Climate Change and Public Health

Thinking, Communicating, Acting

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Introduction

A decade ago there was active debate about whether human-induced climate change was real, and whether human contributions have played a major causal role in the recently observed global warming. That debate is largely over, although the inherent complexities of climate system science and various uncertainties over details remain. A corollary question—whether climate change would have implications for public health—also has been settled. The answer is yes. A range of possible effects has been identified, some now fairly well understood and others yet unclear.[1–7]

Public health and preventive medicine, as applied disciplines, share a common mission: to prevent illness, injury, and premature mortality, and to promote health and well-being. This mission therefore carries a mandate to address climate change.[8–13] Fortunately, the basic concepts and tools of public health and preventive medicine provide a sound basis for addressing climate change,[14] although some tools, such as epidemiologic research methods, need to be extended and elaborated to meet the unfamiliar and often daunting challenges.[15]

Climate change, an environmental health hazard of unprecedented scale and complexity, necessitates health professionals developing new ways of thinking, communicating, and acting. With regard to **thinking**, it requires addressing a far longer time frame than has been customary in health planning, and it needs a systems approach that extends well beyond the current boundaries of the health sciences and the formal health sector. **Communicating** about the risks posed by climate change requires messages that motivate constructive engagement and support wise policy choices, rather than engendering indifference, fear, or despair. **Actions** that address climate change should offer a range of health, environmental, economic, and social benefits.

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The questions at present, then, are not so much *whether* or *why*, but *what* and *how?* What do we do to prevent injury, illness, and suffering related to climate change, and how do we do it most effectively? This issue of the *American Journal of Preventive Medicine* offers a range of articles that helps answer these questions.[16–26] Meanwhile, there also remains for health researchers the extremely important task of assisting society understand the current and future risks to health, as part of the information base for policy decisions about the mitigation of climate change itself.

In this article we address several cross-cutting themes that underlie the health-sector response to climate change. The first is the need for long-term thinking. The second is the need for systems thinking. The third is the need for effective framing and communicating of the issue. The fourth is the opportunity for health-sector leadership. Finally, the opportunity for co-benefits to health from both mitigation and adaptation actions is a key, and positive, consideration.

Long Time Frame

Health planners focus on characterizing current need and meeting that need. Ideally, they also project future need, and plan to put resources in place to meet that need. To date, health planning rarely has extended forward over decades. Climate change, however, requires public health and preventive medicine to engage and anticipate health needs on an unprecedented time scale.

Cultural traditions, from indigenous practice to religious faith, offer much precedent for such long-range thinking. The Great Law of Peace of the Haudenosaunee (the Six Nations Iroquois Confederacy) mandated that chiefs consider the impact of their decisions on the seventh generation yet to come.[27] Contemporary religious leaders have called for "creation care"—stewardship of the earth as both a religious obligation and an obligation to future generations.[28–30] Ethicists have argued that intergenerational justice is a moral basis for action on climate change.[31,32]

These perspectives have relevance to public health and preventive medicine. If the clinical paradigm focuses on individuals, while the public health paradigm extends to entire communities, then a longer-horizon legacy paradigm—caring for future generations—is

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warranted to address climate change. In words attributed to Jonas Salk: "Our greatest responsibility is to be good ancestors" (thinkexist.com/quotes/jonas_salk/). In practical terms, this suggests that the scientific techniques of futuring—scenario-building, modeling and forecasting, and timely actions to address coming challenges—should be incorporated into public health and preventive medicine.[33,34]

Systems Thinking

Climate change confronts health professionals and others with enormous complexity. Most of the success of modern Western science has been achieved via the classic methods of reductionism and experimentation; that is, learning about the whole by studying, in controlled context, each of the disaggregated parts. But to understand how complex systems (such as the climate system or an ecosystem) behave, it is important to study the system as a whole, apprehending the emergent properties of systemic behavior.[35,36] Accordingly, epidemiologic methods must evolve to accommodate the unusual scale and complexity of the health risks of climate change and to engage in scenario-based modeling of likely future risks in relation to plausible scenarios of climate change.[37]

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Natural systems such as ice sheets and forests, human systems such as capital markets and transportation policies, and combined human–natural systems such as watersheds and farms interact in continual cycles of growth, accumulation, restructuring, and renewal.[38] Such coupled human–natural systems demonstrate several features,[39] each highly relevant to climate change.

First, there are *reciprocal effects and feedback loops.* For example, climate change increases the probability of urban heatwaves; when these events occur, they increase the demand for air conditioning, which increases the combustion of coal in power plants, further contributing to climate change (not to mention local air pollution). Second, complex systems feature *nonlinearity and thresholds.* These can result in "tipping points," where small changes make big differences. Climate change examples include coral bleaching that could lead to collapse of some of the world's fisheries within decades, a rapid rise in sea level from accelerated melting of the Greenland Ice Sheet, the melting of permafrost or increases in soil respiration leading to fast changes in the carbon cycle, and the shutdown of the thermohaline circulation that drives ocean currents and maintains moderate temperatures in much of Europe.[40] These scenarios, in turn, signal the possibility of *surprises,* another feature of complex systems.[41]

Such systems also feature *legacy effects and time lags*: Events or actions may have ramifications that occur much later. For example, because atmospheric carbon dioxide has a half-life measured in many decades, today's emissions will continue to exert effects for at least two generations. On the other hand, both natural and human systems exhibit *resilience*, the ability to retain similar structure and function following perturbations. Indeed, understanding and enhancing resilience are core considerations in adapting to climate change. Finally, complex systems exhibit *heterogeneity across both space and time.* Warmer temperatures will result in drought in some locations and greater precipitation in other areas, underscoring the need for local assessments and adaptive strategies.

Climate change is not the only contemporary large-scale process that poses risks to health. Population growth is continuing, with the global population expected to stabilize at between 9 and 10 billion people by mid-century.[42] Urbanization is continuing; during this decade, more than half the world's population became urban.[43] Petroleum, a plentiful and inexpensive source of energy for the past 150 years, soon will almost certainly become scarce relative to demand.[44] Other resources, such as potable water and arable land, already are becoming scarce in specific regions.

To address this complexity, several strategies are needed.[39] Analyses should address complex interactions and feedback between human and natural systems, including not only ecologic and human variables but also variables that link natural and human components, such as the use of ecosystem services. Scientists, policymakers, and health professionals should all rely on interdisciplinary teams. Health professionals must collaborate with earth scientists, ecologists, economists, demographers, emergency management officials, and others.[45] These teams need a range of tools and techniques from ecology, the social sciences, and other disciplines, including remote sensing and geographic information sciences for data collection, management, analysis, modeling, and integration. Finally, analyses should be simultaneously context-specific and extend over periods of time, so that the full dimensions of climate change can be understood and adaptive measures planned. These strategies can be applied to every domain in which climate change might affect health, from urban design[46–48] to infectious disease.[49]

Positive Messages

Health professionals know that effective communication is essential. People need to take actions to protect their health, and some of these actions are confusing, counterintuitive, or downright unpleasant: changing what they eat, undergoing colonoscopy, taking medications, wearing condoms. In the case of climate change, communication goals extend beyond behavior change to knowledge and attitudes as well. People need to know enough about climate change to choose appropriate responses, at personal, household and community levels, and to support preferred government policies. They need information that facilitates an attitude of constructive engagement, thus avoiding cynicism, despair, and disengagement. Health professionals should motivate people toward both appropriate personal behaviors and collective decisions that will protect health from the effects of climate change.

Much climate change communication appears to fall short of this mark. A 2006 British study[50] found that alarmism, nihilism, and other styles were disturbingly common in popular climate change discourse (although these had abated somewhat a year later[51]), and a recent analysis[52] in the U.S. suggested that pervasive negativity and a sense of narrow special interest bedeviled the public discussion of climate change. There may be a role for frightening messages, as discussed by Maibach and colleagues[21] in this special issue, but they can backfire if not managed appropriately. Clearly, more effective communication is needed.

At least three frameworks, all commonly used in public health and preventive medicine, may be helpful. First, social marketing is used to elicit behavior change by appealing to self-interest.[53] Key steps in developing and delivering messages include understanding the competition, understanding target markets, creating mutually beneficial exchanges, segmenting markets, and basing targeting on anticipated return.[54] Second, risk communication is more typically used in high-stress, high-concern, or controversial situations.[55,56] Risk communication emphasizes two-way communication, aiming to build credibility, trust, knowledge, and cooperation in addressing a problem. Developing a shared understanding of "probabilities" rather than "certainties" is also important. Third, health communication, a more general term, is applied to communication that aims to inform people about health, assist them with health decision making, and/or change health behavior.[57–59] It is based on theory—the health belief model,[60] the theories of reasoned action and planned behavior,[61,62] the transtheoretical model,[63–65] and others—and it includes a strong tradition of program evaluation to test empirically whether communication goals were met.

Increasing attention is being devoted to effective communication about climate change.[66] Given the potential for ineffective communication to harm people and for effective communication to promote public health directly and indirectly, and given the strong tradition of health communication in public health and preventive medicine, this challenge needs to remain at the center of health-sector activity.

Health-Sector Leadership

The health sector has an opportunity to demonstrate leadership at the local and national levels. There is a tradition of health-sector leadership in confronting such large-scale challenges as nuclear war,[67] poverty,[68] environmental pollution,[69,70] tobacco use,[71,72] and community design.[73] The same opportunity and responsibility exist in the area of climate change.[8–13,70] Through a combination of moral authority, professional prestige, and science-based analysis, health professionals can provide guidance to industry, to policymakers, and to the general public.

The health sector can also lead through exemplary performance. Health care is a large component of the economy—approximately one sixth in the U.S.—and it is an energy-intensive sector. Hospitals and clinics can be designed, built, and operated in ways that lower energy demand, reduce waste streams, and link with local transit systems to cut driving among staff, patients, and visitors.[74] Clinical research can be conducted in ways that minimize energy use and greenhouse gas emissions.[75] "Green purchasing" refers to the preferential purchasing of environmentally friendly supplies and equipment, another set of strategies to reduce the health sector's contribution to climate change. The British National Health Service has adopted these approaches as policy,[76] and technical advice is available to U.S. health organizations in peer-reviewed literature[77]; in sources such as the *Green Guide for Health Care*[78]; from organizations such as Hospitals for a Healthy Environment (www.h2e-online.org/); and from private architects and consultants.

Co-Benefits for Health

A vitally important aspect of climate change policy is the opportunity offered to the public's health by co-benefits from both mitigation and adaptation activities. If an action that addresses climate change—reducing greenhouse gas emissions, developing and deploying sustainable energy technologies, and/or adapting to climate change—yields multiple benefits, then that action represents a "sweet spot."[79] Health professionals need to be alert to such opportunities, to identify the health co-benefits, and to work to optimize the potential positive health impacts. Four case studies, ranging from relatively simple to more complex actions, are exemplary.

Planting trees in cities. Trees have long been recognized as an attractive feature of cities,[80] but appreciation of their role as a climate change intervention has emerged only recently. Trees are useful in several ways. First, they act as a carbon dioxide sink, removing carbon dioxide during photosynthesis.[81–83] This is useful not only on a global scale, but on the smaller spatial scale of a city, where carbon dioxide may reach high local concentrations.[84] Second, trees help cool cities, buffering them against heatwaves and thereby serving an important adaptive function.[85–87] Urban parks can be up to 5°C (9°F) cooler than surrounding neighborhoods,[85,87] and one study[86] calculated that a 10% increase in urban green space could cool a city's average surface temperature by up to 4°C (7°F). Third, this cooling effect reduces power demands during hot weather, which in turn reduces carbon emissions from power plants.[82]

Planting trees in cities does more than help address climate change; it offers important co-benefits.[88,89] Having trees near residences and businesses seems to promote physical activity,[90] mental health,[91] and social capital.[92] Trees play a role in reducing air pollution,[93–95] conserving water, reducing soil erosion, controlling noise,[96] and promoting ecosystem diversity.[97] They provide recreational venues and increase property values.[98,99] Urban trees are a simple example of a climate change intervention that promotes health while yielding a plethora of additional benefits.

Eating less meat. Animal protein forms a prominent part of many people's diets, especially in wealthy countries. Principal sources include ruminants (cattle, sheep, goats, and buffalo); monogastric animals (pigs); poultry (chickens, turkeys); and fish. Livestock production is highly resource-intensive. For example, 26% of the earth's ice-free land surface is used for grazing, and 33% of all arable land is used for growing feed-crops for livestock.[100] Livestock production is also a major contributor to climate change, accounting for almost one fifth of total global anthropogenic greenhouse emissions (9% of CO_2, 37% of CH_4, and 65% of N_2O)—estimated in terms of the 100-year CO_2-equivalent warming effect of those gases.[100,101] However, when that estimate is confined to just the next several decades, livestock's proportional contribution (with its high content of gases of much greater warming potential, although shorter half-lives, than CO_2) is markedly increased. Livestock production contributes to climate change in numerous ways, including deforestation to create pastures for grazing and cropland for feed-crops and the production of enteric methane by ruminants. Other contributions include fossil fuel use on farms and nitrous oxide deriving from soil management, fertilizer production (needed to raise corn and other feed-crops), and livestock manure.[100]

Vegetables and fruits are far less carbon-intensive to produce than livestock (although some practices, such as raising tomatoes in greenhouses or refrigerating carrots for long periods, can increase the carbon footprint substantially).[102] Producing 1 kg (2.2 lbs) of beef is estimated to have the same climatic impact as driving an average automobile 250 km (155 miles),[103] and the difference between a red meat diet and a vegetarian diet is comparable in magnitude to the difference between driving a conventional automobile and a highly efficient hybrid.[104] Therefore, it has been proposed that diets containing less meat and more cereals, grains, beans, fruits, and vegetables could help reduce greenhouse gas emissions.[101,104] One calculation suggests that achieving an equitably shared global average of 90 g (3 oz) of meat per person per day (as compared to the current average of 224 g [8 oz] per day in developed nations), with no more than 50 g (1.8 oz) coming from ruminant livestock, would stabilize greenhouse gas emissions from the livestock sector.[101]

In addition to its climate change benefits, such a diet would yield co-benefits. Some of these co-benefits pertain to health: Diets lower in meat are associated with reduced risks of colorectal,[105–107] breast,[108,109] and other cancers[110,111]; a probable reduced risk of ischemic heart disease[112]; and a possible reduced risk of other chronic diseases, such as arthritis.[113] Such diets may also increase longevity.[114] Vegetables, fruit, legumes, and whole grains have similar protective effects.[114–116] Less reliance on meat also could help address other health problems related to meat consumption: exposure to bacterial contaminants such as *E. coli*, campylobacter, and salmonella[117]; the development of and exposure to antibiotic-resistant organisms[118–120]; and exposure to emerging infectious diseases such as bovine spongiform encephalopathy and Nipah virus.[121,122] Less reliance on meat could also yield environmental and economic benefits, such as the more efficient use of farmland and reduced air and water pollution.[100,123]

Energy policy and air pollution control. Reducing greenhouse gas emissions can also help reduce air pollution—a compelling co-benefit, given the morbidity and mortality attributed to particulate matter (PM) and ozone. A 1997 study[124] estimated that a worldwide reduction of fossil fuel combustion in accordance with a hypothetical climate policy could reduce respirable particulates emissions enough, between 2000 and 2020, to prevent 8 million deaths globally, four fifths of them in developing nations. Similarly, a study[125] of four cities—Santiago, São Paulo, México City, and New York—calculated that readily available technologies to reduce CO_2 emissions in those cities also would reduce PM and ozone levels enough to prevent 64,000 premature deaths, 65,000 cases of chronic bronchitis, and 37 million person-days of work loss or restricted activity. More recent studies have helped identify specific interventions that both reduce CO_2 emissions and prevent air pollution–related deaths and illness. For example, a study[126] in Shanxi province, China, examined a range of options for reducing CO_2 and air pollutants and identified two likely candidates: energy-saving and clean-coal options at the electric arc furnaces of a large iron and steel plant in one city, and modifying or replacing obsolete industrial boilers in another city.

Not all such studies show co-benefits, but even negative results can help guide policy. For example, a European study[127] that focused on using diesel fuel in motor vehicles found mixed results—reduced CO_2 emissions but higher PM emissions—suggesting the need to balance the two goals. Similarly, the modeling of Mexico City's air pollution–control program, PROAIRE (Programa para mejorar la calidad del aire en la Zona Metropolitana del Valle de México 2002–2010), has suggested relatively few co-benefits in terms of reducing CO_2 emissions.[128] However, a study[129] that examined the specific components of PROAIRE—upgrading the city's taxi fleet, extending the subway system, deploying hybrid buses, repairing liquid petroleum gas leaks, and implementing energy co-generation in industries—yielded useful insights. Co-generation greatly reduced the city's CO_2 emissions but offered no pollution-related health benefits, whereas the use of hybrid buses reduced PM emissions but had little effect on CO_2. Upgrading the taxi fleet yielded both benefits, and was highly cost effective due to fuel savings.[129] Such analyses, when replicated and confirmed, can identify strategies to optimize both climate change mitigation and air pollution reductions, yielding both immediate and long-term health benefits.[130]

Land use and transportation planning for smart growth. Smart growth is an approach to community design that includes both land-use and transportation elements, and contributes to climate change mitigation by improving energy use and efficiency. It emphasizes strong neighborhood and town centers (as opposed to sprawl); mixed-land uses (as opposed to segregating residential, commercial, and other uses); compact design, with traditional town or city density (as opposed to the low density of many suburban and exurban developments); a highly connected street network (as opposed to "loop-and-lollypop" subdivisions off arterial roads); and transportation alternatives oriented to walking, bicycling, and transit (as opposed to purely automobile-oriented transportation design). This approach, which shares much with "traditional neighborhood development" and "new urbanism," arose in the last 2 decades in the fields of architecture, urban planning, and transportation planning. It originally centered on achieving aesthetic, social, and environmental goals. More recently health professionals have emphasized that smart growth also yields substantial health benefits.[131,132]

These benefits accrue in several ways. A shift to walking and bicycling promotes routine physical activity, with benefits that include weight loss, cardiovascular health, cancer prevention, and others.[133,134] Using mass transit, which requires walking to and from transit stops, does the same.[135] These same transportation strategies improve local air quality, reducing the risk factors for asthma, myocardial infarction, and other diseases.[136,137] Sprawling development patterns are associated with an increased risk of motor vehicle crashes,[138] and walkable neighborhoods are associated with increased community interaction and, hence, social capital,[139] which in turn promotes health.[140]

Along with these health benefits, smart growth is increasingly recognized as an effective strategy for addressing climate change.[26] Compact cities, with energy-efficient buildings and transportation systems, reduce travel demand, reduce energy use, reduce the need for total and per capita fuel use, and thereby reduce greenhouse gas emissions. Such cities, via infrastructure design and green space usage, also reduce their contribution to the urban heat island,[141] representing an important adaptation to climate change. These observations have given rise to a literature focusing on urban design as a climate change strategy.[48,142–145] This intersection gives meaning to the concept of "sustainable cities" by combining environmental, human health, and economic benefits over the period of many generations.[146–148]

Conclusion

The articles in this special issue of the *American Journal of Preventive Medicine*[16–26] reflect a growing engagement of health professionals in addressing the challenge of climate change. This engagement will necessarily entail thinking on a much longer time frame than has been customary or necessary in public health and preventive medicine. Our thinking must confront complexity and range across systems that extend well beyond the formal health sector. We need to draw on the insights of health communication, delivering messages that motivate constructive engagement and support wise policy choices, rather than engendering indifference, fear, or despair. We need to assist communities and government to develop broad and long-sighted strategies that avert prolonged climate change and to achieve a sustainable way of living with and within the natural environment. The health sector needs to demonstrate leadership through its own activities, and by engaging collaboratively with a wide spectrum of other sectors. Finally, we need to identify and promote co-benefits, so that actions that address climate change also yield health, environmental, economic, and social benefits.

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