



Effect of Climate Change on Public Health: A Review

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Introduction

There is general agreement among scientists that there is a change in the global climate, as evidenced by rising surface temperatures, melting ice and snow, rising sea levels, and increased climatic variability. The effects of these changes on human health are anticipated to be significant. For many of these effects, there are well-established, efficient public health remedies, but the magnitude, speed, and complexity of climate change are unprecedented. We suggest a public health strategy for combating climate change that is based on fundamental public health services, encompasses clinical and population health services, and places a strong emphasis on collaboration among federal, state, and local governments, academia, the business community, and nongovernmental organizations.

Since Hippocrates' day, weather and climate have been recognised to have an impact on human health.

Hyperthermia is brought on by heat, hypothermia is brought on by cold, and famine results from droughts. Floods, hurricanes, tornadoes, and forest fires all cause injuries, evictions, and fatalities. The term "tropical diseases" refers to an entire class of illnesses; weather and environment have an impact on the prevalence and danger of numerous vector-borne illnesses like malaria, Rift Valley fever, plague, and dengue fever. The danger of developing infectious illnesses including the hantavirus, the Ebola hemorrhagic fever, and the West Nile virus is also influenced by the weather. The relationship between weather and mortality from cardiovascular and respiratory diseases is well-established but less obvious.

Since ancient times, the global climate has been mostly steady, with a strong temperate central tendency and a practically constant quantity of carbon dioxide in the atmosphere (CO₂).

But levels have been stagnant for almost a century, growing levels of CO₂, methane, and other greenhouse gases, a pattern linked to modifications in the climate and other earth systems. For instance, the average global temperature has risen by around 0.6°C since 1860, rainfall patterns have altered significantly in many places, and sea levels have risen. Despite the fact that the science on this issue is not certain, there is evidence that severe storms are becoming more frequent. Since CO₂ emissions are still rising globally and CO₂ stays in the atmosphere for around 100 years, the climate will likely continue to change for the foreseeable future. According to models, the global mean temperature would climb by 1.8 to 4.0°C by 2100, sea levels will rise by 0.18 to 0.59 m, and there will be a major increase in weather unpredictability.

There has been a thorough examination of the possible health implications of climate change. The main issues are heat-related illnesses and injuries, infectious diseases linked to altered vector biology, tainted water, and food, allergic symptoms linked to elevated allergen production, respiratory and cardiovascular diseases linked to worsening air pollution, and nutritional shortages linked to altered food production. Concerns about mental health, population shift, and civil war are examples of indirect issues for which there is less evidence to support estimates and more uncertainty. The composition and functioning of ecosystems can be altered by changes in the patterns of pests, parasites, and diseases that affect animals, cattle, crops, forests, and coastal marine creatures. These changes in these life-support systems have an impact on human health. As climate change intensifies, the burden of these conditions is anticipated to rise in the United States.

There is proof that the health of people has already been impacted by climate change. According to estimates from the World Health Organization (WHO), the number of extra fatalities caused by sickness worldwide in 2000 exceeded 150 000. The increasing frequency of hurricanes like Hurricane Katrina implies that climate change has already had an impact on public health in the United States, even though specific weather events cannot be linked to it. Planners and experts in public health at the state and municipal levels, legislators, and the general public must all take health into account as a key aspect of climate change and act accordingly.

Public Health Perspectives on Climate Change

On both practical and ethical reasons, scientists, doctors, and public health experts have urged attention to climate change. Several firmly established principles support a forceful, proactive public health response to climate change.

The idea of prevention is one such one. Clinical examples of primary prevention include vaccination, efforts to quit smoking, and the usage of bicycle helmets. Primary prevention tries to stop the development of harm or illness. Clinical examples of secondary prevention include screening for

hypertension, hyperlipidemia, and breast cancer. Secondary prevention tries to identify illness early to control its progression and lessen the resultant health burden. After a disease has been identified, tertiary prevention attempts to lessen morbidity, avert complications, and restore function.

The method used to combat climate change has obvious similarities. Primary mitigation, which involves lowering greenhouse gas emissions, aims to halt, moderate, or reverse climate change. Secondary and tertiary prevention equates to adaptation, which entails making preparations in advance of the effects of climate change in order to lessen the burden on public health that results from them. Mitigation efforts will primarily be made in industries other than health, such as energy, transportation, and architecture (although the health sciences can contribute useful information regarding the choice of safe, healthful technologies). On the other hand, adaptation initiatives closely resemble traditional medical and public health procedures.

Public health preparedness refers to this collection of procedures. In recent years, public health preparations have taken centre stage. Health professionals are required to research, anticipate, and get ready for such occurrences due to the threat of terrorist attacks, especially since September 11, 2001; the emergence of new infectious diseases and the reemergence of old ones; the possibility of pandemics like avian influenza; and the occurrence of natural disasters like earthquakes and hurricanes. This strategy is aligned with public health readiness for the projected consequences of climate change.

The presence of scientific ambiguity frequently results in preparedness. Even though it is impossible to forecast some events like hurricanes, terrorist attacks, or influenza pandemics, safeguarding public health is still vital. Specific climate change outcomes are uncertain, especially indirect and derivative outcomes like population displacement. The precautionary principle, as stated at the 1998 Wingspread Conference, states that "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically." The use of "margins of safety" to assure safer circumstances and the idea that actions to safeguard the public from the hazards of climate change cannot wait for complete scientific certainty, however, are compatible with current public health practice.

The US Environmental Protection Agency mandates that businesses that manufacture, use, or store hazardous chemicals analyze their processes (including considering worst-case scenarios), identify vulnerable steps, develop strategies to reduce the risk of chemical releases or other mishaps, and then implement those strategies.⁵¹ In a similar vein, the hazard analysis and critical control points (HACCP) framework mandates They can offer information to help decision-making and, in certain situations, advocate specific steps to safeguard the public health using approaches such health impact assessment^{53, 54}.

Benefits offer another crucial foundation for public health climate change action. Climate change mitigation measures typically have additional, indirect health advantages. For instance, lowering greenhouse gas emissions from power plants can also improve local air quality, which has direct advantages for respiratory and cardiovascular health.^{55–57} Additionally, lowering vehicle miles travelled by promoting walking, bicycling, and transit use not only reduces motor vehicle contributions to climate change but also encourages physical activity, a key strategy for combating the obesity epidemic.^{58,59} Finally, steps that lessen social isolation not only enhance overall health but also have positive effects on the health of the individual.

Economic factors are very important when planning for public health. Climate change is a major consideration in the obligation to maximise health protection at the least expensive short- and long-term costs. The Stern Review on the Economics of Climate Change, published by the United Kingdom Government Economic Service in 2006, predicted that early mitigation and adaptation efforts would be much less expensive than later ones and that climate change would incur enormous costs, including medical expenses. In fact, taking prompt action to address the health effects of climate change makes sound economic sense⁴³. The costs of waiting may actually be far higher than the benefits.

Finally, ethical considerations direct public health efforts to address climate change. Medical ethics are typically based on four principles: autonomy, beneficence, nonmaleficence, and justice. Addressing climate change embodies beneficence because it safeguards current and future generations, and nonmaleficence because it prevents harms (including far-off "downstream" harms) that result from climate change. The disparities that define the effects of climate change and our capacity to deal with them give rise to justice considerations.^{67,68}

Three traditions that provide justification for combating climate change, utilitarianism, liberalism, and communitarianism⁶⁹, are reflected in public health ethics. Utilitarians would observe that if the health effects of climate change are reduced, the overall level of human well-being—especially when future generations are taken into account—will probably rise. Following Kant, liberal thinkers would assert a right to a healthy environment and, as a result, advocate laws and procedures that stop environmental deterioration. According to communitarians, climate change threatens the prerequisites for a stable social order. Public health should focus primarily on the fundamental causes of disease and requirements for health, aiming to prevent adverse health outcomes, according to the principles of the ethical practise of public health as presented by Thomas et al. This means that attention to climate change is required by the traditions of both medical and public health ethics.

Actions in Public Health To Control Climate Change

The necessity for public health action to foresee, control, and lessen the health consequences that climate change would impose has become a given. The American Public Health Association and a coalition of federal, state, and local agencies and partners created the 10 Essential Services of Public Health in 1994.⁷¹ These services, with examples relevant to climate change, are included in Table 2 and are covered in more detail in this section.

Public health professionals will have to face a number of practical issues as they plan and execute programmes to address climate change. The first is that each region will experience climate change's consequences differently. Second, they will differ depending on the population; not everyone is equally prone. Third, because these consequences are so complicated, multifaceted preparation and action will be required.

The human health effects of climate change will vary by region, topography, and capacity for response.³¹ For instance, far northern locations will see relatively dramatic changes in temperature, hydrology, and ecosystem conditions, with effects ranging from infectious disease risk to inability to adapt.⁷² Regional variation will play a critical role in public health responses to climate change.

Health inequalities are widely acknowledged in clinical practise and public health, and it is a fundamental principle of public health that they must be removed. Environmental risks that disproportionately threaten certain populations, especially the poor and people of colour, are a factor in health disparities.^{79,80} This is the basis for environmental justice advocacy.⁸¹ Climate change is predicted to continue this trend. Events like Hurricane Katrina highlighted the vulnerability of the poor in New Orleans, Louisiana.^{82–84} People in poor countries will face great challenges on a global scale.

One essential characteristic of climate change is complexity. Numerous feedback loops exist, a vast array of elements have an impact on meteorological systems, and the necessary data are rarely available. The same is true of how climate change affects human health. These consequences will manifest over the following decades against a backdrop of other changes, including urbanisation, population shifts due to population growth and ageing, the rising scarcity of fossil resources, and migration to Southern and Southwestern states. Public health scientists will need to practise systems thinking⁸⁹ and acquire and put to use tools like system dynamics modeling⁹⁰ in order to properly deal with this complexity.

Recognizing these three realities—geographic diversity, demographic variability, and complexity—set the basis for assessing public health responses to climate change based on the following 10 important public health services.

Tracking Health Status to Spot and Address Community Health Issues

A responsive and effective public health system depends on information. In order to identify vulnerable or affected individuals and locations, recognise disease clusters, and plan, implement, and evaluate public health interventions, data from public health surveillance or tracking systems are used.⁹¹ When these data are systematically collected, analysed, interpreted, and disseminated, they serve as a guide for the creation of effective public health interventions and the wise use of public health resources.

Several types of data—on environmental hazards, susceptibility, and disease—are required to adapt to climate change. Weather information (such as temperature patterns) and ecological information are a few of examples of risk data (such as mosquito density). Indicators of vulnerability include social factors like isolation and poverty as well as physical ones like elevation, urban infrastructure, loss of forest cover, and the prevalence of household air conditioning^{92–95}. One example is the Climate Vulnerability Index, which focuses on flood susceptibility using a combination of factors measured at the local level.⁹⁴ Disease surveillance is a traditional public health function; data systems for infectious diseases are used to monitor infectious diseases.

These data—on risk, vulnerability, and disease—are often gathered at various geographical scales and using various techniques. They must be coordinated and included, which is vital. Epidemic early warning systems combine clinical data from emergency rooms and outpatient clinics with data on the environment, vector biology, clinical laboratory data, veterinary data, hotline call tracking, pharmaceutical use, and other data.^{99–103} These systems are common in many parts of the world for vector-borne, foodborne, waterborne, respiratory, and terrorism-related diseases. Health authorities will be able to better understand how long-term climate changes, weather patterns, ecological changes, and both direct and indirect health impacts are related.

Determine and look at community health risks and issues

The community's counterpart of a doctor's diagnostic workups of individuals, identifying, researching, and explaining health concerns at the population level are basic public health tasks. These tasks are widely established in public health and directly follow the preceding one (monitoring health status). However, the health system will need to develop its diagnostic and investigative capabilities. For instance, ecological changes may modify the dynamics of classic vector-borne diseases, potentially changing the local and regional definitions of animal hosts, vectors, and illness consequences. The capability of public health laboratories must be improved to allow quick detection and reporting of illnesses that are reintroduced or change in distribution. Methods to measure health susceptibility to climate change have been presented and give a proactive approach to diagnosis.

In British Columbia, an outbreak of *Cryptococcus gattii*, a once-tropical organism, was noticed in 2001.^{118,119} Investigation of the outbreak, a collaborative effort of a university and a provincial centre for disease control, included such novel sampling techniques as testing of air, soil, trees, garden waste, vehicle wheel wells, and the shoes of sampling personnel.

Determining the degree to which health issues may be attributable to climate change is a part of diagnosis and inquiry. Developing the most efficient and cost-effective tactics for the health system's reaction will be made easier with an understanding of attribution. Risk assessment-like methodologies are used in methods for evaluating the health impact of climate change.^{39,121} These methods require additional application and refinement.

Health Issues: Inform, Educate, and Empower People

Only 1 in 5 Americans report knowing climate change very well, despite the majority of Americans believing that it is already having consequences and a sizable and growing plurality reporting that they are "extremely concerned" about it. There is a high and growing level of concern, but it is evident that the public's understanding of climate change is incomplete, and the majority lacks confidence in the information presented in the media. Moreover, Americans are evenly divided among those who think that media coverage of climate change is exaggerated, correct, and underestimated.¹²²

Health practitioners are familiar with this predicament, which in many ways mirrors how the general population feels about health and sickness. Although experience with topics like smoking cessation, HIV prevention, promoting physical activity, and other health concerns has produced rich insights into successful health communication^{123,124}, little of this information has been applied to climate change.^{125–128}

The public and policymakers will be informed about possible health implications and risk reduction measures through effective health communication on climate change. The message must be tailored to certain audiences, taking into consideration their various degrees of comprehension, cultural and racial diversity, susceptibility to the consequences of climate change on their health, among other things. People should be given the tools they need to access and utilise the appropriate health resources. Designing messages that reduce negative reactions and encourage positive behaviours is crucial since terrifying events can make people feel hopeless and helpless. For instance, the Environmental Protection Agency has a "What You Can Do" Web page¹²⁹ that includes user-friendly resources including a personal greenhouse gas emissions calculator along with advice for use at home, at work, on the go, and in school. Other countries might serve as valuable models. For instance, Health Canada provides a regular periodical titled *Your Health and a Changing Climate*, a user-friendly website, and other informational resources to the Canadian public. Research is required to determine the best methods of communication, and after implementation, communication techniques should be tested for effectiveness.

Increase Community Partnerships to Recognize and Address Health Issues

The development of collaborations between federal, state, and local government agencies, academia, nonprofit groups, and the corporate sector should be the main goal in order to address the health concerns brought on by climate change. Since identifying health hazards and vulnerable populations, creating and implementing adaptive measures, and responding to emergencies mostly take place at the municipal and state levels, many of these relationships must develop there.

Although it is important to improve current ties with established public health partners, new partnerships also need to be formed. Collaborations with city planners and architects, whose designs can reduce energy demand and limit vulnerability to risks like heat, flooding, and others, with transportation planners, whose work can create transportation systems that reduce greenhouse gas emissions and encourage safe, healthy travel, and with the religious community, are some prime examples (which shares an emphasis on long-term stewardship and can help disseminate public health information). For instance, the National Religious Partnership for the Environment¹³¹ recognises that a key concern in climate change is human health, providing a solid foundation for cooperation with public health organisations.

Create plans and policies to support community and individual health initiatives.

In the upcoming years, it is expected that national policies on climate change mitigation will shift. Although the health sector is not directly responsible for decreasing greenhouse gas emissions, health contribution is acceptable in at least two areas. First, medical practitioners may outline the reduced morbidity and death as the health case for mitigating climate change. Second, using methods like health impact assessment, health scientists may present information on the health effects of various strategies for mitigating climate change (including cobenefits and drawbacks),¹³² contributing to the development of policies that best safeguard public health.^{53,54}

Plans that address the health hazards brought on by climate change should heavily involve the health sector. For instance, cities at risk for heat waves need preparedness plans^{133,134} that offer early warnings, educate the public and health care professionals, identify vulnerable people and places,¹³⁵ implement health surveillance, create buddy systems and other rescue plans, identify shelter facilities, make sure backup generators are available and well-stocked with fuel, prepare transport and evacuation plans, and set up clinical facilities to provide appropriate care, including including. For planning and achieving "hospitals safe from catastrophes," the Pan-American Health Organization's Hospital Safety Index is an excellent example.¹³⁹ Health information may also be used to develop "climate-proof" homes, improved infectious disease management programmes, early warning systems, and other strategies. Planning and practising need cooperation between public health authorities and other organisations, such as those in charge of law enforcement and disaster response. Local health departments' involvement in such planning is seen by initiatives in Seattle, Washington, and Portland, Oregon.

Internal to the health system are other plans and rules that deal with how medical institutions are run. Like many other industries, the health sector can assess its own greenhouse gas emissions and take steps to cut them. Hospitals and clinics may be built, run, and planned in ways that use less energy, produce less waste, and minimise the amount of time employees, patients, and visitors spend driving to and from the facility. "Green purchasing" is another set of measures to lessen the impact of the health sector on climate change. It refers to the preference for buying ecologically friendly materials and equipment. Technical guidance is available to US health organisations in the peer-reviewed literature¹⁴³ in sources like the Green Guide for Health Care,¹⁴⁴ from organisations like Hospitals for a Healthy Environment¹⁴⁵, and from private architects and consultants. The British National Health Service has adopted these approaches as policy.

Ensure Safety and Health by Enforcing Laws and Regulations

There are not many public health policies and regulations that directly address climate change. Public health, however, may offer evidence-based recommendations for legislation and regulations in the fields of the environment, transportation, and energy. As restrictions are formalised, state and municipal public health organisations may have a role in enforcing laws governing air pollution, water quality, and building requirements.

Linking Individuals to Needed Health Services and Ensuring Care

The health response to climate change must include a robust delivery system for medical treatment. Support is required for the development of local, regional, and national emergency medical systems as well as strengthening their ability for disaster response, including specialised services and surge capacity, in order to be ready for disasters like hurricanes, floods, and heat waves. Although disaster medical planning frequently focuses on trauma care,

disasters may interrupt ongoing care for diseases like HIV infection and renal failure, routine laboratory testing such as newborn screening, and other services, all of which must be restored. These requirements are included as part of the National Response Plan under Emergency Support Function No. 8, called Public Health and Medical Services.¹⁴⁶ The requirement for efficient, coordinated methods of delivering healthcare treatments was made obvious by system failures during and following Hurricane Katrina.^{147–150}

In the context of climate change, mental health services might be a crucial part of the provision of healthcare. In addition, the long-term stresses of climate change—living with uncertainty, environmental threats, and changes in familiar habitats and habits—may impose a chronic mental health burden.^{158–163} The health system needs the ability to quickly assess needs, provide mental health services, and provide long-term follow-up.^{151–155} This is especially true for high-risk groups like children.^{156,157}

Make Ensuring the Public and Personal Health Care Workforce is Competent

The success of the health system depends on having a trained and competent workforce.¹⁶⁵ A concerted effort at the local, state, and federal levels will be needed to prepare the health workforce for potential climate change effects as well as for a variety of other challenges over the coming decades. It will include establishing a fundamental set of abilities across the board and cultivating a workforce of scientists with diverse, specialised talents in unorthodox disciplines.

Medical professionals should get training in identifying and managing new health risks that might be brought on by climate change. Training networks for public health professionals must offer a structured approach to instruction that is closely related to the crucial services and requirements noted by regional and national health authorities. To provide cutting-edge training for healthcare professionals in unconventional fields including economics, health impact evaluations, ecology, urban health, and vulnerability modelling, collaborations between health science schools and other academic institutions are needed. To fully address the issues of climate change, the health system must acquire a larger spectrum of skills at every level. Numerous colleges offer courses on climate change for health professionals, such the graduate certificate in humans and the environment offered by the University of Wisconsin and the Harvard course on human health and global environmental change¹⁶⁶.

Analyze the efficiency, availability, and standard of the health services

Health professionals must take responsibility for the efficacy, availability, and calibre of programmes and treatments as they try to lessen the effects of climate change on human health. In addition to enhancing public health activities, evaluating preparation plans, health communication strategies, and other measures can make it easier to communicate with important community stakeholders.

Strong surveillance capabilities, a skilled public health staff, and established, effective, and dependable procedures for information exchange among various governmental levels and sectors of the healthcare industry are necessary for evaluation. Additionally, it necessitates a regular examination of the services that are offered and their accessibility to the most vulnerable individuals they are intended to assist. The evaluation of climate change and health will have cobenefits with other crucial public health initiatives and probably demonstrate synergistic effects in bolstering the country's public health system, much like many other crucial public health services.

Look for Fresh Perspectives and Cutting-Edge Treatments for Health Issues

To provide data-based support for public health action on climate change, several lines of health research are required.^{168,169} These include empirical research on the relationship between climate change and health, scenario development to forecast health impacts and vulnerabilities, and development and testing of risk-reduction strategies. Research is required on the amount of public health protection generated by each intervention as well as on associated costs.

Conclusions

There is broad scientific agreement that climate change is occurring. A growing body of research points to present and foreseeable implications on human health, including hazards to food and water supplies, increases in allergy, respiratory, vector-borne, and waterborne diseases, and injuries and illnesses brought on by extreme weather, floods, and heat exposure. The results of mass migration and regional conflicts, as well as anxiety and sadness, are examples of indirect repercussions.

It is important for public health to address these events. Although the challenge's size and complexity are unprecedented, the conceptual underpinning for its solution is based on well-established public health principles. To avoid injuries and diseases, improve public health readiness, and lower risk, a successful public health response to climate change is necessary. Making decisions based on science and guided by public health ethics will reduce uncertainty and improve economic, environmental, and health outcomes. Planning and carrying out a public health response can be facilitated by using the Essential Services of Public Health as a framework.

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