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An Overview of Human Health Issues

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Anticipated climate changes threaten to decrease air quality, increase the spread of animal and microbial sources of disease, and increase danger from extreme weather events.

Maine's readiness for climate disruptions will require expansion of its public health monitoring systems, especially for infectious disease and lung health, improved connections with regional and federal health systems, and increased disaster response capability.

Humans can survive and even thrive in a wide range of climates. Although humans have built physical and technological buffers against some conditions, our health ultimately depends on the whole of our environmental surroundings, both natural and built—our modern human ecology. This is particularly evident in our vulnerability to factors mediated by climate, such as air and water quality, the spread of animal and microbial sources of disease, and the dangers posed by extreme weather events. Climate change has major implications for human health around the world, and this section provides a generalized overview of the issues most relevant to public health in Maine.

Climate and human health

Humans, like all other species, have adapted to a range of temperatures and available food sources, in systematic relationship to the plants, animals, and even the germs in our environment. This ecological view places humans in nature in an interacting community of organisms which feed us, and also which transmit disease. Just as our health is influenced by diseases in our environment, germs and viruses depend on humans for survival. All parts of a living community are affected by changes in temperature, rainfall, or the geographic ranges of organisms. Some of these effects are predictable, but the huge complexity of biological relationships creates uncertainty. The major areas of human health vulnerability include: (1) threats to clean air and fresh water; (2) a largely unpredictable influx of new germ-caused diseases; (3) increasing extreme weather events; and (4) mental health issues produced by disasters and human population death, injury, and displacement.

Temperature affects the geographic range of infectious diseases, but weather events affect the timing and intensity of outbreaks. The United Nation's World Health Organization (WHO) has warned that more storms, floods, droughts, and heat waves will be accompanied by an increase in climate-sensitive diseases, including malnutrition, diarrhea (an important cause of infant mortality), and malaria (McMichael *et al.* 2003). Two inches of rain in 24 hours is the threshold for the spread of infectious diseases, which have increased 14% in the US (Epstein 2008). Drought punctuated by heavy rains can be particularly destabilizing. Clusters of disease (borne by water, rodents, and mosquitoes) follow disasters, as public health infrastructure is damaged.

The future of public health in Maine

In Maine, climate change may have positive effects on health by increasing the agricultural growing season and reducing stress, injury, or deaths due to the cold. Nevertheless, most health effects are expected to be negative, and Maine will be influenced by climate effects on the health of populations around the world.

Warmer temperatures in the summer months and more frequent heat waves will increase heat-related illness. Heat stroke claimed tens of thousands of lives in Europe during 2003, and some US cities have also experienced increased deaths (Epstein 2005).

As temperatures increase, the geographic territories of disease-bearing insects will likely change, although the exact mechanisms are too complex for precise modeling. Because insects have metamorphic life cycles, temperature extremes and averages may affect life stages (*e.g.*, eggs, larva, and adult) differently. For example, Lyme disease is carried by the deer tick, *Ixodes scapularis,* which is associated with abundant deciduous forest, a moist climate, and the distribution of its most common animal host, the white-tailed deer (Rand *et al.* 2004). The deer tick also carries at least two other human diseases: human granulocytic anaplasmosis and babesiosis, and may carry Powassan encephalitis as well.

Lyme disease, identified in 1979 in Lyme, Connecticut, appeared in Maine at about the same time the first deer ticks were identified, the late 1980s (Rand *et al.* 2007). The incidence of Lyme disease, tracked by the Maine Center for Disease Control and Prevention (Robbins 2007), increased gradually at first, and has accelerated since the late 1990s, with a 37% increase in 2006 and 56% increase in 2007 (528 cases; *Figure 25*).

Since 1989, the Vector-Borne Disease Laboratory at Maine Medical Research Institute has researched ticks and their association with Lyme disease. Most cases are reported in southern and coastal Maine, particularly York and Cumberland counties, contiguous with the greatest frequency of identified deer ticks (*Figure 26*). The distribution of deer ticks has been moving north along the coast and up the major river valleys.

Cases of Lyme Disease in Maine, 1986-2007

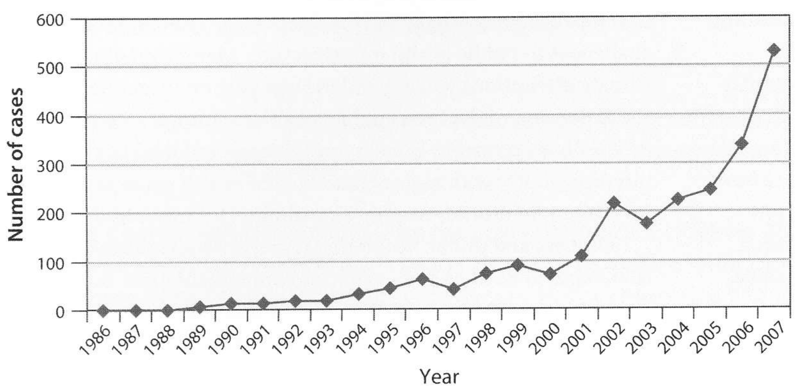

Figure 25 Number of cases of Lyme disease reported to the Maine Center for Disease Control, 1986-2007 (Robbins 2007).

Similarly, cases of Lyme disease have increased in Sagadahoc, Knox, and Lincoln counties, and in the lower Kennebec River valley. Model studies show that all of Maine will have conditions conducive to Lyme disease by 2080 (Epstein 2008).

Unstable weather is expected to alter the distribution of disease-causing mosquito species (Rosenzweig *et al.* 2001), and mosquito-borne diseases are increasing in Maine. Both West Nile virus and Eastern equine encephalitis have been identified in Maine animals, although no human cases have been reported.

Climate change extremes, including heavy precipitation in some areas and drought in others, can affect the supply of fresh water. More than 100 pathogens can cause illness through contact with water contaminated by sewage, including norovirus Norwalk, hepatitis A, and E. coli. Maine is at risk for water contamination with increased flood events, particularly in communities where sewer systems are not separate from stormwater systems, or in areas where surface water supplies are vulnerable to contamination. Outbreaks of water-borne disease such as giardiasis and cryptosporidiosis are expected to increase due to local precipitation-caused flooding (Relman *et al.* 2008). Giardiasis, sometimes called "beaver fever," is an intestinal parasite that lives in humans and other mammals and can contaminate drinking water. The number of giardiasis cases in Maine has fluctuated from 238 in 2000 to 197 in 2007 (Robbins 2007). Cryptosporidiosis, caused by an intestinal parasite, is frequently found in contaminated water such as swimming pools (it is resistant to many chlorine disinfectants), and is often linked to contact with farm animals. Reports of cryptosporidiosis cases remained stable at 20 reports in both 2000 and 2001, rising to 30 in 2005, 52 in 2006, and 56 in 2007 (Robbins 2007).

With rising ocean levels, coastal groundwater is at risk from increased salinity as seawater invades formerly freshwater aquifers. Warmer temperatures and increased rain and snowfall may increase the length and intensity of toxic algal blooms or "red tides" in coastal waters (Edwards *et al.* 2006; see also the Gulf of Maine section of this report).

Scientists expect air quality to diminish (Patz *et al.* 2000, McMichael *et al.* 2003, Weiland *et al.* 2004, Confalonieri *et al.* 2007). Increasing ozone and CO_2 contribute to smog, which causes more hospitalizations and deaths from asthma and chronic obstructive pulmonary disease (COPD; ALA 2007, Bell *et al.* 2007). In contrast to reductions in atmospheric concentrations of sulfate and toxic metals (page 14), deposition of nitrate, an acid rain-forming compound and an important forest nutrient, has not declined and remains an environmental concern. Nitrate, along with sunlight and airborne hydrocarbons, is important in the formation of ground-level ozone (or tropospheric ozone). The relatively constant levels of nitrate, sunlight, and natural hydrocarbons in the air assures a continuing presence of unhealthy ozone episodes. This is not to be confused with stratospheric or "good" ozone, which at high elevations (six to 30 miles) in the atmosphere protects life from the sun's ultraviolet light.

Distribution of Deer Ticks, 1989 - 2007

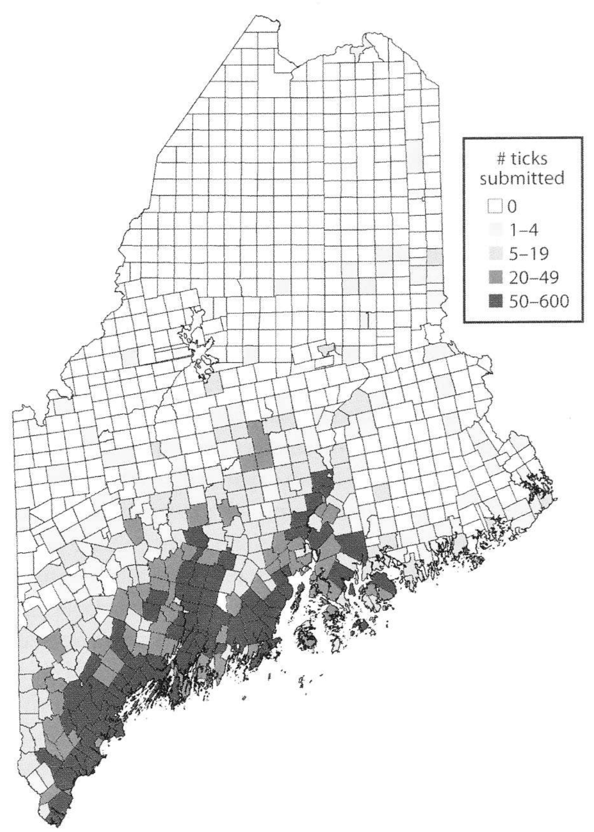

Figure 26 Cumulative number of deer ticks submitted for identification through 2007 to the Vector-Borne Disease Laboratory at Maine Medical Research Institute.

Emissions of synthetic chemicals from human activity (*e.g.*, chlorofluorocarbons) have depleted this ozone layer, leading to increased risks to human health.

Rising amounts of particulate matter, which can originate in areas outside Maine or locally from heating fuels and other combustion processes, also impair lung health. As heating oil becomes more expensive and Mainers are encouraged to burn wood, the potential exists for air quality degradation from wood smoke, even with newer stove types. Recent research comparing residential heating systems has found that, while the new pellet stoves produce about 10 times less particulate matter than conventional wood stoves, they still produce about 50 times more particulates than conventional oil furnaces, and more of some toxic substances (polycyclic organic compounds and naphthalene) than either conventional wood stoves or conventional oil furnaces (Dixon 2008). Thus, decisions about heating are linked to public health, especially the health of children and elders, and should be considered as part of the cost-benefit analysis in setting priorities (Byun 2008).

Pollen is one form of airborne particulate matter that can cause allergic responses, potentially compounding problems from air pollution, especially for those with asthma and/or COPD. Plants that produce allergenic pollens such as ragweed may be more numerous with higher levels of carbon dioxide, and produce greater quanities of pollen, or pollen that is more allergenic (Epstein 2005).

Finally, with the anticipated increase in severe weather events, along with the rising sea levels, the probability that people will be displaced from their homes will also increase. Mental health issues that accompany such family disasters are also expected to increase.

Opportunities & Adaptation

Public health successes in the 20th century, mostly focused on better sanitation and immunization, made great strides in reducing deaths due to infectious childhood diseases. Newer challenges have come from chronic diseases and diseases of addiction, and the behavioral changes needed to combat them. Now we must be prepared for an expanded variety of problems, some of which are difficult or impossible to predict (Frumkin *et al.* 2008).

Maine's statewide public health system is still relatively new, and will need to grow quickly and remain nimble as it faces the incoming threats that will be created with the changing climate. A robust public health system is one that can respond quickly to a range of potential problems, including issues with water supplies, air pollution, and a changing and largely new assortment of infectious diseases that need to be monitored and addressed (Epstein 2002).

Our ability to adapt to climate changes that affect health depends on having the knowledge to define and address new and emerging problems. It also depends on the speed with which we can respond to threats. Movement away from homeostatic systems of weather and climate, for which we have developed solutions to known problems, will present strong challenges to public health infrastructure. Maine's readiness for climate disruptions will depend in large part on investment in the expansion of the state's public health monitoring systems, especially with respect to infectious disease and lung health, interoperability with regional and federal health systems, and investment in disaster response capability (Frumkin *et al.* 2008).

Disaster and public health threat preparedness presents challenges in both policymaking and implementation. Some decisions about climate-related interventions for health will have to be made in the absence of secure data, and our public health infrastructure will need to incorporate expertise and resources for managing uncertainty (Glass 2008). The climate influences on health involve traditional public health topics of disease morbidity, mortality, and epidemics, but they also involve interactions among large-scale ecological processes and socioeconomic systems, and so public health planning will increasingly play an explicit role in policy decisions influencing the environment and the economy.

Knowledge gaps

Can we evaluate the public health risks posed by storms, flooding, and sea-level rise to water quality, and prioritize investment in upgrading wastewater treatment plants, combined sewer overflows, and private subsurface wastewater disposal systems?

More research is needed on emerging disease ecologies, particularly for vector-borne diseases as they invade temperate climates. Species-specific models will be required to differentiate complex relationships between vectors, hosts, and within an environment of changing population density, land-use patterns, and biodiversity issues.

Little is known about the specific pollutants carried in air and their effects on human health. Such pollutants change with new industrial and agricultural use and atmospheric release of chemicals, and potentially react with other substances in the air or water. What are the acute and chronic effects of these chemicals?

How can we create residential heating methods for Maine that reduce dependence on fossil fuels, but do not further pollute air and cause respiratory health problems?

Health policy research is needed to refine understanding of the complex public health needs and the roles of the public health system in natural disasters, including benefit/cost assessments that consider the diverse health consequences that occur: trauma, infection, nutritional deprivation, psychological damage, population displacement, economic loss.

Research is needed to develop methods of death investigation that better serve public health and safety surveillance and outcome evaluation. Expanded skills and protocols are needed to consider and document environmental causes of death.