# 8. Quality of Life

## Human Health

*study conducted by*

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### Current Stresses

#### Heat-related Morbidity or Mortality

A variety of weather phenomena can cause injury and death to humans. People who lack protection to extremely hot or cold weather will eventually suffer from disturbances of normal physiological functions. Exposure to extreme, prolonged heat is associated with cramps, fainting (syncope), heat exhaustion, and ultimately heat stroke. Within limits, however, what is meant by "extreme" is somewhat relative, partly depending on previous exposure, physiological adaptation, age, and other health conditions. Furthermore, the impact of temperature extremes depends on the length of time that people have been exposed to local conditions, socioeconomic status and ability to cope, genetic predispositions to various conditions, and various physiological factors [8-1]. Some "heat waves" may last for a few days or for weeks, but the difference can influence how people with previous exposure or social conditions respond. Long or repeated heat waves may not allow people's bodies to recover from the heat. Also, since heat waves often occur with little or no rain, high humidity, elevated ozone, and other air pollutants ($NO_2$, $SO_2$, and particulates), susceptibility to these conditions also will affect health outcomes.

Climate change impacts on human health in the Great Lakes region are likely to be greatest in urban areas, especially where extremely high temperatures historically have been rare. For example, July 1999 was the hottest on record in New York. As many as 70 people died in Chicago during a 1999 summer heat wave with temperatures reaching 99°F [8-2]. But, heat waves are not new to Chicago. In 1995, more than 700 (most of them elderly) died from exposure to extreme heat. The impact from heat stress can be minimized through appropriate behavioral adaptations, e.g., using air conditioning, wearing light clothing, and maintaining hydration. Perhaps more important than the daytime high temperatures are the high nighttime lows, particularly in urban areas. Because the poor, elderly, very young, and otherwise ill tend to be less able to withstand extreme temperatures, they are more susceptible to the effects of these extremes. In addition, persons who must work outside or who lack access to indoor cooling also are at greater risk.

Output from the HadCM2 and CGCM1 models was examined to see how high temperatures would increase from the present (e.g., 1975-1994) to the end of the 21st century (e.g., 2080-2100). Model-forecasted atmospheric thicknesses were used rather than model-forecasted high temperatures, based on the assumption that this deep tropospheric parameter is a more accurately-forecasted variable than surface temperatures and so is a better proxy for identifying extreme heat episodes in GCMs. The results from both models for the warm season (May 1 – October 31) are shown in Figure 8.1. The CGCM1 model suggests a significant increase in days above 90°F – while the HadCM2 model suggests a more modest increase. Additionally, the distribution of temperatures in the HadCM2 model is broader than that in the CGCM1. Interestingly, both models suggest a decrease in interannual variability – in contrast to the popular notion that weather may become more variable.

## Severe Weather Events

In addition to extreme temperatures, other impacts from short-term, extreme weather events such as floods, tornadoes, and blizzards, may affect health. In the Great Lakes region, heavy precipitation events have increased in frequency over the last 100 years. Both the HadCM2 and CGCM1 suggest these will continue to occur with increasing frequency. Unlike the prolonged periods of extreme heat that gradually cause death, extensive precipitation producing floods can cause immediate injury and death. Future changes in other extreme weather events are difficult to assess. The historical record indicates a slight decrease in thunderstorms for the Central US and a significant increase for the entire US in tornadoes over the last 50 years [8-3]. Because a tornado has to be seen before it can be counted, these numbers may be skewed by increasing population density. Additionally, GCM limitations (e.g., in resolution), preclude an ability to assess whether frequencies or intensities of these types of (small scale) extreme weather events, such as severe thunderstorms or tornadoes, will change. Even if such events decrease (slightly) in frequency, they will likely continue to cause more property damage because of increases in population, wealth, and inflation that will likely continue. Indirect effects from wind, flooding or drought may also produce longer lasting and further reaching impacts on housing, food production, drinking water, and social infrastructure. The extent to which such events will harm people's well-being largely depends on early warning and disaster preparedness.

## Air Pollution and Respiratory Diseases

Another possible impact of climate change and variability on health in the region involves the air that we breathe. Many forecasts suggest increases in ground level air pollutants, some of which may exacerbate asthma and other respiratory illnesses and tax cardiac function [8-4].

Local levels of gases such as sulfur dioxide, nitrous oxides and ozone, as well as various kinds of aerosolized particulate matter already have been increasing in some areas. In addition, warmer weather can enhance fungal spores and pollen, which in turn may increase allergic reactions. As with most possible health impacts, the association with climate is not well understood, making forecasts of future risk is uncertain. In the Great Lakes region, air pollution associated respiratory disease has not been well studied. Results suggest that air pollutants are but some of many factors involved in the etiology of respiratory diseases. Furthermore, different studies have produced inconsistent results.

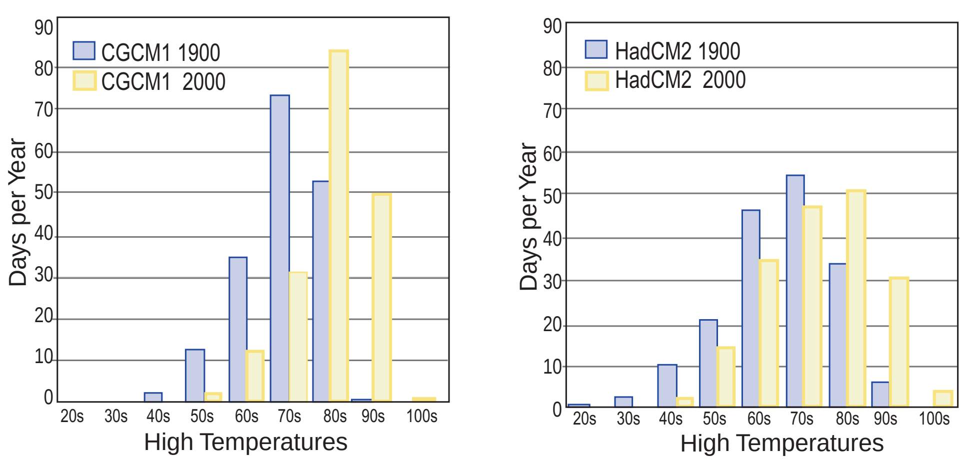


*Figure 8.1: Annual GCM-derived distributions of days with high temperatures per year for the warm season (May – October) for a current 20 year period (labeled 1900) and for a future 20 year period (labeled 2000). For the CGCM1 model (left) the current period is 1975-1994 and the future period is 2080-2099. For the HadCM2 model (right) the current period is 1970-1989 and the future period is 2078-2097.*

A simple analysis of the output from the CGCM1 and HadCM2 models suggests that the number of days with synoptic patterns that are conducive to high ozone will increase by the end of this century. High ozone days are basically characterized synoptically by southwesterly flow, high pressure (e.g., anti-cyclonic flow), and high heat (e.g., temperatures above 90°F). Table 8.1 shows how the number of days when all three conditions exist simultaneously will increase for Detroit, Michigan – primarily as a result of more days with high heat.

### Infectious Diseases and Weather Variation

Many impacts of climate change on infectious diseases have been suggested. New studies are currently underway to examine whether temporal variation in incidence of selected infectious diseases is related to that of temperature, precipitation, and other weather variables [8-5]. In collaboration with the Michigan Department of Community Health, case data from 1984 through 1998 are being studied using time-series analysis. County-specific data for reported cases of aseptic meningitis, hepatitis A, and salmonellosis have been transferred and organized for initial study. Possible links to climate are suggested for all three diseases since the temporal pattern of each is strongly seasonal and there is considerable variability from one year to the next. However, before more extensive time-series and autocorrelation analysis can be undertaken, the data must be adjusted in various ways. First, local, point source outbreaks must be considered and possibly eliminated. Second, GIS-based mapping by county shows that there is considerable variability among regions, suggesting that analysis by subregions may be needed. In that case, weather data from stations within each region will be used in conjunction with synthetic monthly average data to search for temporal patterns. Finally, it may be necessary to calculate age-specific incidence rates since each disease has more cases in certain age groups and the proportion of the population in each age group may differ among regions and over time. Once these adjustments have been made, it will be necessary to search for patterns of association over time that might demonstrate occurrence of excessive cases following unusual weather patterns. In addition to these diseases, similar analyses of cases are planned for cryptosporidiosis, giardiasis, histoplasmosis, influenza, and leptospirosis, among others.

## Coping Strategies

Responses to various health threats posed by climate change will vary considerably depending on the etiology of each condition [8-6]. Extreme heat-associated morbidity and mortality is well understood and technically easy to prevent. If increased extreme heat events were to occur in the future, then a combi-

| Model | Years | Southwest flow | High pressure | High heat | High ozone |
|---|---|---|---|---|---|
| **Current 20-year period** | | | | | |
| CGCM1 | 1975-1994 | 1570 | 2205 | 10 | 3 |
| HadCM2 | 1970-1989 | 1295 | 2162 | 140 | 22 |
| **Future 20-year period** | | | | | |
| CGCM1 | 2080-2099 | 1603 | 2171 | 987 | 377 |
| HadCM2 | 2078-2097 | 1254 | 2167 | 582 | 157 |

*Table 8.1: Total number days with favorable synoptic conditions for high ozone during the warm season (May – October), in Detroit, Michigan . For the CGCM1 model the current period is 1975-1994 and the future period is 2080-2099. For the HadCM2 model the current period is 1970-1989 and the future period is 2078-2097.*

nation of improved forecasting, information distribution, and special assistance to high risk populations should compensate for most of the increased risk. Physiological adaptation is possible over a period of years, but since most stress occurs during short-term extreme events, this may not allow for such adaptation. Improved economic well being and education of urban poor and elderly would allow these groups to better cope through increased use of fluids and air conditioning.

Other extreme events such as tornadoes or floods demand better forecasting and advance warning, but responses depend more on preparedness and disaster relief than individual behaviors. Preventing construction of dwellings on flood plains, improving the construction of houses, and enhancing knowledge of responses to extreme winds or floods should help to reduce impacts from these events. Unusual precipitation that may not produce catastrophic flooding yet may impact on infectious diseases can be addressed with a combination of improved storm drainage systems, and warnings to avoid high-risk areas. The impacts of air pollutants on health can be decreased if susceptible people are given warning of severe conditions. The eldery or those with preexisting respiratory conditions may be warned to minimize time spent outdoors during the stagnant air conditions assoiciated with increased ground level air pollutants. In extreme cases, the only response may be to move from more polluted urban areas, or even to leave the Great Lakes region entirely for less polluted and less humid climates.

The climate link to variability in infectious disease risk is different for each disease, but appears to be important for certain diseases. Most are highly seasonal, suggesting that normal variation can be foreseen and appropriate warning made. A few such diseases (e.g. influenza, rabies, Lyme disease) have effective vaccines, which can be obtained prior to exposure. Others have known behaviors associated with risk, making education and behavior changes the most effective response. For example, risk of most vector-borne diseases of the region (e.g. Lyme disease, Eastern Equine Encephalitis, etc.) can be reduced significantly by changes in activity, clothing, or housing, so that responses mostly involve education. Finally, many of these diseases respond to post-exposure antibiotics, permitting treatment that is usually curative.

## Information & Research Needs

The difficulties, inadequacies, and uncertainties in both the forecasts of possible climate change and the effects on public health demonstrate that major research efforts are needed to better understand and develop eventual mitigation strategies [8-7]. Diverse biological and physical systems, the long time during which processes are likely to occur, and the uncertainty inherent in these interactions all suggest that research has become vitally important, yet extremely difficult. More research is needed, but so is a shift in the kinds of investigations. At present, systematic, long-term surveillance data on many diseases is inadequate to permit rigorous study of historical patterns. Many of the important interactions involve diverse variables that range from physiology to economic policy, from microbiology to social behavior. New theory and analytic tools are needed that not only incorporate such interactions, but also analyze climate variability as part of a much larger arena of environmental change, that considers human disease as part of political ecology.

### Long-Term Monitoring and Analyses

As many recent reports have argued, the problem of emerging diseases, disease surveillance in the US, and surveillance assistance to other countries are woefully inadequate. Without systematically gathered epidemiological records, the basic information needed to track and retrospectively analyze changes in disease patterns is lacking. Disease gathering in the Great Lakes region differs among cities and states, making some surveillance data difficult to interpret. These data are critical to studies aimed at understanding disease trends, analyzing retrospectively changes associated with the environment, and eventually modeling future outbreaks and situations of high risk. Such data is vital for developing casual hypotheses and is the best way to test these predictions prospectively. In addition to the important role that surveillance plays in recognizing new and emerging diseases, surveillance data is essential to the study of climate impacts on health.

## Environmentally-Based Research and Evaluation

Another new research emphasis could focus on identifying and understanding disease-specific environmental factors that can be used to prevent outbreaks before they occur. Climate variables are among many such environmental factors. In the Great Lakes region, well-designed experiments are needed to explore how multiple variables interact, and how diverse climate conditions impact on their interactions. Classical laboratory experiments aimed at demonstrating dose-response or transmission of infectious agents cannot fully replicate the diverse conditions that occur under natural climate variation. Unfortunately, an increasing focus on simple experiments that produce rapid results has meant that long-term prospective observations have declined. Other experiments that evaluate how changing environments may lead to rapid evolution will enhance understanding of when adaptation may occur in the face of gradual climate change during the next century.

## Multidisciplinary Perspectives and New Analytic Techniques

Not only must the extent and coverage of observations be improved, but new methods for gathering or analyzing data and interpreting patterns are also needed. The complex interactions among physical, biological, and socioeconomic variables that determine disease risk suggests that more multidisciplinary studies are needed. In addition to the traditional disciplines such as climatology, immunology, or physiology, the determinants of health outcome involve sociology, psychology, and economics, etc. Thus, new methods are needed that could include theoretical studies of complex dynamic behavior, spatial statistical investigations of disease ecology during environmental change, or integrative modeling of socioeconomic development impacts on pathogen transmission. Studies of multivariable interactions that may have spatio-temporal fluctuations, nonlinearities, thresholds, or time-lags will require different conceptual foundations and new analytic tools. Methods for studying interactions among qualitatively different kinds of variables are needed to address the complex processes that occur as climate change impacts on health. More simulation modeling involving socioeconomic and behavioral adaptation will be particularly instructive.