other slow-onset climate impacts affect women's empowerment and health over time. Fourth, there may be unobserved confounding factors uncontrolled for in our model. While we attempted to control for the main household factors that may act as confounders, it is possible that other social or family factors that are correlated with drought could vary systematically within and between households. The country fixed effects used in the model are only able to control for economic, cultural, social, and political factors varying across countries that might be correlated with women's empowerment and drought. Finally, while we propose potential pathways through which

drought could shape women's empowerment, we lacked the data to assess potential mediating pathways. Future research should explore such mediating factors.

Despite these limitations, our results, based on a nationally representative sample of over 147,000 women from a wide range of socioeconomic backgrounds, country contexts, and experiences of drought conditions, point to an important area for understanding the relationship between climate change and health – particularly for women currently exposed to climate risk. Women's empowerment is a well-documented predictor of both women's and children's health (22). We find that drought exposure amplifies this risk for those individuals who are experiencing drought, and thus, local efforts to bolster empowerment could include consideration of climate-related factors. However, at the population level, the relative impact of drought on empowerment appears marginal. Thus, interventions that aim to improve women's empowerment should likely focus on other drivers of empowerment – such as economic development – given the relatively small effect of drought on empowerment and the comparatively small population currently at risk of drought. Drought is one of many climate risks that could impact similar pathways towards empowerment. This study does not quantify the cumulative effect of climate vulnerability on empowerment, which may be larger than drought alone, and may increase adverse impacts increase over time.

Climate change adaptation strategies pursued at the household, community, and national levels can reinforce and increase gender inequities when gender is not taken explicitly into consideration in the design and implementation of these responses (87,88). While the

effect of drought on empowerment appears small, it nonetheless contributes to a growing literature on the unique risks faced by women. Community and health system interventions designed to respond to drought should therefore include a focus on women and meaningfully integrate women in programs for drought and climate resilience. For instance, drought resilience and response initiatives could emphasize strategies that bolster women's empowerment through access to economic, adaptation, education, and livelihoods resources. Health systems responses could similarly integrate gender-sensitive responses to support families and buffer against potential impacts to empowerment or gender-based violence. Women are also underrepresented in climate policy making at all levels (89); in sub-Saharan Africa, few countries explicitly integrate gender into climate policy (90). Policies developed to prepare for, mitigate, and respond to drought, must similarly incorporate efforts to avoid adverse impacts on gender equality.

This study highlights how the disempowerment of women is a potential and understudied pathway through which climate change can impact health. It points to possible new areas for study to understand the pathways through which climate change could affect women's health and climate resilience. With drought and other climate threats projected to increase in the coming years, additional research to understand further the relationship between climate change, women's empowerment, and health could assist in identifying effective strategies for addressing the unique risks faced by women and in determining where to focus the attention of current efforts to bolster women's empowerment.

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Chapter Four

Pathways from Climate Change to Emotional Wellbeing: A Qualitative Study of Kenyan Smallholder Farmers Living with HIV

Introduction

Climate change adversely impacts a wide range of health outcomes (1–3), with growing concern for mental health and emotional wellbeing (4–6). Studies link climate change to anxiety, depression, post-traumatic stress disorder, mood disorders, and suicidality (7,8). Many studies have focused on how discrete climate risks impact specific mental health outcomes (9,10). However, there is growing evidence pointing to the need for research on cumulative impacts of climate change and the ways in which those impacts affect mental health (11–13), which could range from trauma, to climate effects on livelihood and culture, to hopelessness and fear of the future (14–17).

Current literature on climate change and mental health emphasizes concepts of eco-anxiety (16), ecological grief (18), and solastalgia, which focus on the mental health impacts arising from ecological loss and the attachment to ecological places and resources (19,20). Climate vulnerability is shaped by social and economic factors that affect exposure to climate hazards and access to resources for resilience and risk mitigation (21,22). Yet comparatively few studies examine the social and economic pathways through which climate change affects mental health (23), even as these social determinants – including economic insecurity, job

insecurity and sense of control over one's employment, social cohesion, and family support – are well-documented drivers of mental health across the life course (24–28). These social and economic factors can amplify the health risks and adverse health outcomes caused by climate change (29).

Mental health impacts of climate change are disproportionately experienced by communities that depend on environmental resources for economic security and cultural wellbeing, including Indigenous communities and farmers, as well as by people in low- and middle-income countries (6,7,18,30). However, research on climate change and mental health is largely based in high-income countries (9), and while there is growing research in low- and middle-income countries (15,31–33) and Indigenous communities (34), little focuses on sub-Saharan Africa (9).

The objective of this study was to identify the potential social and economic pathways by which climatic changes impact mental and emotional wellbeing, focusing on an especially vulnerable population of smallholder farmers in Kenya living with HIV. Climate change is adversely affecting smallholder agriculture and food production, with harmful impacts on the economic and food security of farmers (35,36). For them, climate change and the climate adaptation strategies they adopt are playing out in the context of largescale economic and agricultural changes in rural economies (37) that also have implications for mental health. Climate change – and drought specifically – is associated with HIV transmission and outcomes, as people living with HIV face higher risk of poverty, food insecurity, and other compounding

vulnerabilities that make it harder to adapt to climate impacts and that increase HIV risk (38–40). People living with HIV are also at risk of poorer mental health outcomes (41,42).

For this study, we took advantage of the infrastructure of a larger study of Kenyan smallholder farmers living with HIV, described below, to conduct semi-structured interviews that explore how climate change shapes the mental and emotional wellbeing in communities already experiencing the day-to-day impacts of climate change. Drawing upon this case study, we propose a conceptual model for future studies of vulnerable populations in low- and middle-income countries and outline potential applications of this knowledge for public health programs, policy, and research.

Methods

This is a qualitative research study located in Kisumu, Homa Bay, and Migori counties in western Kenya. This study is a sub-study of the *Shamba Maisha* cluster-randomized controlled trial (NCT02815579): a 16-site study testing the effectiveness of an agricultural and finance intervention to improve health outcomes among farmers living with HIV. The *Shamba Maisha* intervention has been described in detail in other publications; intervention measures included provision of a non-electric water pump, a small loan for the purchase of farm supplies, and training on farming and financial management practices (43,44). Data collection for this study took place part-way through implementation of the *Shamba Maisha* study and included participants in both the control and intervention arms. Interviews were not designed to be evaluative of the impact of the intervention on mental health, but rather focused on the

mechanisms through which climate change impacted mental health in a population highly vulnerable to adverse mental health outcomes. Ethical approval for the study was obtained from the review boards of the University of California San Francisco and the Kenya Medical Research Institute.

Research setting and population

The East Africa region, and Kenya, is a climate vulnerable region experiencing climatic changes such as warming temperatures and extreme rainfall events (45,46). Climate-related morbidity and mortality is also projected to increase in the future as these trends continue (47). Climate change is projected to significantly reduce yields of Kenya's major staple crops (48), contributing to food insecurity and malnutrition (49). Food insecurity is a pathway by which climate change can impact mental health (23,34,50,51). In rural Kenya, a large share of the population relies on agriculture as a primary source of food and income (52). There are 1.5 million people living with HIV in Kenya (53), and HIV positive households face significantly higher rates of food insecurity (54). Farmers (16) and people living with HIV (42) are distinctly susceptible to adverse mental health outcomes.

Study population

We purposively selected forty *Shamba Maisha* participants for enrollment in this study to include equal numbers of men and women, as well as and control and intervention participants across the three study counties. *Shamba Maisha* project coordinators managed participant selection at study clinics; study research assistants conducted study enrollment and

consent. Eligibility criteria for the parent study included (a) living with HIV and receiving antiretroviral therapy (ART), (b) experiencing moderate to severe food insecurity or malnutrition at time of study enrollment (BMI <18.5), (c) being 18 years or older, and (d) having access to farmland and surface water. Eligibility criteria for this study additionally included participation in the parent study for a minimum of one year.

Data collection

Two research assistants, trained by the study team in qualitative interviewing and use of the interview guides, conducted in-depth interviews with participants. Interviews, conducted in Luo or Swahili, took place in study clinics, participants' homes, or participants' farms, depending on participant preference. We piloted interview guides in July and August of 2018 and collected data from September 2018 to February 2019. Throughout the piloting and data collection phases, we held weekly meetings between the U.S. and Kenya-based researchers to discuss interview findings and modify interview guides to address emergent themes.

We developed semi-structured interview guides collaboratively with both the U.S.- and Kenya-based research teams. Interview guides covered the following topics: perceived climatic changes and their causes; experience with discrete weather events and long-term weather changes; perceived impact of climate change on agricultural practices and outputs, income and economic security, and health outcomes and behaviors; pathways through which climate change affects HIV and mental health; and gender differences in the experience of and response to climate change. Interviews lasted from 90 – 120 minutes; all participants provided

written informed consent. All individuals invited to participate participated in the interviews. Participants were paid approximately four USD and reimbursed for transportation if the interview took place outside of their home. Interviews were audio recorded, then simultaneously translated and transcribed into English by the research assistants.

Data analysis

We utilized a thematic analysis approach (55,56) to analyze the interview data. Prior to coding the interviews, we read the transcripts to familiarize ourselves with the data and develop initial concepts for future coding. All coding in this analysis was based on emergent codes. For the early coding analysis, we applied an open coding approach with two researchers (NB, TN) independently creating and applying codes to each piece of transcript text. Subsequently, four researchers from both the U.S. and Kenya (NB, TN, GO, SJ) double coded a subset of interviews to jointly describe and discuss codes and code definitions, and to ensure the coding scheme accounted for and reflected the local context. Discrepancies in coding were resolved through discussion among all coders. We then developed a codebook through discussion of emerging concepts and themes, and used it to re-code interview transcripts in a more focused manner. In the final analysis, one author (NB) re-read and re-coded transcripts focusing on the themes of personal and communal mental health and wellbeing, to generate a deeper understanding of the themes that make up the focus of this paper. We considered participant characteristics including HIV status and participation in the farming intervention, in our analysis.

Results

This study included forty participants between the ages of 23 and 58 years of age, half of whom were men and half women. Participants described four major pathways through which climate change contributed to the emotional health and wellbeing impacts they experienced. First, participants reported direct mental health impacts from losing their homes or farms in extreme weather events. Second, participants reported emotional distress due to growing economic insecurity, largely resulting from climate impacts on agriculture and in some cases exacerbated by agricultural and development policies. Third, participants described changes to community, family, and social cohesion resulting from this rising economic insecurity – changes which led to emotional stress and weakened emotional resilience. Finally, for a subset of participants, a shifting sense of personal and professional identity driven by economic, employment, and family stress contributed to a decline in their emotional wellbeing. Across these pathways, participants described both directly-experienced impacts, and anticipated impacts – those that were expected to occur. Both experienced and anticipated impacts contributed to emotional distress. We found the mechanisms through which climate change impacted emotional wellbeing to be similar among participants in the intervention and control groups.

Direct impacts of climate change on the mental and emotional well-being of Kenyan farmers

Respondents nearly universally reported experiencing some level of climate change impact on their mental and emotional wellbeing. As one respondent commented, "Those of us who are farming are the ones likely to bear the brunt of climate change" (Man, 48 years,

Migori). All study respondents reported direct experiences of changing weather, including higher temperatures; more drought, extreme rain events, and flooding; changes in the timing of the rainy season; and increasing weather unpredictability; though not all participants attributed these changes to the broader global phenomena of climate change. Participants described feeling “stressed”, “depressed”, “annoyed”, “demoralized”, “discouraged,” and “hopeless” because of these changes. One respondent explained that “the weather disoriented me completely" (Man, 38 years, Kisumu). Another described the stress of coping with unpredictability:

> "You plant with so much hope of a better and food secure future…Then suddenly it rains, and everything is destroyed. You will be forced to start from zero. You get so affected mentally. Your thinking is distorted. You worry endlessly...You cannot know what happiness is at these times." (Man, 37 years, Kisumu)

Nearly all participants in the study described experiences of major damage to their homes and farms due to climate-related extreme weather events, losses that caused emotional distress and grief. One respondent described the loss of his farm as “equated to the death of a loved one. It was very painful” (Man, 53 years, Kisumu). Another participant reflected on how these emotional impacts affected his physical health:

> “All my work had been drained just like that. I was deflated…My heart was bleeding, and my body became weak…Every time I would go to the farm, I would remember the loss…I lost appetite completely. I was so stressed up and worried.” (Man, 52 years, Kisumu)

Many participants described anger at the losses experienced. One participant reflected on the loss of her home and farm in a flood saying: “I could have jailed the rain

if it was a human being" (Woman, 43 years, Kisumu). Other respondents spoke to the toll this took on their mental and economic well-being over time:

> "I felt so devastated. I was depressed to the extent that I fainted. I couldn't believe the loss I had just incurred and the damage the rain had done…I have never healed from that experience. I cannot do anything when it is raining because I get extremely scared…Weather has made me very angry and traumatized." (Woman, 38 years, Kisumu)

In addition to these direct experiences of climate change, participants described anticipated future changes. Participants reported anticipating that future would be "difficult", "rough" and "worse", and that there was "no expectation for things to get better" (Woman, 27 years, Homa Bay). These negative expectations and fears about the future were a significant source of anxiety and worry.

Pathways through which climate change impacts mental wellbeing

In addition to the direct impacts of climate change on emotional wellbeing described above, we identified three social and economic pathways through which climate change contributed to participants' emotional health and wellbeing. These included economic impacts, such as declining agricultural productivity and economic stability; impacts to community social cohesion, such as declining social support; and impacts to personal identity, such as changes in professional and family role.

Climate change erodes economic security of smallholder farmers

Economic insecurity was a major reported driver of participants' mental and emotional distress. Participants described increasing economic insecurity resulting from direct climate

impacts on agriculture, including declining agricultural productivity, property and crop losses. and the income unpredictability and instability that resulted. Climate disasters, such as unseasonable rain and flooding, destroyed farms and acutely impacted harvests. Participants "depend on farming" for their food and income; climate-related farm losses thus impacted their economic and food security. Many participants described experiencing significant declines in the productivity of their farms, sharing memories like this: "Floods came in April and all the maize, beans, and other cereals I had planted were swept away…There was nothing to harvest. The floods took all that we had worked for" (Man, 38 years, Kisumu).

Long-term climatic changes, such as drought and changing rainfall patterns also reduced farm productivity. As one participant described: "Droughts are more severe and frequent nowadays…We have no option but to sell our cattle at a throw away price. Nobody wants to be associated with such heavy losses" (Man, 27 years, Kisumu). Participants perceived these impacts to be widespread. One described: "There was a time when drought destroyed all the crops I had planted…This happens quite frequently, and to most farmers across this vast region" (Man, 23 years, Migori).

Many described immediate economic hardship following climate events. One participant described how a single night of heavy rainfall destroyed her home and crops and "took me back to poverty" (Woman, 38 years, Kisumu). Other respondents described how longer-term declines in farm yields led to long-term economic stress; "Income from the farm

has greatly reduced, and this is because of the direct effect of the weather. We have suffered so much in our farming journeys" (Man, 45 years, Kisumu).

Economic losses led to extreme stress as a result both of the experienced disruptions to their livelihoods, and the anticipation that these experiences would continue or worsen in the future. As one respondent said "I had so many worries because I depended on the returns from my farm...Where was I going to get school fees? How was I going to feed my family?" (Woman, 47 years, Migori). Another stated: "Famine and poverty have pushed us to the wall" (Man, 58 years, Kisumu). Thus, not only did immediate economic stress and insecurity undermine emotional wellbeing, but also worry and fear about their expected economic prospects and their ability to provide for their families contributed to emotional distress independent of direct economic losses. In the words of one participant: "Being wealthy as a result of hard work is no longer a working narrative" (Man, 58 years, Kisumu).

Participants universally reported adapting their farming practices to respond to experienced and expected weather changes and to mitigate future losses. Participants described that climate change caused new farming challenges including pests and plant diseases, declining soil quality, and declining productivity of traditional crops. This necessitated a transition from "the practice our grandmothers taught us" (Man, 37 years, Kisumu) to more input-intensive farming techniques. Many respondents reported expanding the use of pesticides, fertilizers, and non-indigenous hybrid seeds.

However, participants described varying success in managing climatic changes and buffering economic stability. For some, these strategies made farming “more costly” and at times reinforced participants’ financial precarity and thus economic stress – and thus were actually maladaptive from a health perspective. As one participant said: “The amount of money we use in farming has tremendously increased…In the past you could farm and have plenty of harvest at zero costs. Now, I must buy fertilizer and seeds" (Man, 37 years, Migori). Often, as a result of adaptive strategies being insufficient to mitigate climate-related farm losses, those same strategies amplified economic insecurity. One participant described: "The capital we invest in the farm is much more than what we get from our farms" (Man, 42 years, Kisumu).

Wider land use and economic changes in the region also made it harder for smallholder farmers to cope with climate change and deepened economic insecurity. The growth of large-scale commercial agriculture and urban development reduced access to land, leaving "very small pieces of land that cannot produce enough food" (Man, 37 years, Migori). This impacted participants’ economic and food security, as related by one participant: "Where this hospital and school are currently located, these were farms. We could grow millet and sorghum. All those commercial rice fields you saw were places where sorghum and millet were grown…So, there is a lot of famine” (Man, 58 years, Kisumu).

Some participants also perceived changes in the region’s agricultural markets to affect their income. Several respondents described local markets “over-flooded” with imported products, such that even when their harvests were strong, “the market was bad” and “prices

fell greatly" (Man, 53 years, Kisumu). Another participant remarked: "We don't know where to take [our] rice…The [local] market is flooded with imported rice...The supply is too much. It outstrips demand…we sell the rice at a throwaway price" (Man, 58 years, Kisumu). One participant described changes in agricultural policies that affected their ability to earn income from farm products: "Recently people grew maize, but the government is not giving them market…The government is buying maize at a throw away price" (Man, 54 years, Kisumu). As climate change makes farming a less stable livelihood, these other pressures further strain the economic security of smallholder farmers and consequently impact mental wellbeing.

Economic insecurity undermines community support systems

Participants described how the economic impacts of climate change also affected the social drivers of emotional health at the community level. The widespread economic insecurity experienced by participants, together with an increase in perceived economic and food scarcity, disrupted community social cohesion by interrupting systems of communal support and mutual aid that historically buffered individual economic losses. This was an additional driver of worsening mental and emotional outcomes for some participants. Participants noted that those smaller harvests reduced community food availability: "In the past we had so much yield that we had to store in large granaries that were built outside our houses. Right now, you can walk for thousands of miles before seeing just one such granary." (Man, 37 years, Kisumu). As food insecurity grew, respondents described a shift in the culture of food sharing; "in earlier days you would walk into someone's granary and take grains enough for your use, for free.

Nowadays no one has harvest" (Man, 52 years, Kisumu). Another respondent said: “Nobody is giving out food for free. There is scarcity everywhere” (Man, 45 years, Kisumu).

As with economic impacts, both experienced and expected changes in social cohesion affected mental health. Some respondents perceived a reduced willingness among community members to support each other, reporting that people were “more individualistic”, “selfish”, and “concentrate only on [their] family”. One participant reflected: “Climate change and hard economic times have barred people from being as generous as they would want” (Man, 34 years, Migori), while others highlighted tension in balancing their desire to support others with the reality of scarcity: ”The urge to give you some small tin will be there, yes, but I will have to reflect on how this might affect me and my family and then definitely I will tell you ‘No’” (Man, 50 years, Kisumu). The loss of social support systems contributed to emotional distress, as participants felt they had to rely on themselves even in times of need. Perceived lack of community support affected emotional health even when that support was not tested. As one woman described: “I would rather sleep hungry than beg my neighbors…I do not want that kind of shame” (Woman, 45 years, Migori).

Economic insecurity affects personal identity

Finally, economic loss and insecurity also impacted emotional wellbeing by threatening participants’ personal expectations and sense of identity as caregivers and farmers, affecting individual level social drivers of poor mental health. This pathway to emotional stress was primarily discussed by men. Some participants reported a high degree of emotional distress

when they were unable to provide for their family, challenging expectations they had for themselves as family head and primary household earner. As one participant described:

> "[My] children wanted food which I couldn't afford…It appeared to them that I hated them and did not want to provide as I should. This brought me a lot of mental torture. I wanted to give them the very best, but I couldn't afford it…As a father, when you cannot provide for your children, it degenerates into a mental case." (Man, 36 years, Kisumu)

Emotional distress from the inability to meet one's personal expectations of their role as a caregiver could result from the direct experience of being unable to provide, as described above, or from the anticipated fear of future failure or declining social status. For instance, one participant described: "Your kids will constantly view you as a failure…You feel you cannot provide…The respect I expect from my wife and children won't be given. I am almost useless " (Man, 52 years, Kisumu). These real and awaited changes in family cohesion created another potential stressor on participants' emotional wellbeing.

A second disruption to participants' sense of identity resulted from changes in agricultural work that affected the experience of farming, sense of control over their labor, and level of satisfaction in the profession. These changes could result in direct challenges to their farming identity, and consequently emotional distress. Some respondents reported taking on other jobs to supplement their income. This was another source of emotional stress, particularly for men, as having to work for others was viewed as demeaning: "I had gotten used to being my own boss. Now I had to start working at the mercy of other people…They deal with you the way they want. You are scolded like a kid in front of people" (Man, 26 years, Kisumu). Several men described embarrassment, disappointment, or loss of dignity at not being able to

farm. One said: “You can’t even call me a farmer. I am a consumer. I live hand to mouth” (Man, 58 years, Kisumu). Others described how farming itself was increasingly viewed as a profession that could not sustain a person economically; in the words of a respondent: "[Farming] has been left to…those perceived to be poor" (Man, 45 years, Kisumu). The redefinition of farmers’ perceived role and position economically and socially was a source of emotional distress for these participants.

Distress could also result from anticipated threats to identity. As one respondent described: “You may have the [farming] knowledge, but the unpredictable weather pattern renders you useless” (GO12). Unpredictability and repeated losses led some participants to feel a sense of futility about the future of agriculture. As one respondent asked: "Why plant crops only for the sun to scorch? Why plant crops for the floods to wash away? You cannot predict the weather, it either rains too much or there is too much drought" (Man, 42 years, Kisumu).

Proposed conceptual framework

We developed a preliminary conceptual framework to capture these economic and social pathways by which climate change can shape mental and emotional wellbeing (Fig 4.1). Note that the arrows, as described in the text above, can represent both experienced and anticipated impacts in these domains.

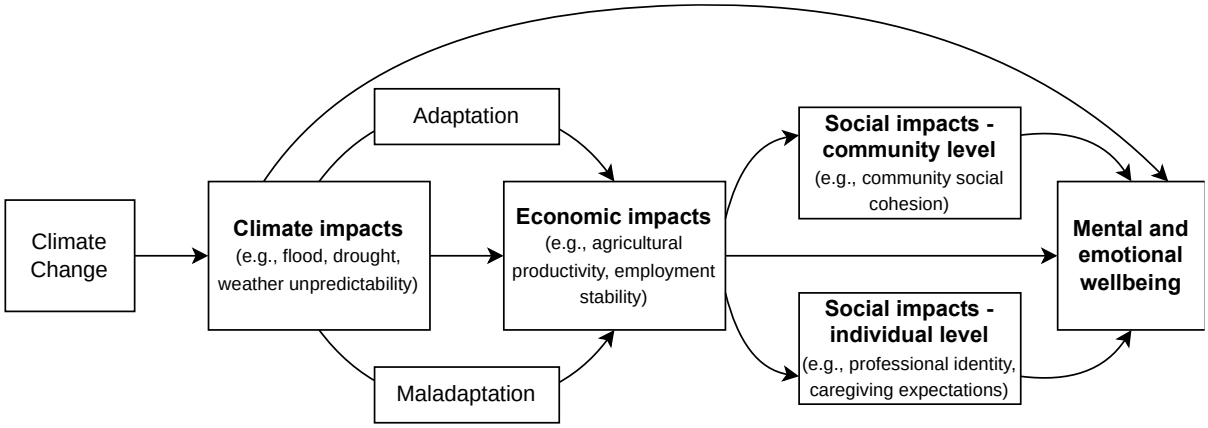

Figure 4.1. Simplified Conceptual Model of Social and Economic Pathways Linking Climate Change to Emotional Wellbeing

Discussion and conclusion

Climate change is having significant, cumulative effects on the mental and emotional wellbeing of Kenyan smallholder farmers living with HIV. As this population is especially vulnerable to both climate change impacts and poor mental health outcomes, it is thus an important community in which to develop a model of the intersection pathways between climate change and mental wellbeing. Emotional impacts experienced by participants include high degrees of stress, fear and concern about the future, and sense of sadness, worry, and anxiety stemming from the experience of losing one's home or farm, or from a changing sense of personal and professional identity. These impacts on participants' mental and emotional wellbeing were mediated by profound changes in the social and economic determinants of mental health, including increasing economic and food insecurity, declining status and economic viability of agricultural work, and the fragmentation of sources of resilience such as social cohesion.

Drawing upon these findings, we proposed a preliminary conceptual framework that includes four primary social and economic pathways that link climate change to adverse mental and emotional health, based on the lived experience of one highly vulnerable population (Figure 4.1). Studies in other countries have focused on discrete mental health outcomes (e.g., depression) or have largely captured these impacts using concepts such as eco-anxiety and ecological grief. Participants in this study described a wide range of impacts on their mental and emotional wellbeing from more general feelings of loss and sadness to more extreme experiences of emotional distress. While some participants in our study described feelings of eco-anxiety and grief, their predominant experiences were better captured as stress, worry, and identity displacement, experienced in terms of the social and economic changes wrought by climate change.

Our study found that individual adaptive strategies are likely insufficient to protect mental health in a rapidly changing climate. The psychology literature on coping identifies three broad categories of coping strategies: problem-focused – those that aim to directly change the stressor; social – those that draw on community and social support; and emotional – those that aim to manage personal emotional responses to the stressor (57). This study shows how climate change is creating new stressors while also limiting many of these coping strategies. We find that, though farmers were proactively adapting their agricultural practices in the face of climate and economic volatility (i.e., problem-focused coping), often these strategies were insufficient to manage the level of disruption to their lives and their livelihoods, or to bolster the economic viability of small farms. Indeed, in some cases these strategies could exacerbate

economic precariousness. These results suggest that these approaches, which are widely used by smallholder farmers in Kenya (58–64), may not be effective in buffering farmers from mental health stressors and poor mental and emotional wellbeing and may actually be maladaptive.

We additionally found that social coping strategies were increasingly limited due to the economic impacts of climate change. Participants experienced and anticipated changes in community trust, family and social cohesion, and emotional and economic support systems that traditionally buffer and protect from changing social and economic determinants. These social and cultural factors, identified in the social determinants of health literature as particularly important for mental health resilience (24), were being weakened as a result of climate change. Emotion-focused coping strategies may also be limited as emotional resilience declined in the face of growing stressors placed on individuals' personal and professional sense of identity. Finally, across all pathways, we found that both directly-experienced and anticipated changes contributed to growing emotional distress, aligning with a broader psychology literature highlighting the importance of both lived and anticipated experience for mental health (65,66). This may be particularly important in the context of climate change, as, even if people are able to effectively adapt to and cope with current climate change, mental distress from anticipated impacts may grow as awareness of the directionality of future climate change increases.

We also found that the socially and economically mediated experiences of climate change may vary by gender. Men more often emphasized stressors associated not only with the inability to meet gendered expectations to provide for their families, but also with their shifting

identity as farmers. While all participants experienced economic stressors, several men particularly emphasized the viability of farming itself and the identity changes that accompanied their challenges to succeed in this livelihood including their changing role and status within the family – something not discussed by women participants.

These findings, on the constraints individuals experience in adaptation and coping strategies, suggest that community and policy interventions are likely needed to adequately protect emotional and mental health in the face of climate change. This aligns with the broader adaptation literature research suggesting that individual level adaptation strategies can at times increase social risks and vulnerabilities (67–70). However, an unexpected finding in our study was that agricultural and development policies were a concern for some smallholder farmers, with some policies perceived to increase exposure to climate risk and to undermine economic security. Understanding the policy context is thus relevant for mental health, as this can contribute to economic insecurity – a primary driver of emotional distress.

There are several important limitations to the current study. The study was embedded within a larger trial testing the impact of an agricultural and finance support intervention on HIV health; therefore, the participant sample is limited to individuals who are living with HIV and includes participants in an agricultural intervention that could impact their food and economic insecurity – factors which are themselves deeply connected to mental health. These characteristics of the participants were considered throughout the analysis; however, this may limit the external validity and generalizability of the results. This study found several emergent

themes, such as the importance of agricultural and development policies to mental health pathways, on which further data collection was not possible within the study and should be investigated more fully. Additionally, the study was limited to interviews with farmers engaged in the *Shamba Maisha* trial and did not include other stakeholders such as local government or health care system representatives who could speak to the policy response to climate change and mental health.

Despite these limitations, our findings point to several important areas for future research and intervention in the growing field of climate change and mental health. First, future research could explore gendered pathways through which climate change shapes mental health. As climate adaptive strategies also differ by gender (71), this investigation should include understanding how various adaptation strategies protect or harm mental health across genders. Future research could also explore strategies to strengthen mental and emotional resilience for vulnerable populations, which could include community and health system approaches such as leveraging existing health care services to expand and integrate mental health care. However, while such mental health supports are important, our study highlights the fact that efforts to improve global mental health must simultaneously address climate change and the social and economic determinants of mental and emotional wellbeing, and that clinical mental health interventions alone are unlikely to protect mental and emotional wellbeing in a rapidly changing climate. Thus, future research should focus on such solutions. Studies could include investigations of adaptation solutions: to understand whether they would be responsive to vulnerabilities that may result from local coping practices, what impact they

might have on mental health risks, and in what ways they could be strengthened to foster more successful adaptation and to protect against the mental health risks of climate change. A multisectoral policy approach, engaging health, environment, and economic sectors, is needed to buffer the mental health risks of climate change – yet these policy issues are infrequently discussed in the mental health literature. Given the centrality of economic pathways to mental wellbeing in this study, this multisectoral policy approach should be an additional focus for future research.

This study highlights the profound emotional distress experienced in this climate vulnerable community. It advances the literature on climate change and mental health by describing the importance of economic and social determinants in mediating the relationship between climate change and mental health, and by elevating the importance of policy solutions as both contributors to growing emotional distress and as essential responses in the face of adaptation constraints. Further exploration of potential economic and social factors is therefore important, to understand how climatic changes – and the adaptation and coping responses people turn to in response to them – shape the mental and emotional wellbeing of climate vulnerable communities.

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Chapter Five

Conclusion

Introduction

The harms to health are growing as greenhouse gas emissions continue unabated and climate risks and impacts accelerate (1,2). In 2021, atmospheric concentrations of greenhouse gases reached record levels (3), rebounding after a brief pandemic-driven decline (4,5). The last eight years are likely the warmest eight years since record keeping of climate data began (6).

Scientific evidence shows clearly that addressing climate change is a foremost health priority – a priority essential to achieving many other global development goals which themselves could significant affect health (1,2,7). Yet current efforts both to slow climate change and to protect people's health from the same remain insufficient. To protect health we must rapidly transition away from the use of fossil fuels (8) while simultaneously building the resilience of our communities and health systems. Doing so requires a large-scale transformation of our economies and societies (9). Gaps in the literature on climate change and health limit the development of the evidence base needed to accelerate this transformation. In this dissertation, I proposed that a social determinants of health approach to research could help narrow the gap in our understanding and expand our toolkit for action. In this conclusion I first summarize the explanatory framework of the dissertation and the key findings that emerge from my dissertation research. I then outline a set of future research priorities. Finally, I offer some thoughts on how this research can shape global health policy and action.

Summary of explanatory framework and findings

Research on climate change and health has increased over the past decade (1,10); however there remain significant gaps both in our understanding of the relationship between the two and in the translation of research into policy and practice to protect health. In this dissertation, I aimed to address a particular gap in the literature – the lack of research, globally, on the intersection of climate change and the social determinants of health, and, correspondingly the limited understanding of opportunities to protect health from climate change through exploring social and economic pathways for action (10).

My motivation for addressing this gap emerged from my analysis of the extant literature. This literature, I felt, offers far more insight into the "what" – the specific health impacts of climate change – than into the "how" – the pathways through which climate change shapes health and global health inequities. Understanding the intersection of climate change and the social, economic, and political determinants of health is critical to address, in turn, the impacts of climate change on health. This intersection is multi-dimensional. Social and economic factors shape exposure to climate threats, contribute to the health inequities that heighten individual vulnerability to climate risks, and mediate the capacity to respond to those same risks. Economic, racial, and gender inequities are known drivers of both adverse health outcomes and climate vulnerability, with low-wealth households and communities, communities of color, and women, disproportionately impacted by climate threats and less able to adapt to climate change (11–13). At the same time, climate change amplifies pre-existing structural inequities that independently harm health.

As one example, consider the intersection of heat and poverty. At a population level lower-income communities are more exposed to extreme heat, while at an individual level lower-income people have higher susceptibility to heat illness and fewer resources to manage heat exposure. Globally, lower-income countries and regions with the least adaptive capacity have already experienced more pronounced heat trends. As climate change increases extreme heat, there will be tremendous impacts on labor productivity, potentially impacting economic security in turn. Lower-income countries and communities will be disproportionately affected.

To help integrate these complex intersections of climate and social determinants, I reviewed existing frameworks and found none that explicitly addressed climate change and meaningfully considered the full range of social determinants at play in climate impacts on health. Nancy Krieger's ecosocial theory of disease distribution provided an explanatory framework that I found useful as I considered how to address gaps in our knowledge and inform strategies that could better integrate research evidence into climate and health policy.

Ecosocial theory focuses on understanding health inequities through explicit attention paid to how people's health is shaped by the social and ecological context within which they live. In Krieger's terms, people "embody" this context (14,15). The theory uses four core conceptual elements to generate this understanding (14,15): (1) *embodiment*: how social and economic pathways are expressed biologically. (2) *pathways of embodiment*: the pathways through which the social, political, ecological, and historical context affect health. (2) *cumulative interplay of exposure, susceptibility, and resistance*: the way these pathways

intersect to cumulatively shape both vulnerability and resilience to climate and health threats. (3) *agency and accountability*: the institutional structures that govern and shape these pathways and resulting health outcomes. Each of my three dissertation papers explored a different social determinant of health and climate change, using one of these conceptual elements of Krieger's ecosocial theory as a critical framework.

Chapter Two examined the intersection of climate change and the commercial determinants of health by analyzing the strategies and messaging used by the fossil fuel industry in connection to the emergent science on climate change and health. This paper, referencing Krieger's concept of "agency and accountability", documented how the Global Climate Coalition (GCC) responded to the emergent field of climate change and health as part of a broader effort to delay climate policy in the U.S. Chapter Three addressed the gendered determinants of health, offering a quantitative exploration of "pathways to embodiment" through statistical analysis of the association between drought, a growing climate risk, and women's empowerment, an important determinant of health for women and their children. Chapter Four referenced Krieger's concept of "cumulative exposure, susceptibility, and resistance" through a qualitative exploration of the lived experience of climate change among a community of Kenyan smallholder farmers living with HIV. It presented a proposed conceptual framework for thinking about how climate change intersects with social and economic determinants of health to shape climate and health vulnerability, adaptive capacity, and cumulative wellbeing.

According to Krieger, analyzing health inequities through an ecosocial lens can identify new opportunities for "prevention, redress, accountability, and change" (14). By focusing on how climate change intersects with social, economic, and political systems to shape health, this dissertation identifies recommendations for new areas of emphasis in global health sciences research that can result in evidence for the action necessary to respond to – and, hopefully, protect against – the health harms of climate change. In the subsequent sections of this conclusion, I first discuss key cross-cutting themes from this dissertation, and then address how future work in the field can advance these findings – especially as relates to the generation of policy-relevant research.

Cross-cutting themes

Taken together, the papers that make up this dissertation point to several cross-cutting themes.

Social determinants as pathways between climate change and health

Ecosocial theory suggests that separating social and ecological factors will undermine efforts both to understand current patterns of health inequity and to identify effective strategies for protecting health. Broadly, climate change and the social determinants of health are colliding in ways that deepen existing health inequities and expand health vulnerability. The findings from this dissertation are indicative of the complex pathways through which the social determinants of health influence climate-related health outcomes. Because climate change and social and economic factors work together to affect health outcomes and health resilience, program and policy responses to climate change that incorporate strategies to address these

underlying structural drivers of ill health, in concert with addressing climate risks and impacts, are likely to prove more effective in addressing the growing burden of climate-related health outcomes. Specifically, this dissertation provides insight into three social determinants:

Economic determinants. Poverty and economic inequality are known fundamental determinants of health and are deeply entwined with climate change as both cause and result of climate vulnerability. Two papers in this dissertation demonstrated that economic determinants are, unsurprisingly, a critical mediator in climate health vulnerability, climate risk exposure and adaptation, and climate health outcomes. This dissertation extended the current literature documenting the greater vulnerability of lower-income countries and communities, in order to explore how climate change affects economic status and thus health; specifically, through analyses of these factors in sub-Saharan Africa. In our study of smallholder farmers in Kenya, we found that declining emotional wellbeing is largely driven by profound changes in the economic and social determinants of mental health. Our collected data showed that economic insecurity, resulting from climate impacts to agricultural productivity and the high costs of agricultural adaptation, was a primary cause of emotional distress, and, in addition, placed a significant burden on community support systems; eroding social resources that historically buffered against economic losses. In our study of empowerment, we hypothesized that economic impacts of climate change could be important drivers of the effect of drought on empowerment. We found evidence suggesting that the negative effect of drought on empowerment is higher among women who are more economically insecure. Because climate change works together with social and economic factors to affect health outcomes and health

resilience, effective program and policy responses will need to respond to these underlying structural drivers of ill health.

These papers together suggest that while the interaction of different social determinants merit greater exploration, the intersection between climate vulnerability, climate adaptation, and poverty should be prioritized in the climate and health field. They also suggest that attention be paid to structuring climate solutions across sectors so as to prevent adverse economic consequences stemming from of exacerbation of economic inequality: consequences that may contribute to negative impacts on health. Understanding this relationship is particularly important considering our finding that the fossil fuel industry used the critical importance of economic security for health as a rationale for their argument supporting investments in public health programs rather than climate change. Despite research demonstrating that climate change will become an ever-strengthening driver of worsening poverty (11), the precise extent to which climate change, health, and economics influence each other remains unknown – though the full scale of health-related economic costs of climate is likely undervalued at present (16,17). Thus, effectively engaging with industry, and in climate and health dialogues, regarding investment and policy priorities demands deeper investigation into these multidimensional relationships.

Gender determinants. There is a growing body of literature discussing the gendered dimensions of climate vulnerability, adaptation, and governance (18,19), and of climate-related health burdens (20–23). This literature focuses predominantly on the inequitable burdens born

by women. We found that gendered experiences of climate change are likely to vary across cultures and circumstances, and by health outcomes. In Kenya, we found that the pathways through which climate change affects mental health vary by gender. Men in our study described unique emotional stressors related to gendered expectations of professional and family roles. Our data suggested that men may face greater emotional health burdens than women in this study setting, an important consideration given the literature's current emphasis predominantly on the burdens faced by women.

Gender also intersects with other social determinants to further vulnerability. Prior studies suggest women's gendered climate risk stems from their greater economic disadvantage (24). We extended this in Chapter Three, suggesting that climate impacts could potentially entrench these economic inequities through gendered impacts like reduced women's empowerment. Chapter Four also highlights the intersection of gender and economics, finding that gendered differences in mental health – related to gender norms and gendered role expectations – are strongly influenced by economic factors such as the real and perceived rise in economic insecurity resulting from climate change.

Thus, future research on gendered experiences of climate change and health should explore in greater depth how gender norms and gender inequities differentially affect and drive unique health risks and gender-specific coping strategies, how gendered risks are influenced by other social determinants, and the impact of these factors on differential health outcomes across various cultural contexts.

Commercial determinants. Studies examining the commercial determinants of health form a critical subset of the literature on the social determinants of health literature, and include analyses of multiple health-harming industries (25–28). This dissertation extended this literature to look specifically at the fossil fuel industry, which, though widely studied, has not been explored specifically in the context of health. This is an important gap, given that the products of the fossil fuel industry generate direct health harm (29), amplify health inequity (30), and contribute to climate change (31).

The role and tactics of the fossil fuel industry in delaying, weakening, and blocking regulatory action on climate change has been well-delineated. Our analysis of a small set of documents suggested that it is possible that the fossil fuel industry used similar tactics to influence health research and narratives, and to shape policy maker and general public perceptions of the relationship between climate change, fossil fuel use, and health. We found that, in the mid-1990s, the fossil fuel industry was worried that evidence of the health impacts of climate change would prompt public and policymaker support for climate action. In response, industry partners, including individual companies and industry-led coalitions, sought to influence the science of climate change and health. The strategies of influence included commissioning studies and seeking health professionals to serve as trusted spokespeople to counter the growing evidence on the adverse health impacts of climate change. Fossil fuel industry stakeholders advanced a pro-public health message as part of broader efforts to reduce support for climate mitigation policy. To do so, the fossil fuel industry drew on leading health science, as well as health and health equity narratives and debates from within the

global health community, and aligned with the prevailing public health consensus regarding prioritized investment in public health systems: all to argue that climate change mitigation was unnecessary from a public health perspective.

Prior initiatives to regulate harmful products – notably tobacco – drew heavily on exposing the gap between what the industry knew and what the industry communicated to the public, in order to counter industry messaging and build social and political will for regulation (32). Additional research to further understand what the fossil fuel industry knew about the impact of fossil fuels and climate change on health – and when the industry knew it – could add value to current efforts of global health science to engage in climate policy discussions and to build political will for climate action.

The health community should also pay greater attention to how health evidence and health messages can be used by industry, and work to ensure consistent framing that supports and advances health-protective climate action. As health messaging is elevated within global and local climate policy discussions, it is critical that researchers working at the intersection of climate change and health pay attention to how and by whom health narratives are being used – and ensure that the same narratives do not divert attention from critical progress on mitigation efforts. At the same time, it is important that health researchers not peremptorily dismiss industry research and arguments, but rather endeavor to assess whether they are grounded in and reflect the body of up-to-date independent research, and how these arguments are being used to shape public opinion and policy decisions. Health sciences

research can additionally provide better insight into the health risks and benefits of new industry-supported climate solutions, relative to other climate solutions, and through this identify when collaboration with industry may be merited.

Limits of adaptation and foreclosure of opportunity

Current efforts to adapt to climate change are severely underfunded (33) and are failing to adequately protect against climate impacts and health risks (34). With climate change already wreaking havoc around the world, developing and implementing effective adaptation strategies will be critical to protect health. This dissertation points to several findings relevant to such efforts.

Accelerating climate change is foreclosing opportunities for adaptation and coping, and likely making future adaptation more difficult. In Kenya, our study participants reported an increasingly narrow set of options available to support them in adapting to the climate change they are already experiencing. Economic constraints limited their ability to implement adaptive agricultural strategies, and climate impacts were further constraining their economic security. Social support systems that traditionally helped to buffer acute experiences of economic insecurity, and that could help reduce the mental health effects of climate impacts, were also being undermined as a result of climate change and its attendant economic effects. A similar foreclosure of adaptive capacity is a possible conclusion in our study of empowerment. By reducing women's empowerment – constraining women's control over decision-making and increasing their risk of experiencing violence – we found that drought may contribute to

limitations on women's ability to effectively navigate the consequences of this climate event: in other words – reduce their adaptive capacity.

Adaptive strategies can also be insufficient to respond to the scale of climate risk and may actually increase the risk of poor health outcomes. For instance, in Kenya, farmers' attempts to invest in alternative agricultural techniques in some cases increased economic vulnerability, failed to overcome severe climate impacts, and contributed to emotional distress. Maladaptive strategies that increase rather than reduce risk (35) are more likely to exist when the drivers of vulnerability are unknown or misunderstood (36). Constraints imposed by intensifying climate change and the resulting increased disruption to social, economic, and health systems may increase the risk of maladaptation. Understanding how people are adapting, the constraints they face in doing so, and the health effects of these strategies will be crucial for advancing more effective adaptation.

The depth of disruption and profound despair described by our study participants in Kenya suggests there are limits to adaptation, and refutes the prevalent arguments of the fossil fuel industry that our efforts to protect health should be made predominantly through adaptation. These experiences are indicative of what people all around the world are living through, raising questions about whether our current adaptation strategies can actually enable us to live healthy lives. This dissertation contributes to an emerging body of research indicating that urgent mitigation is imperative if we hope to limit climate change to bounds within which human adaptation remains feasible (37). Our collective inability to take meaningful action on

climate, and the resultant delay in the reduction of greenhouse gas emissions and the transition to a zero-carbon economy, has foreclosed many opportunities and options for effective mitigation, and has increased the risk that adaptation efforts will be overwhelmed.

Moving from individual to structural and policy intervention

Together, the studies in my dissertation showed the limitations of evaluating the impact of climate change on health as a collection of clinical health outcomes. This approach elevates individual-level solutions to help people cope with climate change or manage climate-induced health outcomes, and emphasizes health sector solutions that track and respond to climate-health risks. Those solutions alone are unlikely to effectively protect and improve health in the era of climate change; indeed, they may themselves become overwhelmed as climate impacts accelerate. Additionally, as described above, potential constraints inherent to individual responses may render individuals alone unable to protect against or manage the risks of climate change. Thus, this dissertation suggests that broader multi-sector interventions are needed to protect health and wellbeing and that these efforts must be implemented at the structural or policy level.

At a community level, this means taking a holistic approach that engages the multidimensional causes of poor health. For instance, our findings in Kenya suggested that while leveraging existing health services to expand mental health care is important in climate vulnerable regions, it is essential to address the more fundamental economic drivers of mental health – and this essential task will require engagement outside of the health sector. Further,

strategies that respond to the social determinants of health must move beyond the individual. In Kenya, we found that policy decisions affecting community development, land use patterns, and agricultural markets were hindering adaptation and contributing to economic insecurity. It is thus necessary to pay attention to the unintended health and economic consequences of climate and development policies, as well as to design and implement policies that improve the social and economic determinants of health. Many climate mitigation solutions, appropriately implemented, can bring economic returns. Research into the corresponding health benefits, and conversely, potential health consequences, of these solutions can help guide policymaking that maximizes health equity. For example, bolstering women's empowerment through educational, employment, or political pathways could respond to the multifaceted health risks of intersecting climate and gender vulnerability.

At a global level, our analysis of the fossil fuel industry showed that we must shift attention to the commercial and political determinants of climate change in order not only to overcome political barriers to climate action but also to prevent the wide range of health impacts caused by the burning of fossil fuels. There is overwhelming consensus that to protect our health now and into the future, we must end the extraction and use of fossil fuels (1,38). Our current levels of fossil fuel extraction, production, and use are incompatible with the clean energy transition required to achieve climate targets necessary to ensure human survival (39–43). Despite affordable and competitively priced renewable energy (44,45), fossil fuels remain widely subsidized (1,46), enabling further fossil fuel development, locking in reliance on fossil fuels, impeding investment in clean energy, and enhancing the profits of the fossil fuel industry

(47–49). Individual efforts to reduce the consumption of fossil fuels will most likely be far from sufficient to mitigate climate change. Rather, policy endeavors that revamp our energy and transportation systems, foster the easy adoption of zero-emission technologies, and restructure investments to prioritize clean energy will be required. As the ability to advance climate solutions is shaped by the actions of many stakeholders – including fundamentally consumers, governments, and the fossil fuel industry – efforts to advance climate policy should meaningfully engage across these multiple communities.

Implications for global health sciences research

This dissertation draws conceptually on two overarching bodies of global health sciences literature, that on climate change and health and that on the social determinants of health. Numerous frameworks exist in both domains of study, but, to my knowledge no framework exists that fully integrates the complex relationships between these two domains, in order to guide research at their intersection. Nancy Krieger's ecosocial theory provides a useful foundation to shape broad conceptual domains of research questions that integrate complex social and ecological interactions; however, it is not designed to provide specific priorities for the study of climate change and health. There is a need to identify such priorities. The World Health Organization last updated its climate change and health research agenda in 2009 (50). More recent research agendas focus on high income countries (51,52) and on clinical care (53). Establishing a new research agenda, and possibly a global climate and health research framework, that more deeply integrates the social and structural determinants of health, could facilitate expanded research in this critical area, and would require broad input to develop.

In reviewing the literature on climate change and global health, I identified several research gaps. These gaps included analyses of certain health outcomes (e.g., questions of mental health), of certain geographies (e.g., low- and middle-income countries), and of certain drivers (e.g., commercial determinants of health). I aimed to address some of these gaps through the selection of my three research studies. Based on the findings of my dissertation papers and the cross-cutting themes developed above, I now identify a set of research priorities that should be explored more fully in the future and that could inform an expanded research agenda.

1. **Socioeconomic pathways**: The multiple ways in which climate and social determinants intersect have not been fully elucidated. These intersections provide important research opportunities for understanding how the social determinants of health shape exposure, adaptation, and outcomes; social determinants including, but not limited to, gender, race, etc. This research should focus on addressing the critical question of how the health sector can most effectively intervene, given a wide span of possible climate interventions, to promote and protect health in the context of economic and social vulnerability. This research must also to reflect the complexity of interactions between multiple social determinants. For example, what are the potential short and longer-term health risks and benefits of investments in renewable energy versus expansion of fossil fuel infrastructure in low-income countries where energy access remains low and economic development is essential? Or, how do gender and economic determinant interact to shape differential vulnerabilities by gender and what are the most relevant

economic development or other strategies that respond to these gendered needs and constraints in relation to adaptation solutions?

2. **Industry strategies, impacts, and engagement**: Despite broad recognition of the role of various industries – including tobacco, sugar, and chemicals – in shaping health outcomes (26,28,54–56), comparatively little research has explored the fossil fuel industry from a health perspective. Industry continues to engage in and shape discourse about climate change science and policy today (9,57), and thus should be a focus for research. This research should explore the strategies and messaging currently used by the fossil fuel industry, and how these have evolved over time – including how industry is responding to the renewed attention paid to questions of fossil fuel use, climate change, and health in academic and public spheres. Another area of research should involve examining the strategies used by public health stakeholders to successfully advance policy and regulation concerning other health-harming industries – e.g., tobacco. This research should consider which of these strategies could be relevant to the global health approach to the fossil fuel industry, given the fundamentally different role played by fossil fuels in our economies and societies, compared to those other health-harming products. The fossil fuel industry provides funding for leading research institutions, connected to work they undertake in the global health sciences and on climate change (58). Research suggests there are conflict of interest concerns, with industry-funded centers more likely to publish findings that are favorable to industry (59). Future work in the field should explore the extent and nature of industry funding

for climate change and health research, as well as potential conflicts of interest in this area. Finally, as climate change accelerates, the policy landscape of climate action evolves (e.g., with the passage of the Inflation Reduction Act in the U.S.), and the economics of fossil fuel vs. renewable energy shifts, greater thought should be given to the potential evolution of fossil fuel companies from past denialism to future collaboration, including both where there may be areas for potential collaboration and the frameworks to guide such collaboration given continued efforts by the fossil fuel industry to slow the energy transition.

3. **Economics of climate and health**: Debates remain in both the climate and health fields regarding the relative merits, from an economic perspective, of investing in mitigation vs. adaptation, and of investing in climate change vs. health. These policy debates are shaped by varying conceptual and methodological approaches. For instance, the questions of how we decide, as a society, to value present compared to future risks and benefits, and how we reflect these values in discounting and other inputs to cost-effectiveness analysis. However, these debates also must be informed by accurate accounting for the economic costs and benefits associated with climate change and climate solutions – which, from a health perspective remain underdeveloped at this time. Limited empirical evidence exists on either the health-related benefits of climate action, or the health-related costs of failing to act (17). Gathering this evidence could be an important research task, as the available statistics suggests they are both substantial: for example, a recent analysis of only ten climate events in the U.S. in 2012 found they

resulted in $10 billion of health-related costs (60). Economic tools such as the social cost of carbon, designed to help inform climate policy making, also fail to take these full health costs into account (61). Research should focus on expanding our understanding of the economics of climate change and health, and on considering how to integrate health appropriately and effectively into climate decision tools. Finally, the economic questions of discounting also relate to ethical questions regarding the value of the health of future generations (62) and these questions about intergenerational equity can be further explored within the health community.

4. **Projections**: Developing better methodologies for projecting cumulative impacts and costs over time, including the health outcomes resulting from climate-induced economic and health system disruption, is also necessary. Since the science of climate attribution is rapidly developing, allowing the attribution of specific climate events to climate change, future research should expand the attribution sciences to include health, supporting a more comprehensive look at climate change's health costs. Relatedly, additional research should examine long-term impacts of climate change, including for example, slow-onset illnesses (e.g., cancer) and slow-moving climate threats (e.g., sea level rise). New methodologies are also needed to better understand cumulative risks – similar to the impetus in the environmental health sciences, over the past decade, to improve the methods for understanding the cumulative exposure to different toxins.

5. **Communications**: Research suggests that health offers an effective frame for garnering support at the policy level and in the public sphere for climate action (63,64). Indeed, our analysis found that the fossil fuel industry understood and took seriously the power of a health message to influence climate policy. However, a health frame alone is likely insufficient to drive policy change (65). Our research echoed this hypothetical, finding that in the 1990s, a rapid rise in scientific evidence on climate change and health, a higher engagement of health professionals on the issue, and an increased policymaker interest in using health framing to support climate policy, all failed to break through various barriers in order to advance climate action. In light of this failure, research into climate change and health communications is important. At the least, this work could inform understanding of what messages are most effective to communicate to the public and to policymakers. It is also important for health researchers and health professionals to understand the arguments of the fossil fuel industry in order to effectively shape and promote policies to protect health.

6. **Implementing and evaluating solutions**: Limited data is currently available as to which strategies, within and outside of the health sector, most effectively protect health from climate change (52). Future research should aim to identify – through implementation and evaluation science methods – the opportunities that exist and the solutions that actually work to protect health from the combined effects of climate change and structural inequity. This should include a greater focus on policy research: one that both projects and evaluates the health impacts of different solutions – whether involving

climate adaptation or mitigation policy – to enable prioritization of strategies that protect health. A wide array of climate mitigation solutions are now available – ranging from energy efficiency to forest management to carbon capture and storage – each with potentially significant impacts on health and health equity. The development of methodologies to allow better assessment of the relative health impacts of these different strategies could help integrate health considerations into multi-sector policy. From an adaptation perspective, more work is needed to identify effective health-protective measures at both the individual and societal level.

7. **Governance and finance**: Greater attention to the climate policy process, as well as how the health sector can engage in multi-sector climate policy should be a focus for research – and can support the growing climate and health movement to engage in climate policy debates at all levels of governance. Health – the health sector, health data, and health professionals – is poorly represented in climate policy discussions at the global and national level. There is also woefully inadequate funding for climate change and health research and action. Research should explore the opportunities for integrating health in current governance structures, and should consider what new structures could look like, if they were to improve the integration of climate and health decision making and expand climate and health finance. These considerations should include exploration of the institutional mechanisms necessary to rapidly translate available evidence into programs and policies that can improve health.

Across my three papers, I applied a range of methods – document, quantitative, and qualitative analysis – highlighting the need for mixed methods and multidisciplinary approaches to address the complex intersection of climate change and health. In addition to the above topics, this dissertation points to several methodological considerations for global climate and health research. First, though climate and health research remain largely quantitative, qualitative methods are well-suited to address many outstanding questions. Qualitative research can help expand our understanding of how people experience multiple overlapping climate change risks, how they experience these risks in relation to the social determinants of health, how they manage or adapt to climate change, and how climate change affects holistic wellbeing beyond individual health metrics. Second, climate and health research should draw more from the methods of community-based and co-created research. Climate and the social determinants of health vary significantly across geography. As seen in our Kenya paper, specific climate, development, and cultural contexts shaped climate-related mental health outcomes. Adaptation solutions especially are likely to be highly local. Thus, research conducted jointly with impacted communities may be more effective in understanding intersectional pathways and identifying solutions. Third, transdisciplinary research is critical. We need better systems for integrating, health, economics, energy, social sciences, policy, and other areas of research expertise to address this complex issue.

Implications for global health practice

In addition to the above research priorities, this dissertation points to several priorities for action at the intersection of climate change and health.

Expanded investment in climate and health

There is a significant lack of investment in climate change and health research and programs. In the U.S., research funding through the National Institutes has historically not prioritized climate change and health, and the topic has fallen through the cracks of siloed funding streams (52). In the past year (2022), the Biden Administration committed to expand funding to both the NIH and the CDC for their climate change and health programs. The Wellcome Trust, one of the leading philanthropic research funders, made climate change and health research a funding priority. These are important steps, yet total research funding still remains small in comparison to other health topics – and falls far short of what is needed. Influential funders of global health research, like the Bill & Melinda Gates Foundation, still do not support research connected to climate change and health. Thus, expanding funding for work in this area, and supporting more interdisciplinary efforts, will be important, alongside efforts to enhance coordination and collaboration between research and funding agencies for health, climate, and energy.

Beyond research funding, there is also a need to substantially increase investment made in climate change and health programs and policies. Currently, there is little funding for this intersection: only a small percentage of climate funds support health-related projects and only

a small percentage of health funds support climate-related projects. Gaps in the current research landscape may contribute to the relative lack of funding for climate change and health. Thus, attention should be paid to building a case for climate health investment, and to aligning current investments with need. Efforts to expand funding – across both research and programmatic areas – should also address the constraints posed by funding silos, which inhibit the type of transdisciplinary research and cross-sectoral action required for action on climate change and health.

Proactive engagement in climate policy creation and implementation

The emergent climate and health movement – while calling for a zero-carbon economy – focuses action predominantly within the health sector. Their work includes characterizing climate health vulnerabilities, documenting the health impacts of climate change, educating the health workforce on climate, supporting health care sector decarbonization and resilience efforts, and expanding access to health solutions such as early warning systems and surveillance systems for climate-related diseases.

These endeavors are appropriate, necessary, and important, but in isolation are unlikely to overcome present political barriers to climate action, and risk being overwhelmed without efforts to avert the worst effects of unchecked climate change. Health remains underrepresented and insufficiently engaged in international and national climate policy dialogues (65–67). This is a significant missed opportunity to advance global health equity. It is estimated that achieving the goals of the Paris Agreement will save over one million lives each

year from reductions in air pollution alone (68,69), with significantly larger overall reductions in mortality (70,71). Climate solutions across sectors – including energy, food, agriculture, and transportation – have significant health co-benefits: e.g., those resulting from cleaner air and water (72), active transportation (73), and healthier diets (74–77). The economic savings from the reduced morbidity and mortality associated with climate solutions are estimated to be large (78) and may outweigh the costs of climate action (68).

An internal focus by the health sector may additionally come at the expense of effectively leveraging the power of the health voice to advance the scale and speed of climate policy implementation in other sectors: an implementation required to protect health and to optimize the health benefits of climate action. Climate mitigation and adaptation solutions can deepen or alleviate inequity depending on their design and implementation. Health professionals must engage in the climate policy process to ensure these efforts do not exacerbate inequities, whether in the social determinants of health or in exposure to climate threats. An adequately funded and more expansive global health sciences research agenda rooted in the social determinants of health could provide a foundation for that engagement.

Conclusion

This dissertation highlights the urgency of action on climate change. Failing to implement climate solutions now will create an even more exigent challenge later, with accelerating, irreversible impacts and locked in future harms. The dangers of climate change were well known by the 1970s, while the risks of climate change to health were understood by

the mid-1990s. Our analysis of the fossil fuel industry highlights some of the factors at play in the delay of climate action, while our studies of mental health and women's empowerment highlight the consequence of these decades of delay – that is, profound harm to all aspects of personal, professional, family, communal, and economic wellbeing. These studies are indicative of the deep devastation being experienced around the world: a devastation that will only increase as wildfires, heat waves, droughts, hurricanes, floods and related poverty, conflict, and migration become more severe.

We now live in an era in which every part of our bodies and our lives are harmed by fossil fuel pollution, climate change, and the destabilizing effects of climate events on our health, social, economic, cultural, and political systems. Responding to the intersecting threats of climate change and pervasive social and economic inequity can improve health now and for future generations.

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Supplement 1

The Role of the Fossil Fuel Industry in Shaping the Narrative on Climate Change and Health: A Historical Case Study of the Global Climate Coalition, 1995 – 1998

Figure S1.1. Timeline of Global Climate Coalition Activities 1989 – 2001.

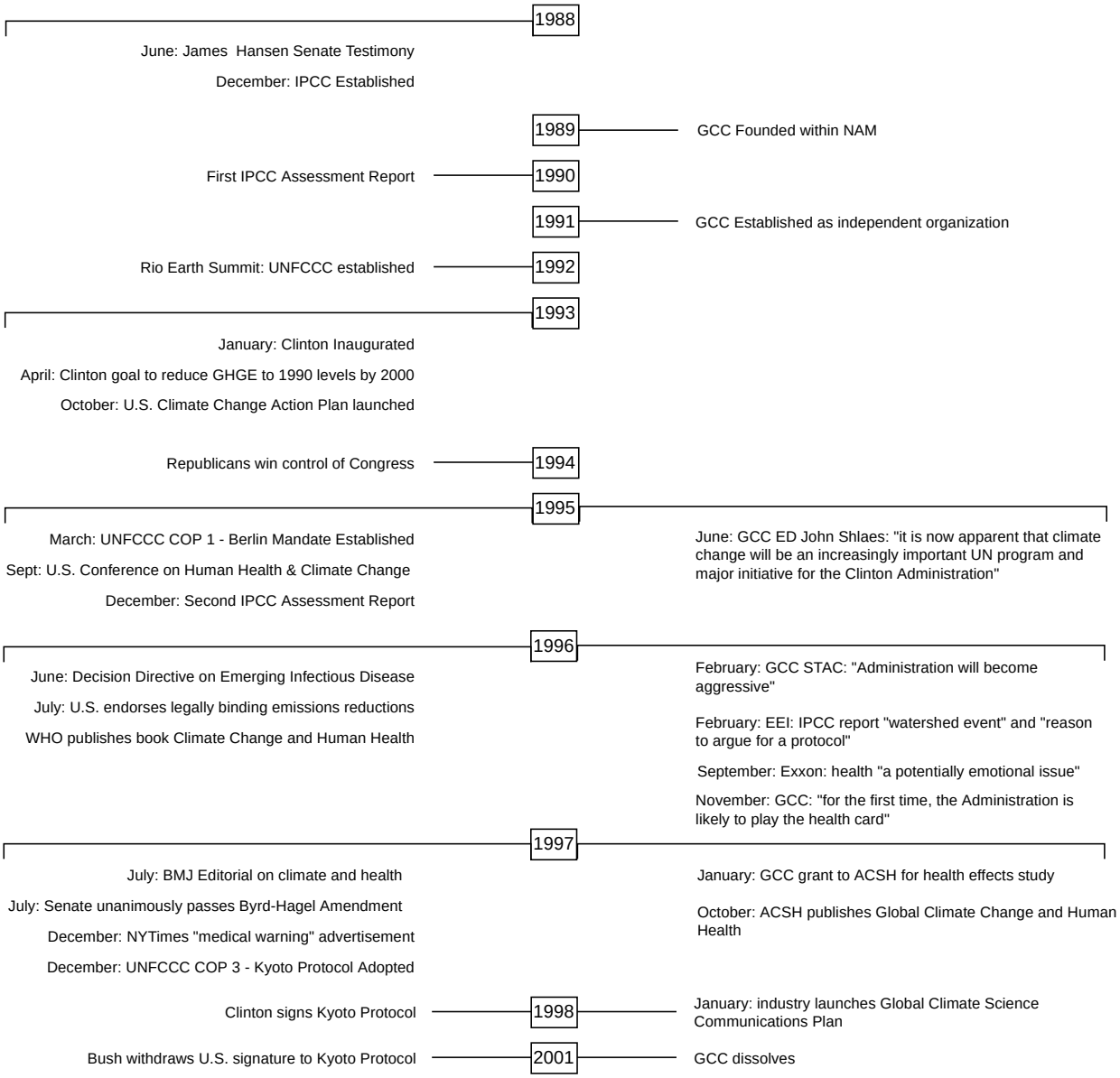

Table S1.1. Global Climate Coalition Membership 1996 – 1998	
Trade Associations	Air Transport Association;[c] Aluminum Association, Inc.;[a] American Automobile Manufacturers Association;[c*] American Forest & Paper Association;[c] American Iron & Steel Institute;[c] American Petroleum Institute;[c*] American Portland Cement Alliance;[c] Association of American Railroads;[c] Association of International Automobile Manufacturers;[a*] Chemical Manufacturers Association;[c*] Council of Industrial Boiler Owners;[c] National Association of Manufacturers;[c] National Lime Association;[c] National Mining Association;[c*] National Rural Electric Cooperative Association;[c*] Process Gas Consumers Group;[c] Rail Progress Institute;[b] Society of the Plastics Industry;[c] Western Fuels Association, Inc.[c*]
Coal, Oil, & Gas Companies	ABB Vetco Gray, Inc.;[b] Amoco Corporation;[c] ARCO (Atlantic Richfield Company);[c] BP America, Inc.;[a] Chevron;[c] Dresser Industries;[b] Drummond Company;[c] Exxon;[c*] Mobil Corporation;[c*] Parker Drilling Company;[b] Santa Fe International Corporation;[b] Shell Oil Company;[a] TECO, Inc.;[b] Texaco, Inc.[c]
Utility Companies	Allegheny Power;[c*] Ameren Services;[b] American Electric Power Service Corporation;[a] Arizona Public Service Company;[a] Cinergy Services;[c*] Consumers Energy;[b] Duke Power;[c*] Edison Electric Institute;[c*] ELCON;[c] Electric Power Research Institute;[*] Illinois Power Company;[c*] Northern Indiana Public Service Company;[c] Ohio Edison Company;[c] Southern Company Services, Inc.;[c*] Union Electric Company;[a*] Virgina Power[b]
Transportation Companies	American Commercial Barge Line Company;[b] Burlington Northern Railroad;[a] Chrysler Corporation;[c*] CONRAIL;[a] CSX Transport;[c] Ford Motor Company;[c] General Motors;[b*] Goodyear Tire and Rubber Company;[c] McDonnell Douglas;[b] Norfolk Southern Corporation;[c] Petroleum Helicopters, Inc.;[b] Union Pacific Railroad[c]
Chemical Companies	Dow Chemical Company;[a] Eastman Chemical;[c] Greencool;[c] Hoechst Celanese Chemical Group;[c] Kaiser Aluminum and Chemical Corporation;[c] Union Carbide Company[c]
Lobbying Organizations	American Farm Bureau Federation;[b] U.S. Chamber of Commerce[c]
Minerals & Mining Companies	Baker Refractories (dolomite lime);[b] BHP Minerals;[c] Cyprus-Amax[b]
Steel Companies	Bethleham Steel;[b] IPSCO Steel Inc.[b]; USX Corporation[b]
Other	Paramount Technical Services[a]

[a] GCC member organizations in 1996 (1)
[b] GCC member organization in 1998 (2)
[c] GCC member organization in both 1996 and 1998
* GCC STAC member. STAC membership is drawn from STAC meeting minutes and attendance lists from STAC meetings held in January 1996 (3), February 1996 (4), September 1996 (5), and January 1997 (6).
Note: Unable to locate a GCC membership list from 1997

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Supplement 2

The Association between Drought and Women's Empowerment: An Analysis of National Survey Data from 24 Countries in Sub-Saharan Africa, 2011 – 2020

Table S2.1. Sample size and year of included DHS surveys

Country	**Year**	**Sample Size**
Angola	2015 - 2016	1,411
Burundi	2016 – 2017	6,419
Democratic Republic of Congo	2013 – 2014	7,375
Cote D'Ivoire	2011 – 2012	3,599
Cameroon	2011	6,027
Cameroon	2018	4,850
Gabon	2012	1,039
Ghana	2014	3,529
Guinea	2012	5,951
Kenya	2014	7,316
Liberia	2013	2,521
Liberia	2019 – 2020	1,881
Lesotho	2014	3,140
Mali	2018	7,543
Malawi	2015 – 2016	13,677
Mozambique	2011	4,613
Namibia	2013	1,366
Rwanda	2014 – 2015	4,027
Rwanda	2019 – 2020	3,986
Sierra Leone	2013	8,759
Sierra Leone	2019	8,168
Chad	2014 – 2015	10,323
Togo	2013 – 2014	4,400
Tanzania	2015 – 2016	5,307
Uganda	2016	5,048
South Africa	2016	1,442
Zambia	2013 – 2014	8,506
Zimbabwe	2015	5,216

Table S2.2 Associations between drought and women's empowerment among married women ages 15 – 49 (n = 147,502)

Outcome	**Unadjusted**	**Adjusted**
Woman has a say in decision-making	0.89** (0.84, 0.94)	0.90*** (0.86, 0.95)
Healthcare decisions	0.90*** (0.85, 0.95)	0.90*** (0.85, 0.95)
Large household purchases	0.86*** (0.81, 0.92)	0.86*** (0.81, 0.91)
Visit family or relatives	1.01 (0.95, 1.08)	1.01 (0.95, 1.08)
Woman disagrees with justifications for wife-beating	0.87*** (0.82, 0.93)	0.86*** (0.81, 0.92)
Burning food, not justified	0.86** (0.79, 0.94)	0.85** (0.78, 0.93)
Arguing with husband, not justified	0.89*** (0.84, 0.95)	0.89*** (0.83, 0.94)
Going out without notifying husband, not justified	0.89** (0.83, 0.95)	0.87*** (0.81, 0.93)
Neglecting the children, not justified	0.85*** (0.8, 0.91)	0.85*** (0.79, 0.90)
Refusing sex with husband, not justified	1.14*** (1.06, 1.22)	1.16*** (1.08, 1.24)

Odds ratios estimated from logistic regression models with 95% confidence intervals. The unadjusted model includes survey-level fixed effects. The adjusted model includes calendar month, wealth quintile, age category, literacy, number of births, household size, rural residence, and employment status. Standard errors are clustered at the EA level. Level of significance: ***p<0.001; **p<0.01; *p<0.05.

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