Commentary

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The future of climate health research

An urgent call for equitable action- and solution-oriented science

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Introduction

Climate change is vastly affecting our world, with significant repercussions on human society.[1] With risks including storms, extreme heat, infrastructure damage, air pollution, disease vectors, human displacement, and social dynamics, climate change is affecting nearly all aspects of our lives and our health—with disparate effects across populations. As these impacts become more acute and frequent with time, urgency is growing for climate and health researchers to engage in action- and solution-oriented research.

The potential public health consequences of climate change have been studied in the scientific community for decades[2]—long before we began seeing the current dramatic climatic effects. As these effects have become more frequent, more severe, and more devastating, climate health research has grown significantly.[3] Most existing research focuses on quantifying exposure-response effects for topics with a wealth of existent data, such as morbidity and mortality due to heat and air pollution, especially in urban-dwelling populations.[3] While these studies are valuable and an important first step toward action, we now also need innovative, solutions-driven science to rigorously test and advance actionable and effective solutions that protect human health. There remain significant gaps in our understanding of how to effectively and equitably combat adverse climate change impacts on human health.

Yet filling these gaps is not easy. Climate change is a multifaceted problem with complex roots and diverse yet intertwined drivers and effects. Climate-related hazardous exposures can include long-term trends as well as episodic occurrences and, importantly, do not occur in isolation. Although the root causes driving climate change (i.e., greenhouse gas emissions) can be regulated, we cannot directly regulate most climate-related hazards and environmental exposures that affect human health (e.g., storms, droughts, temperatures, wildfire smoke, and vectors). Thus, the usual approach of quantifying exposure-response, which works well for informing environmental regulations, is not sufficient for climate health research. We must approach the problem differently and push our science further to inform more comprehensively environmental and health policies and interventions.

Climate change and its health impacts are an unprecedented long-term global challenge. We need to quantify the health effects of climate change adaptation and mitigation strategies; we need to understand how and why different populations experience different magnitudes of effects, including more locally relevant and contextualized science; and we need robust projections of future health risks.[4] Many studies have examined these questions, yet we need to move toward more actionable science and data so as to inform effective equitable solutions that can reduce the health burden of climate change.

We present this commentary—directed at public health researchers and transdisciplinary collaborators—to advocate for adopting an action- and solution-oriented approach to climate health research, meaning it must be designed to directly inform actionable solutions to address health risks conferred by climate change rather than simply making observations. This perspective has been expressed by others, including the National Institutes of Health.[5,6] We lay out a set of specific suggestions, and end by highlighting a couple of lessons from the COVID-19 pandemic—a global event that shares similarities with climate change and illustrates the possibility of timely collaborations and solutions and underscored inequities. Additionally, we cannot allow findings to languish, hoping they will eventually be translated into action. We need to make sure climate health research is directly impactful, locally grounded, or contextualized, and that it reaches the appropriate audiences in a timely manner to implement science into solutions.

Action- and solution-oriented approach to climate health research

We suggest the following four action- and solution-oriented areas of focus, some of which share common elements, for future climate health research. To be clear, these areas are not new or comprehensive but are worthy of new focused intensity. We first present an example study, and then describe the focus area more broadly. We should study:

1. Health co-benefits of existing and new climate change mitigation strategies

A California study provided data demonstrating that adoption of zero-emission vehicles—an important climate change mitigation strategy—is already positively impacting human

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health, despite relatively low average adoption rates to date.[7] Yet communities who have the most to gain due to disproportionate traffic-related air pollution exposure may not be fully benefiting due to low adoption, likely driven by structural and systemic barriers impacting economic and societal opportunities and infrastructure. This type of research quantifying health co-benefits felt in the short term is important not only to inform future climate change mitigation policies (e.g., through cost-benefit analyses) but also to make sure implemented strategies and related health co-benefits do not perpetuate historical disparities.

Climate change mitigation strategies (e.g., decreasing greenhouse gas emissions) remain of paramount importance to reduce climate change and its multiple consequences. Yet we still lack empirical data on the consequent human impacts of many of these strategies. Do climate change mitigation strategies that decrease the rate of global warming also have co-benefits for human health? Are there unintended or inequitable adverse health impacts? (e.g., cobalt mining for electric vehicle batteries.[8]) Data-based evidence is needed to assess whether strategies are functioning as intended and to understand their simultaneous impact on our health. This evidence can guide the prioritization and specificity of strategy implementation.

It is important to understand not only the human health impacts of our response to climate change but also how these impacts are distributed across populations, which often is inequitable.[1] Only with such information can we ensure the policies and strategies to respond to climate change meet the WHO Sustainable Development Goals mandate to "leave no one behind." Because new mitigation strategies are constantly being developed and implemented, we also need to understand how these function together with existing or legacy strategies so that we maximize benefits and minimize harms to different populations, especially those who have been historically marginalized.

2. Health effects of climate change adaptation strategies to optimize benefits in different populations

Greenspaces can offset the adverse health impacts of high heat, especially in urban areas. A recent cross-population study examining 452 locations from 24 countries revealed that cities with overall more greenspace have generally reduced risk of heat-related mortality.[9] The authors then estimated mortality reductions under hypothetical scenarios of increased greenspace, for example, a 9% reduction in all-cause mortality with a 20% increase in greenspace. Such broad-scale studies, combined with a counterfactual approach provide important guidance for adaptation strategies. Especially if they consider more dynamic intervention scenarios, such as targeting high-risk populations rather than considering a one-size-fits-all approach (e.g.,[10]).

To maximize their health benefits adaptation strategies must be suited to the local population because climate change does not similarly affect all populations. To guide such tailored strategies, we need data characterizing the effects of different climate adaptation strategies in different populations. For example, we can leverage natural experiments when governmental agencies or community organizations launch new adaptation policies or interventions, comprehensively gauging for whom they did and did not work, and whether and how to translate those findings to other populations.

Further, the health effects of climate change are not only geographically diverse but also highly influenced by social dynamics and psychological barriers within different populations. Factors such as social norms, access to healthcare and other resources, and mental resilience can all influence how adaptation strategies are received and implemented. Adaptation strategies must be flexible and suited to diverse social, clinical, and biological characteristics. Understanding the psychological barriers that might inhibit adaptation—like misinformation, fatalism, or cognitive dissonance—is key to crafting policies that are not only effective but also culturally and socially sensitive. Similarly, recognizing social dynamics, such as power relations and community structure, can better inform the design and deployment of adaptation measures.

3. Effect heterogeneity by characteristics of the climate hazards and/or exposed populations

An analysis of heterogeneity in the health impacts of historic tropical cyclone data showed that max sustained windspeed was the strongest driver of mortality and respiratory risk from tropical cyclones, providing important information for at-risk communities to translate into approaches to keep residents safe during future events.[11] Such implementable information would be impossible to dissect by simply analyzing all tropical cyclones and the effected populations as homogenous groups of outcomes and people. Analogous modeling approaches could be applied to similarly predict risk, identify vulnerable populations and key risk features for other extreme weather and climate events, and to inform tailored strategies to minimize future risk.

Specific characteristics of the climate hazards themselves or of the local conditions and adaptive capacity, as well as underlying population vulnerabilities, can modify the effects of climate hazards. While some climate health studies have examined the impacts of a climate hazard by sociodemographic characteristics of affected populations, many gaps remain, including how relevant sociodemographic characteristics intersect to personalize risk.[4] We should aim to examine effect heterogeneity when feasible in climate health studies (e.g., statistically possible, mechanistically/biologically reasonable). Understanding the distribution of risks is critical to determine if what we are doing in terms of climate health interventions is appropriate and effective, and to ensure action is equitable.

4. Health effects of co-occurring climate events

Co-occurring climate-related effects especially highlight widening social disparities, as seen with the effects of Texas Winter Storm Uri in 2021. People were experiencing not only the storm itself but also widespread power and water outages. The duration of those outages, however, varied across populations (likely driven by structural and systemic bias, e.g., differential investment in infrastructure), with Black households experiencing significantly longer power outages and water outages compared with non-Hispanic White households.[12] Such data quantify the variance in reliability and resilience of essential infrastructure—whose failure could further exacerbate climate hazards[13]—and are critical to guide policy decisions and strategies to equitably protect human health (e.g., guiding investments for the Justice40 Initiative[14]).

Health-threatening environmental exposures due to climate change do not happen in isolation. For example, extreme heat exposure may occur in tandem with high air pollution due to wildfires or with increased food insecurity due to agricultural impacts, both sets of which can have cumulative effects on the health of exposed individuals.[15] Further, infrastructure damage due to extreme weather events may simultaneously and additively strain a population's health.[16] Climate change is predicted to increase the prevalence and severity of future extreme weather events, further stressing infrastructure and affecting health-relevant factors such as power delivery and road access.[13] Co-occurring events will become more frequent, greatly increasing the health-related impacts of climate change.[17] We must consider these co-exposures and their cumulative effects on exposed populations if we are to develop effective strategies to guard human health.

Moving forward—multifaceted solutions for a multifaceted problem

To adequately address the current gaps in climate health research, we need collaborative, transdisciplinary efforts that engage diverse researchers who together can develop and conduct more actionable and synergistic science across a range of disciplines. Effective strategies to address the health threats of climate change must extend from the lab bench to the park bench—incorporating research ranging from molecules to populations, from epigenomics to housing standards. We must not only focus on mechanistic experimental studies but also on social approaches that consider how individuals, their communities, and decision-makers act.

While global-scale problems demand global-scale solutions, it would be a mistake to overlook the power of listening to local communities and stakeholders to facilitate local action in mitigating the health impacts of climate change. Locally focused research can identify community-specific vulnerabilities and needs, cultural considerations, and available resources that may not be visible through a broader lens. Accordingly, community engagement is critical to ensure focus on the needs of the most vulnerable and at-risk populations. Climate health research must ensure that the frontline knowledge of affected communities is valued and that these communities are partners in co-developing equitable and effective solutions. By using community engagement combined with local data, we can build models of intervention that can be adapted and scaled for broader contexts.

Perhaps most importantly, action-oriented research must be followed by action. To better support evidence-based decision-making now and into the future, we must ensure that appropriate research reaches audiences capable of impacting policies and solutions. This requires effective science communication that targets audiences beyond academic journals, such as affected populations and relevant stakeholders. Only through more widespread dissemination and effective outreach through a variety of communication tools can we achieve a critical mass worldwide to effectively implement strategies to address the looming threat of climate change.

Finally, we want to leave you with two key lessons learned from the COVID-19 pandemic. Despite missed opportunities in the response to the pandemic, its global nature provides parallels to the topic at hand. First, we learned that with enough attention and effort devoted to a topic, we can generate solutions very rapidly (e.g., development of the vaccine[18]). Applying the same urgency and attention to climate health research could lead to effective solutions implemented in a timely manner. Second, the pandemic laid bare the disproportionate impact on historically marginalized populations,[19,20] which—as reviewed above—is also a hallmark of climate change impacts. We can and must apply this lesson as we design climate health studies and implement health-protective solutions to climate change to ensure equity across populations, particularly those who are at the highest risk—who often, especially on a global scale, contributed the least to climate change.

"[With climate change] *the rich will find their world to be more expensive, inconvenient, uncomfortable, disrupted, and colorless—in general, more unpleasant and unpredictable, perhaps greatly so. The poor will die*." –Kirk R. Smith, PhD, MPH (1947–2020).

Conflicts of interest statement

The authors declare that they have no conflicts of interest with regard to the content of this report.

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