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VIEWPOINT

# Climate Change and Health Inequities: A Framework for Action

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## BACKGROUND

Climate change has been identified as the greatest health challenge of the 21st century.[1-4] Recently released reports by the Intergovernmental Panel on Climate Change and the U.S. National Climate Assessment summarize the current effects of climate change on health, projections that these effects will surely increase, and the disproportionate impact of climate change on the health of vulnerable populations and disadvantaged communities.[3,5] Yet the public health sector, to date, has not been highly engaged in work to prevent or prepare for climate change, despite calls to do so on the part of numerous public health leaders and organizations.[6-11]

Surveys of local health officials demonstrate some awareness of the health effects of climate change. However, a lack of leadership and resources, limited expertise and workforce capacity, limited support from state and federal agencies, and competing priorities impede proactive work to prevent or prepare for climate change.[12] Many public health agencies are involved in activities that may contribute to climate change mitigation or adaptation (eg, promoting active transportation to increase physical activity), but the links to climate change are rarely articulated and not always understood.[13] Public health professionals are uncertain how to integrate climate change into specific scopes of work with siloed funding streams and are hesitant to address climate change in the face of what seem like more pressing issues (eg, violence or food insecurity) in disadvantaged communities facing stark health inequities.[14]

Given the complex and multifaceted connections between climate change and health and the recent emphasis in public health practice on health inequities, there is potential value in a framework that delineates the relationships among climate change, health, and health inequities, and opportunities for public health engagement. Conceptual frameworks can increase understanding of highly complex issues by organizing and demonstrating relationships among multiple concepts.[15-17] There are many published frameworks addressing health and the environment, climate change and health, and health inequities and the social determinants of health (SDH).[15,18-31] These were reviewed to assess potential use as a tool for promoting public health engagement in climate change work, noting characteristics such as conceptual clarity, scope, flexibility, balance, and usability.[15] None of the reviewed SDH frameworks include reference to climate change; none of the health and environment frameworks specifically address health inequities. One study incorporated the links between urban health inequities and climate change in a model developed to support a research agenda on urban health inequities in lesser developed nations.[18]

Our framework is intended as an action framework for public health practitioners. We sought to develop a conceptual model to achieve the following:

1. Demonstrate the complex relationships between climate change and health inequities;
2. Explicitly build on prevalent public health practice models that address health inequities;
3. Delineate the many opportunities for interventions to promote health and equity, prevent catastrophic climate change, increase climate resilience, and protect people and communities from the inevitable effects of climate change; and
4. Highlight the importance of collaborative action to address the institutions, social relations, and systems that simultaneously drive both climate change and health inequities.

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## FRAMEWORK DEVELOPMENT

Two conceptually and visually aligned models served as the basis for the framework (Fig. 1). The Public Health Framework for Reducing Health Inequities was developed by the Bay Area Regional Health Inequities Initiative (BARHII) to support the efforts of local health departments to better address health inequities in their ongoing public health practice; it shows a linear trajectory of health outcomes rooted in the SDH and a spectrum of opportunities for intervention from "upstream" policy change to "downstream" medical care.[21] Patz's diagrammatic model of the Potential Health Effects of Climate Variability and Change is congruent with the BARHII framework in its depiction of a linearized pathway for climate change impacts on health.[29]

After integrating the BARHII and Patz et al. models, we added several key concepts and then modified a draft diagram through an iterative process that included in-depth discussions with a convenience sample of key informants drawn from local government (public health and other agencies) in the San Francisco Bay Area and not-for-profit and community-based organizations engaged in health and in climate advocacy. The penultimate version of the diagram was shared for comment with >100 participants at a 2013 convening on Climate Change and Health and then revised. Here we share the conceptual development and resultant Climate Change and Health: A Framework for Action.

In an effort to balance comprehensive description of climate and health processes with visual clarity and highlighting of key processes, the framework diagram does not visually represent every relationship among elements or every contributor to health outcomes or climate change health risks. The distinctions among various interventions are not rigid, and interventions may be applied along various parts of the spectrum in addition to where shown on the framework.

## SOCIAL INEQUITIES, INSTITUTIONAL POWER, SYSTEMS

Figure 2 shows the integration of the basic diagrammatic pathways for health outcomes and health inequities and for the health effects of climate change. The upper (blue) "health processes" line is based on the BARHII framework; the lower (green) "climate processes" line is based on Patz et al. Root causes (far left), and final outcomes (far right) are elements common to both pathways.

A critical component of the framework is the recognition that the upstream causes of poor health, health inequities, environmental degradation, and climate change are fundamentally the same. The root causes of both climate change and health inequities are found in social inequities, powerful institutions, and the systems that they produce. Social inequities refers to the unequal distribution of power, money, and resources.[1,32] Powerful institutions (eg, governments, corporations, school systems, large nongovernmental organizations) make decisions with broad impact on social inequities, the physical environment, and access to health-promoting resources and opportunities; these decisions often are influenced by and reinforce prevailing notions of race, class, and sex. For example, racism contributed to discriminatory mortgage lending and housing deed restriction practices that led to the racial segregation of neighborhoods across America and related loss of resources, whereas federal transportation funding fostered suburban sprawl that furthered segregation and increased vehicle miles traveled.[33,34] Institutions and social inequities thus interact dynamically in the design and operation of the systems that organize the large-scale provision of basic needs and largely determine living conditions, human effects on the environment and the climate, and health outcomes.[35] For example:

- Transportation systems determine mobility, effect physical activity, traffic injuries, and access to jobs and services, produce air pollution and loss of farmland and habitat, and contribute significantly to greenhouse gas emissions.[36,37]
- Agriculture and food systems determine food and nutrition access, effect water usage and quality; lead to soil depletion, deforestation, and biodiversity loss; breed antibiotic resistance; generate greenhouse gas (GHG) emissions (GHGEs) from livestock (methane); and spur the use of fossil fuels in production and transport of food products.[37,38]
- Energy systems provide for heating, lighting, and cooking, and result in significant household and ambient air pollution, occupational illness and injury, and the release of GHGs, including carbon dioxide and black carbon.[39]
- Economic systems distribute wealth and allocate resources, foster wealth inequities and differential access to resources, offer access to livelihoods and employment, and determine the valuation of non-marketable health and environmental resources.[40]

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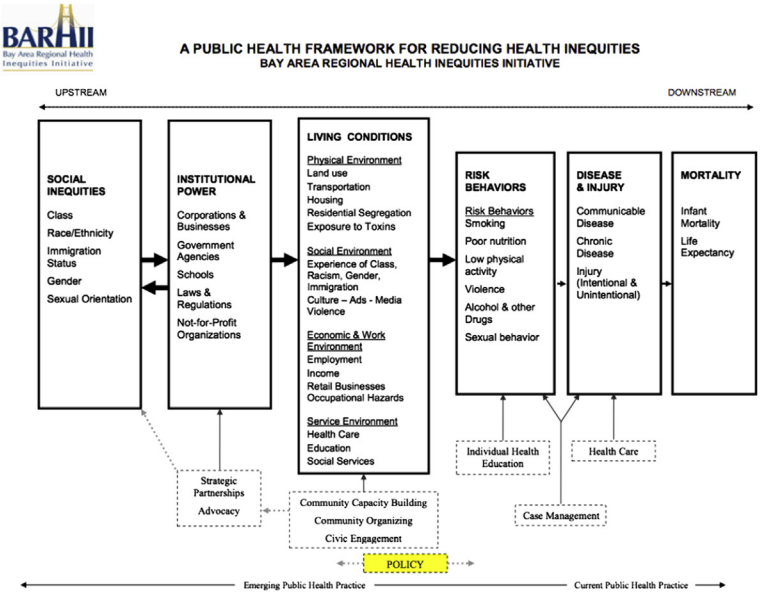


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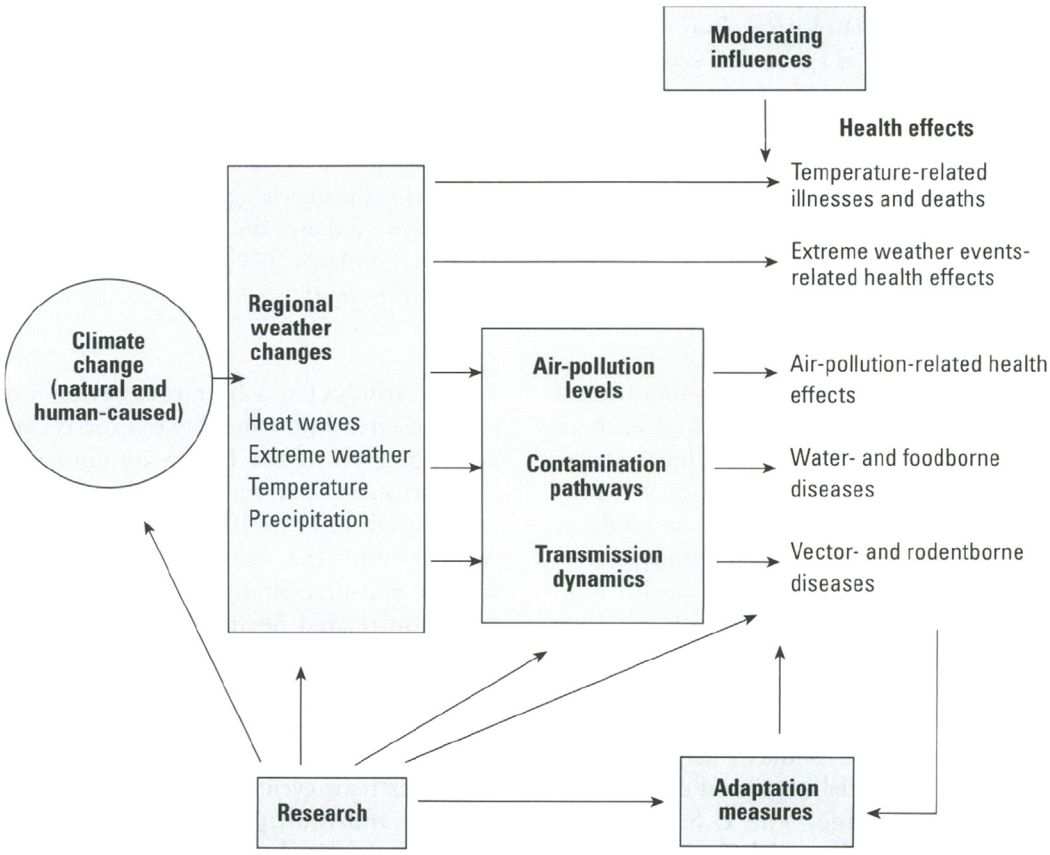


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**Figure 1. Frameworks for health inequities and climate change and health.** Reprinted with permission from BARHII and EHP.[21]

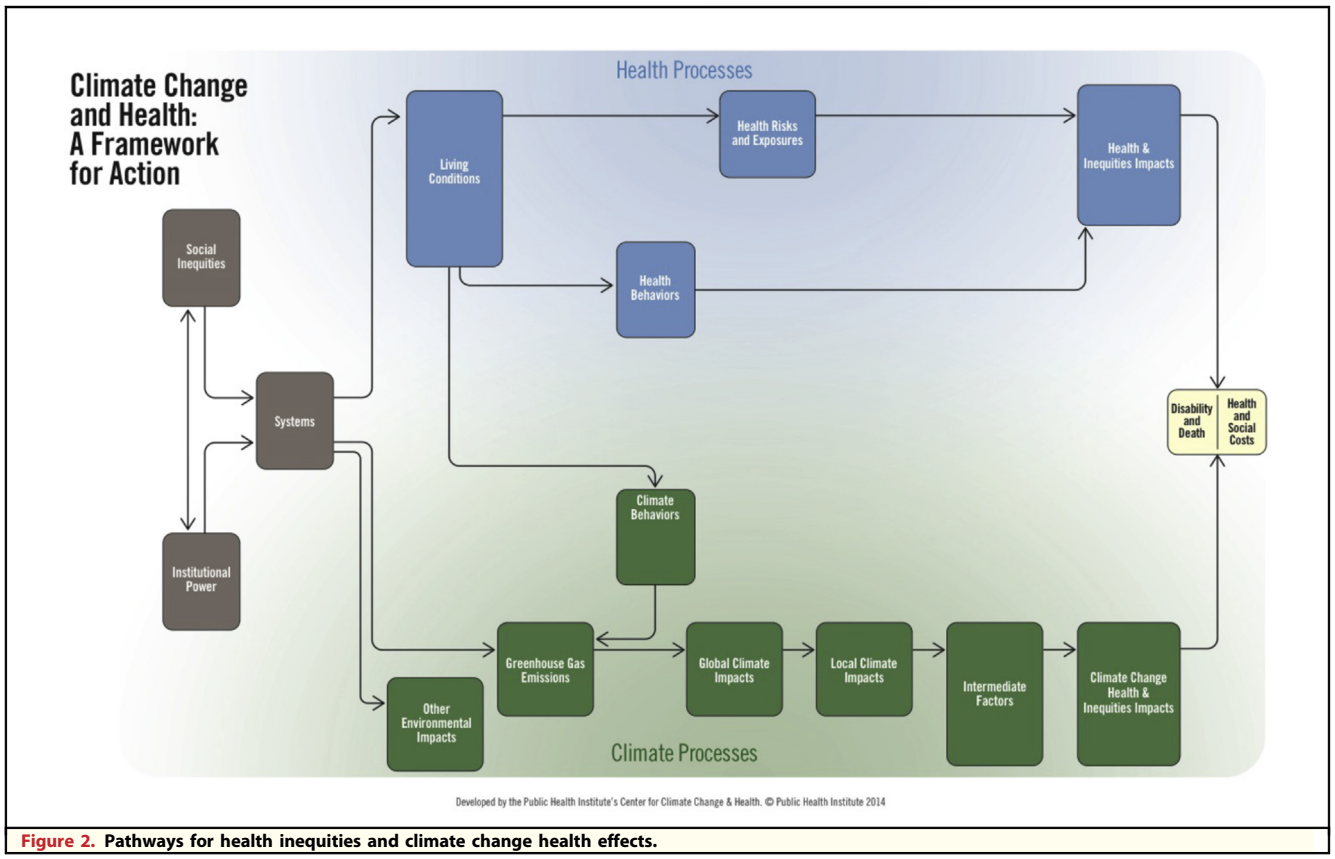


**Figure 2.** **Pathways for health inequities and climate change health effects.**

## HEALTH PROCESSES

**Living Conditions.** Daily living conditions are comprised of the social, physical, economic, and service environments in which people live, work, learn, and play; these environments are largely shaped by systems as described previously and have been well described elsewhere.[32] Inequalities in the conditions of daily life and related access to health resources and opportunities—whether due to place or to social inequities—are key contributors to health inequities.[31,32] These living conditions, along with social inequities, institutional power, and systems described earlier, comprise the SDH.[31,41]

**Health Risks and Exposures, Health Behaviors.** Living conditions engender exposures to health risks and access to health resources (eg, air pollution near freeways; violence near liquor stores; healthy, affordable food choices).[32] Living conditions also shape health behaviors (eg, parks enable physical activity and foster social connections, safe bicycle infrastructure facilitates bike commuting, advertising increases tobacco use).[32]

**Health and Inequities Effects, Disability and Death, and Health and Social Costs.** Living conditions, health risks and exposures, and health behaviors together are the greatest contributors to adverse health outcomes, which in turn may lead to disability, death, and associated health and social costs.[42,43] Social inequities associated with chronic illness and injury account for a large proportion of inequities in life expectancy.[31,44]

**Other Environmental Effects.** The same dynamics that lead to unhealthy living conditions and climate change also produce many other serious environmental effects and potential ecosystems collapse; these include air pollution, drinking water contamination, deforestation, fisheries depletion and collapse, soil degradation and topsoil loss, dead zones in the ocean, wetlands destruction, biodiversity loss, and other environmental problems.[45] These environmental effects pose independent threats to health (not delineated in the framework) and may exacerbate or be exacerbated by the effects of climate change on health and health inequities. For example, drought-related water volume reductions in surface and ground water can increase contaminant

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concentrations; ocean warming and acidification affect fisheries already effected by overfishing and pollution.[45] Feedback loops enhance the effects of deforestation, wildfire, drought, and climate change.[46] The cumulative effects of climate change and ecosystems collapse exacerbate health effects and threaten our long-term survival capacity.[45]

## CLIMATE PROCESSES

**Greenhouse Gas Emissions.** Many natural and human influences shape the earth's climate; since the beginning of the industrial era, the most significant cause of climate change has been human activity that releases GHGs into the atmosphere.[47,48] The most important GHGs are carbon dioxide from the burning of fossil fuels (coal, gas, and oil), methane from livestock production and fossil fuel extraction, nitrous oxide from agricultural activities, and black carbon from household cook stoves in low-income nations.[47,48]

**Climate Behaviors.** Individual behaviors also affect GHGEs: Higher vehicle miles traveled per capita increase transportation GHGE, meat consumption contributes to livestock methane emissions, consumption choices effect energy use and industrial GHGE, and waste affects landfill GHGEs.[49-51] These behaviors are shaped by systems and living conditions: Fuel prices, pedestrian and bicycle safety, and access to public transit influence driving behavior; corn and soy subsidies reduce meat prices and increase meat consumption.[52,53]

**Global and Local Climate Effects.** GHGs trap heat and increase atmospheric and ocean temperatures. Global warming results in changes in precipitation patterns, snow pack loss, and glacial melt and ocean expansion that contribute to sea level rise; carbon dioxide accumulation in the ocean also causes ocean acidification.[3,54] Resultant changes in local weather include more frequent and intense extreme heat events, flooding, drought, and wildfires.[3,54] Geographic location (not shown on framework) also determines local climate effects and exposures (eg, people living in low-lying coastal regions are more vulnerable to sea level rise or saline intrusion into groundwater aquifers).[55,56]

**Intermediate Factors.** Climate and weather changes induce a wide variety of environmental changes. For example, higher atmospheric temperatures increase ground-level ozone production; temperature and rainfall changes alter the distribution of disease-carrying vectors such as ticks and mosquitos; drought and extreme heat and precipitation events contribute to declines in crop yields.[57-61] These changes also lead to sociopolitical economic changes, such as increases in food and water prices; job loss; and conflict over water, land, or food.[37]

**Climate Change Health and Inequities Effects, Disability and Death, and Health and Social Costs.** Climate change threatens critical systems on which human life depends: air, water, food, shelter, and security.[3,54] Respiratory and cardiovascular disease risk increases as a result of increased ground-level ozone and smoke from wildfires.[58,62] Reduced crop yields, in concert with food distribution and pricing systems, increase food insecurity and risk for chronic illnesses such as obesity and diabetes.[38,50] Climate change poses serious threats to the quality and availability of drinking water.[54] Climate change threatens to displace millions of climate refugees whose homes and land will no longer be habitable; violence and displacement associated with civil strife and conflict are likely to increase with tensions over land and resources.[1] All of these climate effects have implications for mental health.[28]

The direct health effects of climate change are due primarily to heat-related morbidity and mortality, and injuries and fatalities associated with other extreme weather events such as flooding, severe storms, or wildfires.[2] Indirect health effects of climate change may be mediated through natural or social systems.[2] Increases in food and water-borne diseases are associated with higher levels of microbial contamination due to warmer water and ambient temperature; dust associated with drought carries infectious agents such as Valley Fever.[63,64] Climate-related changes in vector distribution are associated with changes in diseases such as West Nile Virus or malaria.[59] Increases in the length of pollen season and pollen counts affect asthma and allergies.[65]

**Climate health inequities.** The health effects of climate change disproportionately impact people with chronic illness and low-income and disadvantaged individuals and communities.[3,54,66] Climate change health effects exacerbate and are exacerbated by existing health and social inequities, as described in the section on climate change vulnerability.

**Climate Health and Social Costs.** The health, social, and economic costs of climate change are likely to be enormous.[67,68] One study estimated the health costs of just 6 climate-related events to be about $14 billion.[69] Drought, extreme weather events, loss of coastal infrastructure, and adaptation will cost many billions of dollars, with knock-on effects on funding for health and social needs.[70] Climate change acts

as a "threat multiplier," exacerbating poverty, urban migration, and conflict.

## INDIVIDUAL AND COMMUNITY CLIMATE CHANGE VULNERABILITY AND RESILIENCE

Figure 3 depicts the key concepts of climate change vulnerability and resilience. The International Panel on Climate Change defines vulnerability as "the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change."[54] Vulnerability is a function of interactions among the nature of an adverse event, risk for exposure, an individual's health and functional limitations, community characteristics, and the SDH.[54]

A key component of individual vulnerability to the health effects of climate change is prior health status.[54] For example, people with cardiovascular disease are at greater risk for heat illness; those with asthma are at greater risk from wildfire smoke and increased pollen and ozone levels; and individuals who need medications are more vulnerable to disrupted medical care in a natural disaster.[66]

The SDH are key contributors to community vulnerability: The risk for heat illness is greater in farmworkers and for those living in urban heat islands lacking tree canopy; living in neighborhoods with high ambient pollution levels increases vulnerability to tropospheric ozone increases; inadequate access to transportation impedes evacuation during a hurricane; drought can increase the concentration of contaminants in drinking water; and poverty reduces the capacity to absorb rising food or energy prices.[3,68] The disproportionate effects of climate change on the poor, people of color, indigenous peoples, and people with pre-existing chronic illness threaten to greatly exacerbate existing health and social inequities, globally and within the United States.[66]

Climate change resilience—essentially the inverse of vulnerability—is "the capacity of an individual, community, or institution to dynamically and effectively respond to shifting climate impact circumstances while continuing to function and prosper … the ability to survive, recover from, and even thrive in changing climatic conditions."[71] Core components of community resilience include physical and psychological health, social, and economic equity and

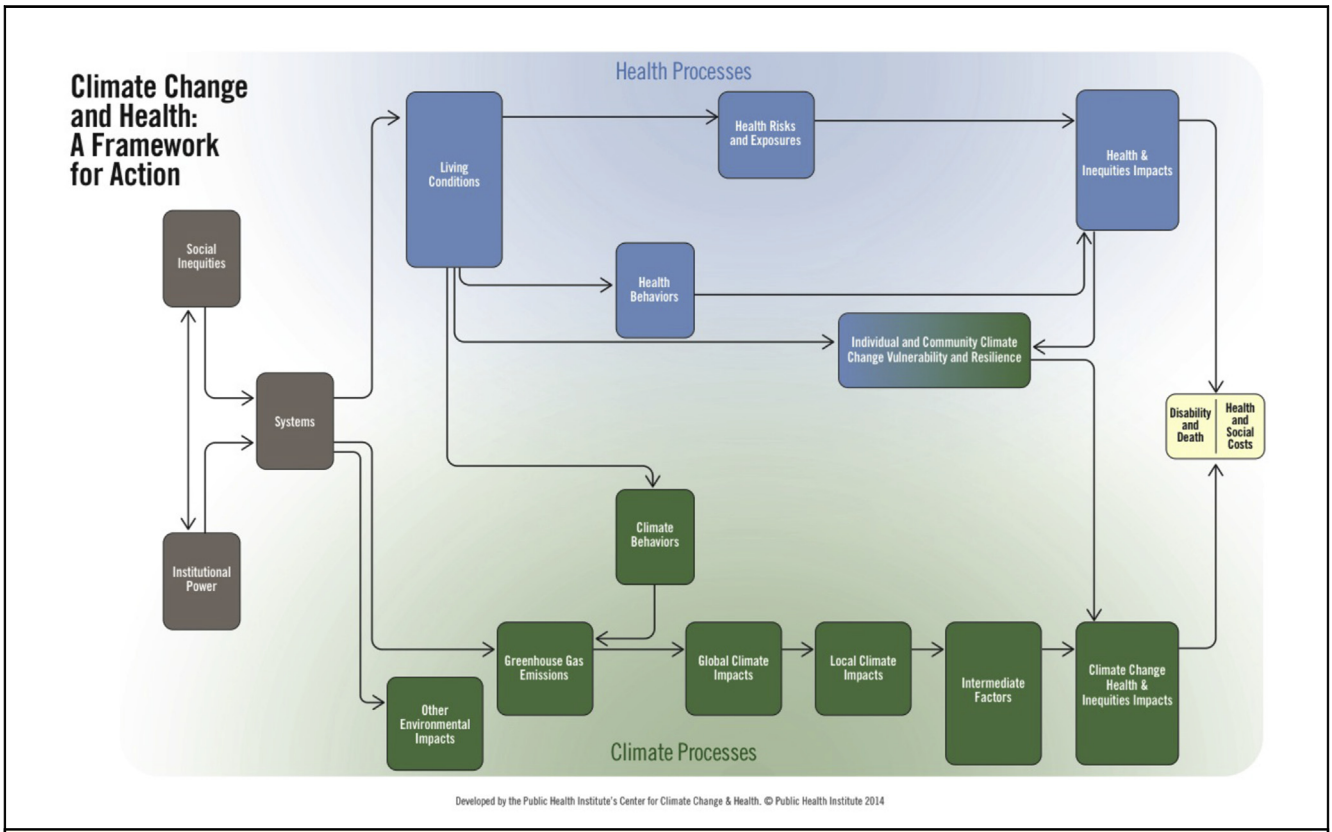


**Figure 3. Climate change vulnerability and resilience.**

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well-being; information and effective risk communication; and integration of governmental and nongovernmental organizations and social capital and connectedness.[71] Characteristics of vulnerability and resilience coexist, in individuals and communities; it is the intersection of these characteristics, risk exposures, and resources that will determine the extent to which climate change affects health and well-being.[54]

## HEALTH AND CLIMATE CHANGE INTERVENTIONS

A wide spectrum of interventions is available to prevent illness and injury and related disability and cost effects; similarly, a wide spectrum of interventions is available to reduce the magnitude of climate change and its effects (see Fig. 4).[20,37]

**Core Intervention Strategies.** A core set of intervention strategies—shown in the oval on the far left of Figure 4—are required to address the social determinants of health and health inequities and to build the economic and political power that will be needed to support the transformative systems changes needed to prevent catastrophic climate change.[31] These core strategies include the following:

- Community capacity building to increase the ability of community residents to analyze and address problems using their own and external resources and to strengthen social cohesion.[72]
- Community engagement processes that work "collaboratively with and through groups of people" to address issues of concern to them with varying degrees of community decision making and control.[72]
- Partnerships and collaboration across sectors and organizations to work toward mutual benefit and goals.[72]
- Advocacy to influence the public and decision makers to change policies, practices, and systems, often in contested areas involving powerful interests.[73]
- Communications to inform individual decisions and social marketing, that incorporates marketing principles and considers product, place, price, promotion, and policy in efforts to influence behavior and practice.[74]
- Surveillance, evaluation, and research that use data to inform, prioritize, develop, assess and improve health and climate change interventions.[75]

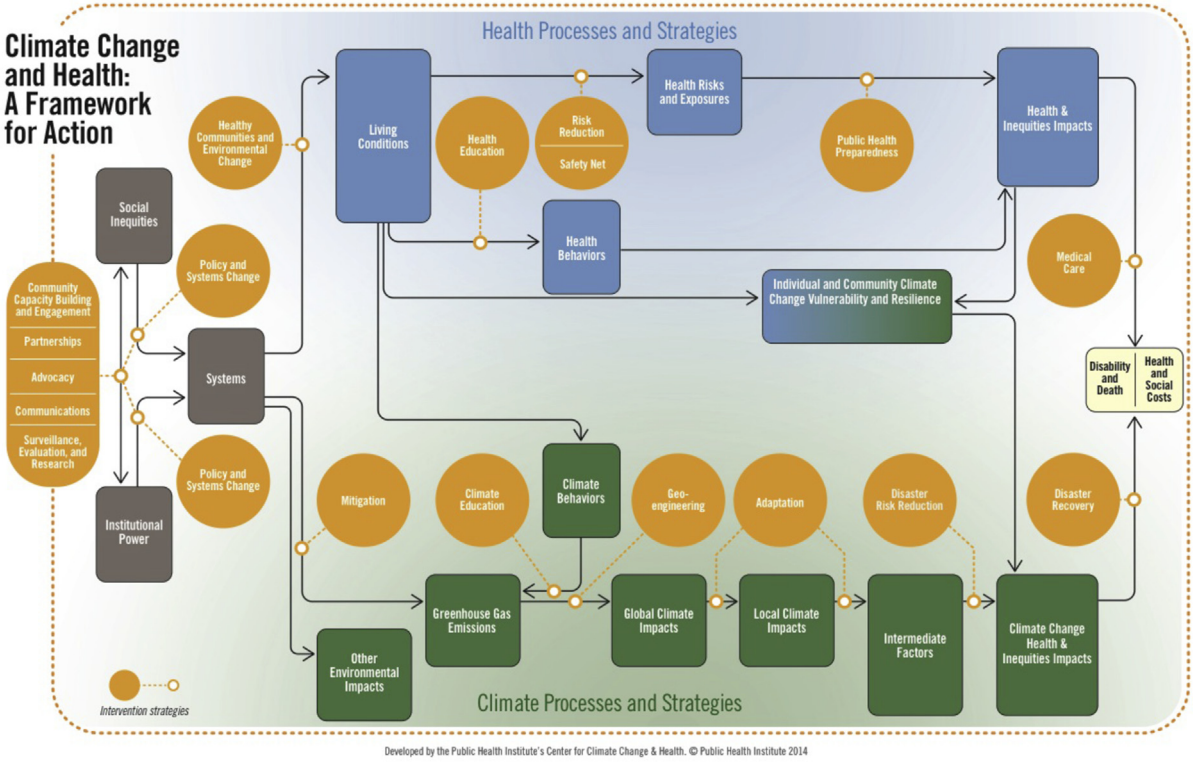


**Figure 4. Interventions for health inequities and climate change.**

The dotted line encircling the framework indicates that these strategies may also increase the effectiveness of interventions across the spectrum of both health and climate interventions; for example, community engagement enhances health behavior interventions and is necessary for effective climate adaptation.

Health intervention strategies include the following:

- Policy and system change strategies to change laws, rules, funding, and processes to affect the operation of systems and institutions to promote health (eg, healthy nutrition standards for schools, vehicle speed limits, or taxes on unhealthy products).[76]
- Healthy communities and environmental change strategies to create healthier communities through improving living conditions. These changes are often facilitated by policy and systems change but require implementation at a local level (eg, "complete streets," farmers' markets and community gardens, or joint use of school playgrounds).[77]
- Health education, which includes "any combination of learning experiences designed to help individuals and communities improve their health, by increasing their knowledge or influencing their attitudes."[78]
- Risk-reduction strategies that reduce exposures to hazards (eg, mold or lead remediation in homes, airbags, or high-efficiency filters to improve indoor air quality).[79]
- Safety net services that provide access to critical services (eg, health care, supplemental food assistance, low-income energy assistance).
- Medical care that provides treatment and support for individuals to reduce progression or effects of illness and injury on function and well-being.
- Public health preparedness that improves the readiness of communities and the public health system to respond quickly and effectively to public health emergencies (eg, infectious disease outbreaks) and natural or human-caused disasters through early detection, planning, and capacity building (eg, health risk assessment, community response teams, medical surge capacity).[80]

Climate change intervention strategies include:

- Policy and systems change through incentives, funding, and requirements to reduce GHGEs and transition to less carbon-intensive systems (eg, carbon tax, cap and trade, renewable energy subsidies, renewable portfolio and energy efficiency standards), and to improve adaptive capacity and resilience (eg, zoning ordinances to limit building in flood plains, energy efficiency standards).[37,54]
- Climate change mitigation strategies that slow climate change and reduce the long-term magnitude of climate change effects by reducing GHGEs or increasing carbon sinks (eg, energy efficiency and the use of renewable energy sources, and the preservation and expansion of forested areas).[37]
- Climate education that provides information through multiple forums to increase individual and community knowledge about the science of climate change, its effects, and strategies to address it and to influence attitudes about climate change action.[81]
- Geo-engineering, which is "the deliberate large-scale intervention in the Earth's natural systems to counteract climate change" through removal of carbon dioxide from the atmosphere (eg, seeding of the ocean with iron filings) or solar radiation management (eg, dispersal of sulfur dioxide particles in the atmosphere, giant mirrors to reflect radiation).[82]
- Adaptation, which is an "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities"[54] (eg, planting crops that are more drought or salt resistant, restoration of wetlands to reduce coastal flooding).
- Disaster risk reduction seeks to reduce harm and damage from climate change by reducing exposure to hazards, increasing resilience, and improving warning and response capacity (eg, setting up public cooling zones during heat waves, weather warnings).[83]
- Disaster recovery includes the steps taken following a disaster to rebuild infrastructure, restore services and resources, regain economic stability, and meet the housing and other needs of displaced persons (eg, response, cleanup, relocation).[84]

## HEALTH COBENEFITS OF CLIMATE CHANGE ACTIONS

Finally, we add the critical concept of cobenefits to the center of the framework (see Fig. 5). Every action to address climate change can potentially affect health for better or for worse. Health cobenefits are the health benefits associated with actions to address climate change, independent of the intended climate effects of those actions.

Climate change action strategies with health cobenefits provide opportunities to simultaneously reduce the risks and effects of climate change and improve the public's health. Some examples include the following:

- Reducing transportation GHGE by shifting to active transportation (walking, biking, and using public transit) can provide considerable additional health benefits through increasing physical activity, including reductions in cardiovascular disease, diabetes, osteoporosis, depression, and some cancers.[85,86]

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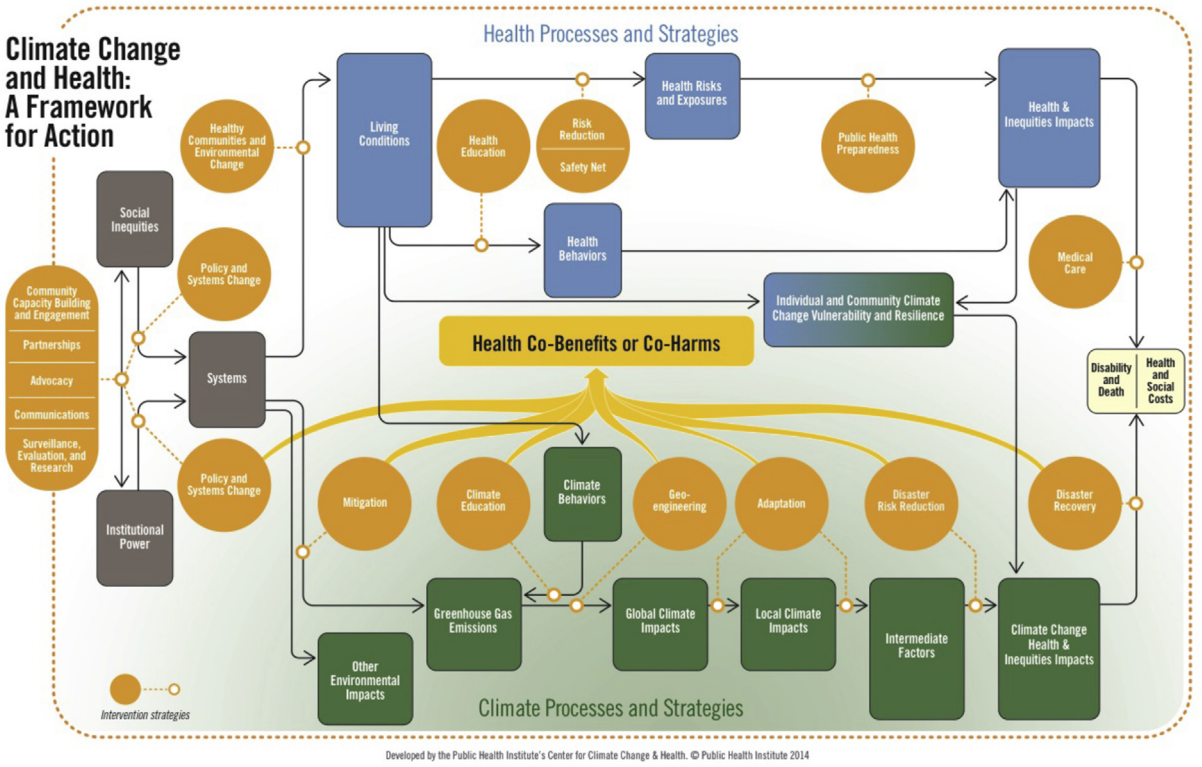


**Figure 5.** **Climate change and health: A framework for action.**

- Low-carbon fuels and vehicle fuel efficiency standards reduce transportation GHGE and disease-causing air pollution from vehicle emissions, such as particulate matter and nitrous oxide.[87,88]
- Switching to clean energy sources yields significant reductions in ambient and household air pollution, with concomitant reductions in respiratory and cardiovascular disease and childhood mortality.[89]
- Reducing meat consumption would have significant benefits for health and the environment, while also reducing GHGEs.[90,91]
- Increasing tree canopy, urban greening, and green infrastructure yield significant benefits on many fronts—reduced air pollution, ground water filtration and replenishment, reduced flood risk, lower energy expenditures, green spaces for physical activity and food production, reduced urban heat islands, decreased crime rates and violence, and sequestration of carbon dioxide.[92,93]
- Some preparedness programs have explicitly incorporated strengthening of community social networks with ancillary mental and other health benefits, and disaster recovery and rebuilding has fostered community engagement in efforts to reduce health inequities and racial segregation.[94]
- Revenues from policies that place a price on carbon can be used to invest in disadvantaged communities to foster community economic development and climate resilience and to improve living conditions to promote health and reduce health inequities.[95,96]

A few climate strategies have potentially adverse consequences on health (called coharms) or may exacerbate health inequities. For example, production of biofuels from food crops may increase food prices or increase pressures on indigenous populations' access to land and water resources. Geoengineering is associated with substantial risks; for example, injecting sulfur dioxide into the earth's atmosphere to produce global cooling could alter global rainfall patterns, with significant food production effects. Carbon cap-and-trade could perpetuate exposure of fence-line communities to stationary air pollution sources. Increased groundwater withdrawal as an adaptation to drought may lead to increased saline incursion into groundwater aquifers.[88,97-102]

## DISCUSSION

Climate change has direct effects on human health and well-being: It exacerbates our existing health

challenges and health inequities; disproportionately effects vulnerable populations and disadvantaged communities; and threatens the air, water, food, shelter, and security on which human survival depends.

Climate Change and Health: A Framework for Action highlights critical intersections among the social determinants of health, health inequities, and climate change and its health effects.

1. Population health outcomes, health inequities, climate change health effects, and the disproportionate impacts of climate change on disadvantaged communities all derive from a complex set of interactions among powerful institutions, social inequities, systems, health processes, community, and climate processes.
2. The root causes of poor health outcomes and inequities (the social determinants of health), climate change, and other adverse environmental effects are largely the same.
3. The effects of climate change on health and health inequities are moderated by individual and community vulnerability and resilience. Interventions that improve the social determinants of health and population health and reduce health inequities can significantly reduce vulnerability and increase resilience to climate change at the individual and community levels. Increasing resilience to climate change will require investing significantly in the public sphere, including in SDH and in public health infrastructure.
4. There is a broad spectrum of opportunities for public health intervention to prevent adverse health outcomes and catastrophic climate disruption and to slow and prepare for climate change.
5. Acting on the root causes of climate change and health inequities will bring about the most significant benefits for human health and the environment. There are opportunities to improve health and reduce the effects of climate change across a wide spectrum of public health and climate change interventions.
6. Many climate actions bring significant health cobenefits, but some may have significant adverse health consequence and/or increase health inequities. Some health interventions also have climate cobenefits.

Climate change is the greatest health challenge of this century. There are many opportunities to improve health outcomes and reduce health inequities and harms from climate change. Actions that address the root causes of both climate change and health inequities are paramount to achieve the magnitude of systemic transformation necessary to avert both climate and public health crises. Integrating and prioritizing health and health equity in climate action planning is a critical strategy to ensure that the challenges of climate change, health, and inequities are addressed in concert. Consideration of the health and equity effects of various climate change interventions is required to optimize health cobenefits and minimize coharms on health, particularly for vulnerable populations.

There is an urgent need for robust and transformative action to reduce GHGEs and to avert catastrophic climate change and its impacts on health and the planet. Health professionals and health organizations have a critical role to play in addressing climate change, in collaboration with those in many other sectors. It is our professional and moral responsibility to take decisive, aggressive, and immediate action to address climate change. Failure to act now will consign people around the world to ever-worse health impacts of climate change and diminished capacity of the health sector to respond effectively to protect health.

Climate Change and Health: A Framework for Action provides a conceptual framework that depicts the complex interrelationships among climate change, health, and equity, and the many opportunities for greater public health engagement in this critical issue.

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