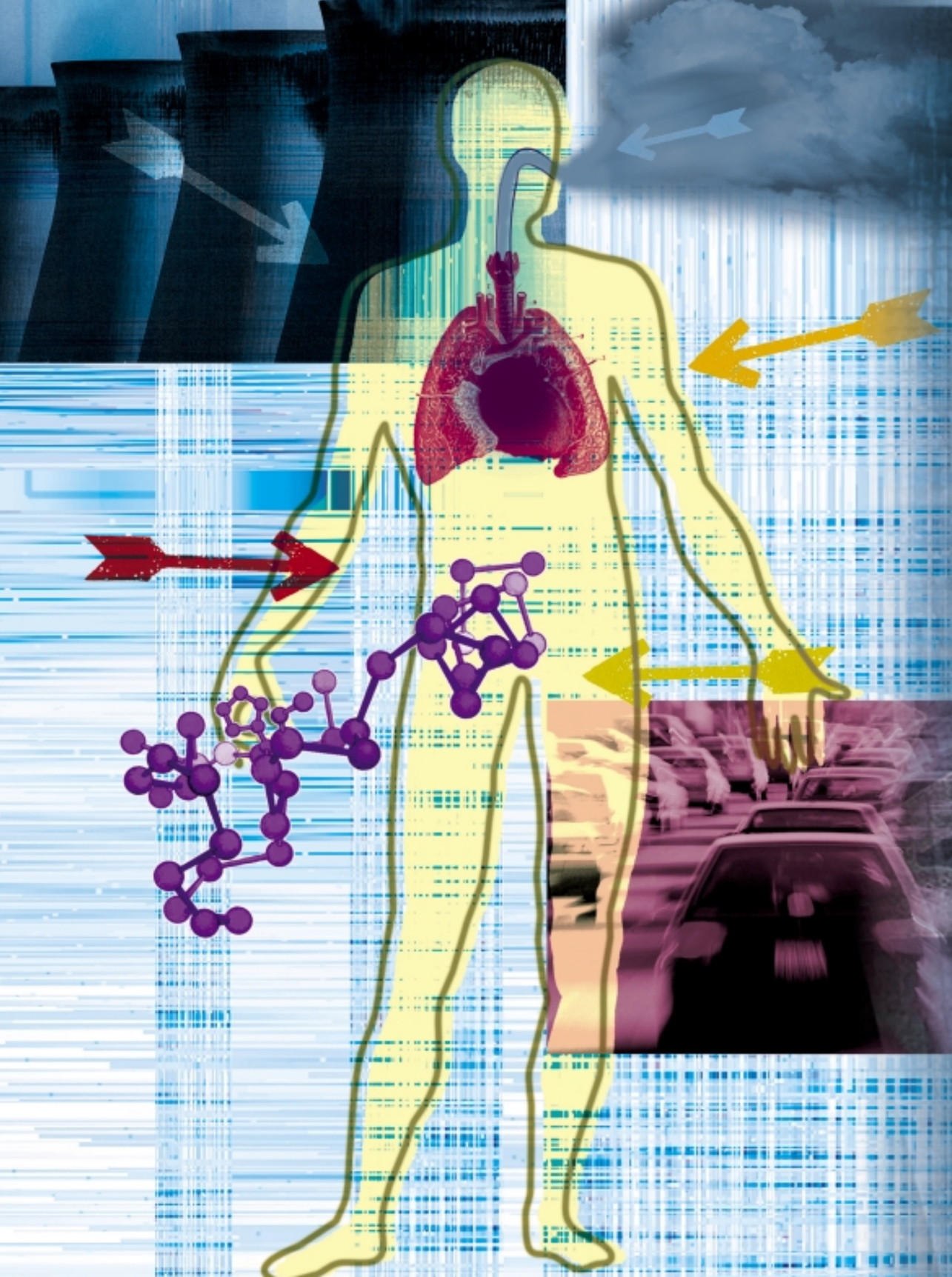
The price of progress

Climate change and human health

by Maria Kelleher, P.Eng.,

Most Canadians have probably heard about the projected impacts of climate change: melting polar ice caps, polar bears weighing in lighter because the ice is thinning and their feeding season shortening, rising sea levels, more storms and erratic weather, warmer winters, maybe longer summers, etc. However, until recently, the impact of warmer temperatures on human health has not received much attention, either from the press or the scientific community. This will slowly change, as more funding is allocated to taking a closer look at what climate change might mean for human health. Here's a summary of some of what we currently know, or suspect.



Scientists believe that climate change is causing disturbances of physical systems (weather patterns, sea levels, water supplies) and of ecosystems (agricultural systems, habitats of disease-bearing insects and animals), which will pose threats to human health worldwide. The extent of these threats will vary by geography and human population vulnerability.

Taking the threats seriously

The major health affects of climate change are expected to include:

Heat and smog. Warmer temperatures will increase the speed of smog formation, resulting in rising air pollution levels. Heat waves combined with air pollution may cause increased deaths due to heat stress, and respiratory and heart problems for vulnerable segments of the population. Studies in selected urban populations in North America, North Africa and East Asia indicate that, unless adaptive measures are taken, the number of heat-related deaths can be expected to increase several fold by the year 2050.

Extreme weather. Scientists have predicted that extreme weather events such as floods, droughts, storms, etc., will occur more often with climate change, causing increases in rates of death, injury and infectious diseases. Recent extreme weather events include the Winnipeg floods, which caused three deaths and left 25,000 people homeless. The 1998 ice storm in southern Quebec and eastern Ontario is associated with 60,000 injuries and 25 deaths, many related to the failure of the electricity grid to deliver power to 3.6 million people.

Infectious diseases. New diseases, or diseases more common in tropical countries, may spread to Canada with climate change. Here's why: Warmer temperatures cause favourable conditions for population increases in insects and animals (referred to as vectors), which spread some infectious diseases. Increases in the geographical distribution (altitude and latitude) of insects and animals that carry various infectious diseases are expected with climate change. Some types of encephalitis, snow shoe hare virus and malaria, dengue and yellow fever could possibly extend northward into Canada.

The range of tick-borne diseases such as Lyme disease and Rocky Mountain spotted fever is also expected to expand. The incidence of hantavirus pulmonary syndrome, which is carried by rodents,

could also increase depending on climate and other variables.

Simulations by mathematical models predict that the portion of the world population living in malaria zones will jump from 45 per cent to 60 per cent by the latter half of this century. This increase, combined with increased travel by Canadians to malaria endemic zones, is expected to significantly boost incidences of imported malaria into Canada (see Figure 1). In anticipation of this increase, Canadian customs forms now carry a warning about infectious diseases picked up overseas (and specifically name malaria) to all travellers entering Canada.

Food and water contamination. Increases in such infectious diseases as cholera, salmonellosis, and other food- and water-related infections are expected, because of the impact of climate change on water distribution and temperature, and microorganism profileration in water. Water contamination due to disease-causing bacteria may increase, along with the incidence of seafood toxins.

Some recent events point to the link between warmer temperatures and food and water contamination: Increased water temperatures were considered responsible for a case of poisoned shellfish in Prince Edward Island. Similarly, a cholera outbreak in Peru was attributed to warmer water temperatures, which enabled disease-causing organisms to survive longer than expected.

The search for reliable models

Most of the research carried out on climate change to date has looked at the impacts of climate change in very broad regional areas. There are about 30 models used worldwide to predict the impacts of climate change, mostly to assess altered precipitation and temperature patterns. The models used by Canada and the United Kingdom are acknowledged to be the best in the world.[1] The Canadian model divides the globe into segments measuring 300 square kilometres, and predicts the impacts in these segments to come up with national estimates of future weather patterns.[2]

However, a model that uses segments measuring 30 sq. km would be required to develop regional estimates with any degree of accuracy. Such a model has yet to be developed.[3] For this reason, comments on the specific health impacts of climate change will cover broad regional areas for the foreseeable future.

Disease outbreaks and changing weather

There is already strong evidence to indicate a correlation between disease outbreaks and changing weather patterns. For example, such weather variations as El Niño and the Southern Oscillation have been linked to increases in the incidence of infectious diseases, including such insect-borne diseases as malaria and Rift Valley fever (RVF), and such epidemic diseases as cholera and shigellosis.[4]

El Niño and the Southern Oscillation (referred to as ENSO in scientific literature) refers to a climatic phenomenon that occurs about every five years, when the ocean off Peru becomes unusually warm for several months, disrupting normal weather patterns, causing heavy rains in some areas and droughts in others, and often resulting in milder winters in the northeastern United States and western Canada. The Southern Oscillation refers to atmospheric changes that occur at the same time as the El Nino warming trend.

Substantial documentation exists on the link between ENSO and such diseases as malaria and RVF. Less well documented, but of increasing interest, are the effects of the ENSO climatic phenomenon on dengue (or breakbone) fever, a largely urban disease present in tropical regions around the world, which is spread by mosquitoes that breed in artificial containers. Dengue fever is present in some of the mosquitos in southern Florida, and the "competent" mosquito vectors (i.e. mosquitos belonging to the mosquito families capable of carrying and spreading the disease) for dengue have reached as far north as Chicago.[5]

Malaria epidemics coincident with ENSO events have been documented in Bolivia, Columbia, Ecuador, Peru and Venezuela in South America; in Rwanda in Africa; and in Pakistan and Sri Lanka in Asia. Historically, in the Punjab region of northeastern Pakistan, the risk of malaria epidemics increases five-fold during the year following a major El Niño event, and in Sri Lanka, the risk of a malaria epidemic increases four-fold during an El Niño year. These increased risks are associated with above-average levels of precipitation in the Punjab and below-average levels of precipitation in Sri Lanka.

What can engineers do?

The potential health impacts of climate change appear to be wide ranging. At this early stage, engineers should be aware of the various health impacts that may need to be addressed in the future. (See "Engineers, climate change and human health," on p. 33.) ◆

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Figure 1. Imported Malaria Cases in Canada

Year	Reported cases of imported malaria[6]	Estimated actual cases of imported malaria
1984	350	580-1170
1985	360	600-1200
1986	420	700-1400
1987	520	870-1740
1988	320	530-1060
1989	300	500-1000
1990	400	670-1340
1991	680	1130-2260
1992	400	670-1340
1993	460	770-1540
1994	430	720-1440
1995	621	1030-2060
1996	1003	1670-3340
1997	1029	1720-3430

References

1. Personal communication, Henry Hengeveld, Meterological Service of Canada (referring to *Science Magazine*).
2. Ibid.
3. Ibid.
4. "El Nino and Health Impacts," *Canada Communicable Disease Report*, vol. 24-22, November 15, 1998 (www.hc-sc.gc.ca/hbl/lcdc/publicat/ccdr).
5. Personal communication, Dr. Robin Lindsey, Canadian Laboratory for Disease Control, Winnipeg, Manitoba.
6. Health Canada CCDR, Vol 25-6, March 15, 1999.

Engineers, climate change and human health

What's the relevance?

Engineers have an important role to play in protecting the public from the potential health impacts of climate change. The two most important concerns for engineers over the short- to medium-term are the impacts of severe or warmer weather on water treatment systems, and the impacts of hotter weather on air quality and therefore human health.

Water treatment system design

Engineers will need to consider the impact of erratic weather and even catastrophic weather events on water quality and water treatment system design. Why? Consider the following: Cryptosporidium outbreaks in British Columbia have been attributed to flash flooding after a period of drought. Although the results of the Walkerton inquiry are not available yet, it's likely that the heavy rainfall that preceded the event contributed in part to contamination of the water supply by E. coli bacteria.

These two examples both illustrate the need to design water treatment systems for more erratic weather events–particularly flash floods–and to consider the impacts these events may have on raw water quality, and therefore treatment requirements. Given that one of the other predicted impacts of climate change is lower water levels in the Great Lakes and degraded raw water quality because of water shortages, water treatment engineers will have their work cut out for them, as conditions change over time. A third, water quality related consideration is the possibility of more cholera episodes, again related to a slight warming of water temperatures, and the ability of the bacteria that cause cholera to survive in areas where the disease has not traditionally been experienced in the past.

Energy use, air quality and human health

A second link engineers need to understand is the one between energy use, air quality and human health. Engineers will need to consider how climate change will affect air quality as it becomes more pronounced, and more importantly, what they can do to tackle the problem.

One of the projected impacts of climate change is more warmer days in summer. London, Ontario, for instance, experienced 10 days per year with temperatures above 30C on average for the years between 1951 and 1980. Scientists have predicted that, unless significant measures are taken to reduce air pollution, the carbon dioxide in the atmosphere will reach twice the level it was before the Industrial Revolution, which is considered the natural CO_2 level without input from human-made sources. Under this "two-times CO_2 scenario," London can expect to see 46 days per year when the weather is hotter than 30C.

Hotter days increase the speed of smog formation, causing health problems related to the respiratory and cardiovascular systems. Several recent studies have put the annual number of premature deaths related to poor air quality in southern Ontario at about 1800. This number is expected to get much higher with climate change.

The compounding problem for Ontario, and many parts of the U.S. that expect warmer weather with climate change, is that as temperatures rise, more people use air conditioners, increasing the demand for electricity. In Ontario, where about 30 per cent of our electricity is generated by coal, hot weather will increase the demand for electricity, and therefore the emissions created. This, in turn, will see smog episodes and health problems related to smog spiral in the wrong direction.

The burning of fossil fuels creates 90 per cent of greenhouse gas emissions, 55 per cent of sulfur dioxide emissions, 90 per cent of nitrous oxide emissions, 55 per cent of volatile organic compound emissions and 90 per cent of carbon monoxide emissions. Therefore, any contribution engineers can make to reducing the burning of fossil fuels will improve air quality and therefore human health.

Options for reducing greenhouse gas emissions include:

- switching to cleaner energy sources–from coal to natural gas or low or zero emission sources (wind, solar, etc.);
- fuel switching in automobiles and other transportation vehicles–from gasoline to propane, ethanol blends or fuel cells, etc.;
- increased energy efficiency in industry, business and homes, resulting in less energy demand;
- energy-efficient agricultural and forestry practices;
- use of carbon sinks and carbon storage to remove CO_2 from the atmosphere; and
- carbon emissions trading.

Engineers also need to realize the urgency of developing non-carbon-based sources of energy to replace some or all of the carbon-based capacity we currently use, and which we will need more of in the future, unless we find alternatives. ◆

Trends to watch for

Other trends related to climate change that affect engineers include:

Building materials and cooling systems. A changing climate will affect the way building materials function. A number of building design engineers have already reported to Environment Canada an unexpected deterioration of building materials, because of higher than expected moisture levels. Increased moisture creates additional mold, which in turn affects indoor air quality and the health of building occupants. Building codes and practices may have to change over time to adapt to subtle changes in air moisture.

Changing climates will also mean changes in the way buildings should function. If we have more warm weather in summer, buildings will need to be designed to take advantage of as much natural shade as possible, to help minimize our requirements for air conditioning and thus electricity. Engineers will also need to design more energy-efficient building cooling systems. The ideal solution is to find ways to cool buildings through renewable energy and non-carbon-based sources

Emergency preparedness. Recent catastrophic climate- or weather-related events, such as the Winnipeg and Saguenay floods and the 1998 ice storm, illustrate the huge human and physical impacts of erratic weather. Before the next catastrophic weather event occurs, emergency plans need to be in place, as well as methods of providing for short-term assistance to affected citizens–particularly in the area of distributed power.