CLIMATE CHANGE AND HUMAN HEALTH

GEORGE LUBER, PhD and NATASHA PRUDENT, MPH (*both by invitation*)

ATLANTA, GEORGIA

ABSTRACT

Climate change science points to an increase in sea surface temperature, increases in the severity of extreme weather events, declining air quality, and destabilizing natural systems due to increases in greenhouse gas emissions. The direct and indirect health results of such a global imbalance include excessive heat-related illnesses, vector- and waterborne diseases, increased exposure to environmental toxins, exacerbation of cardiovascular and respiratory diseases due to declining air quality, and mental health stress among others. Vulnerability to these health effects will increase as elderly and urban populations increase and are less able to adapt to climate change. In addition, the level of vulnerability to certain health impacts will vary by location. As a result, strategies to address climate change must include health as a strategic component on a regional level. The co-benefits of improving health while addressing climate change will improve public health infrastructure today, while mitigating the negative consequences of a changing climate for future generations.

In 2007, the Intergovernmental Panel on Climate Change (IPCC) published a landmark report on climate change. There is unequivocal evidence of global warming. Most of the warming within the past 50 years is very likely attributed to increases in greenhouse gases ([1]). The physical and biological systems on all continents and oceans are already affected by global warming. The next few decades are likely to witness more warming. The effect of emissions in the long term is becoming more evident.

The worldwide effects of climate change are apparent from the evidence of global destabilization of natural systems. These effects include the melting of icecaps and glaciers, the early arrival of spring, the warming of oceans, rising sea levels, extreme weather patterns and the disintegration of coral reefs ([1]). Some projections of future changes in climate as per the IPCC 2007 report are as follows:

Correspondence and reprint requests: George Luber, Associate Director for Global Climate Change, Division of Environmental Hazards and Health Effects, National Center for Environmental Health, CDC, 4770 Buford Highway, NE, MS F-57, Atlanta, Georgia 30341, Tel: 770-488-3429, E-mail: gluber@cdc.gov

Potential Conflicts of Interest: None disclosed

- Very likely (>90% probability) that heat waves will become more intense and more frequent
- Very likely (>90% probability) that heavy precipitation events will become more frequent
- Likely (>66% probability) that tropical cyclones will become more intense, with larger peak wind speeds and heavier rainfall
- Likely (>66% probability) increase in areas affected by drought
- Likely (>66% probability) increase in incidence of extremely high sea level

There will be significant regional variations in the effects of climate change and its affected demographic groups.

Added to the climate change-driven increases in temperature are the effects of the urban "built" environment. In fact, cities and their climates are co-evolving in a manner that will amplify the effect of heat as well as the vulnerability of urban populations to heat-related deaths. For example, more than half of the planet's human population now lives in cities, up from 30% only 50 years ago. Urban areas are gaining an estimated 67 million people per year—about 1.3 million every week ([2]). By 2030, approximately 60% of the projected global population of 8.3 billion will live in the cities. This population increase will accompany rapid urbanization, quickly transitioning communities from native vegetation to an engineered infrastructure that increases thermal-storage capacity, known as the Urban Heat Island (UHI) effect.

The UHI effect can be a powerful force in the local climate. The combined effect of the high thermal mass provided by concrete and blacktop roads and the low ventilation ability of the urban "canyons" created by tall buildings extends the temperature increases created by climate change. Relative to the surrounding rural areas, UHI can add 2–10°F to ambient air temperature ([3–5]). More importantly, UHI absorbs heat during the day and radiates it out at night, raising nighttime minimum temperatures, which have been epidemiologically linked to excess mortality ([6]).

With regard to heat waves, media attention on climate change tends to focus on mean changes in temperature. However, the extremes in temperature impact people more than mean temperature increases and in greater numbers ([7]). In 2003, heat waves (extreme temperature events) killed an estimated 29,817 to 30,617 people in Europe through heat stroke, and exacerbated cardiovascular, cerebrovascular and respiratory diseases ([8]). A large portion of these deaths occurred among the elderly and socially isolated; these are the segments of population most susceptible to extreme heat ([8, 9]). According to the most recent studies, heat waves are projected to increase in frequency and in duration [10].

UHI and the CO_2 dome will influence air quality through their impact on urban aeroallergens. Increased CO_2 levels and temperature will result in a longer growing season, leading to an increase in ragweed and pollen counts [11]. For air quality in rural areas, forest fires present a major threat since climate change affects the hydrologic cycle and cause drier conditions. Young children, pregnant women, the elderly and people with preexisting respiratory and cardiac diseases are the most likely to be affected by poor air quality due to aeroallergens and/or smoke.

Increased frequency of intense rainfall (extreme precipitation events) is associated with an increasing severity of floods, landslides, debris and mud flows [12]. This has already been witnessed in parts of Bangladesh, Nepal, and India. Increases in sea surface temperature have caused an increase in tropical cyclone intensity leading to an increase in the height of storm surges. Large populations live along South Asia's coastline, and they will face the brunt of increasing tropical cyclones.

Increased frequency of extreme precipitation events will bring with it the increased risk of waterborne disease outbreaks [13]. Aging sewer systems or treatment plants, which by design drain excess untreated storm and wastewater runoff into surface water bodies, may quickly become overburdened as a result of heavy rainfall events [14]. In 1993, Milwaukee experienced a *Cryptosporidium* outbreak that resulted in 405,000 exposed persons and 54 fatalities. The outbreak was preceded by the heaviest rainfall in 50 years within the associated Milwaukee watershed [13, 15].

Rising temperatures corresponding with increased CO_2 emissions create more suitable habitats for harmful algal blooms. These blooms thrive in warm surface waters and nutrient runoffs from sewage overflows into surface water bodies. Algal blooms produce powerful liver toxins, are associated with an increased incidence of hepatic cancer and are spreading from tropical waters to historically cooler waters as surface water temperatures rise. The potent toxins produced by the blooms may contaminate drinking water and pose a serious threat to public health infrastructure. Exposure to the toxin may occur indirectly through the consumption of exposed fish, causing Ciguatera fish poisoning [16]. Algal blooms also disrupt existing ecosystems, as seen in the dying-off of sea grass and adjacent coral reef systems in Florida bay estuaries [17].

Climate variability may impact the distribution and abundance of vertebrate host species, leading to an increase of vectorborne and zoonotic diseases ([18, 19]). Climate forecast models suggest that vectors, which serve as bridges between animal and human hosts, are expected to increase in frequency and range. In such models, certain species of ticks that can carry Lyme disease are expected to expand their range from the northeastern United States into Canada due to warming winter months ([20]). Yet the spread of diseases preceded by climatic factors must take into consideration the changing social, economic and epidemiological landscapes that facilitate disease transmission ([18]).

The breadth of potential health consequences due to climate change vary from the direct effects of temperature increases, such as heat waves and other severe weather events, to the indirect effects of population displacement and mental health issues. Strategies to minimize health-related burdens of climate change need to focus on improving responses to many ongoing issues that will occur with greater frequency, intensity and geographic range. Regional strategies are needed since the health and vulnerability of populations to climate change vary by location. Regional collaboration and integration also help to preserve already strained resources.

All strategies will need to include improved surveillance of environmental and health data systems already in place. Regional and citywide needs must be assessed with public health services retooled so that these areas provide effective responses. Another important principle is the concept of co-benefits, or synergies between mitigation efforts and health in the form of adaptation measures. Climate change mitigation programs can provide opportunities to reduce greenhouse gas emissions while benefiting health at the same time ([21]).

To conclude, climate change is now a mainstream issue and must be framed as a public health concern. It is for this reason that the costs of not taking appropriate and timely action are high.

REFERENCES

1. Solomon S, Qin D, Manning M, et al, eds. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK, and New York: Cambridge University Press 2007. (Accessed at http://www.ipcc.ch/ipccreports/ar4-wgl.htm.)
2. United Nations. World Urbanization Prospects: the 2005 revision. In: Department of Economic and Social Affairs, Population Division: Working Paper ESA/P/WP/2000 2006.
3. Luber G, McGeehin M. Climate change and extreme heat events. American Journal of Preventive Medicine 2008;35:429–35.
4. U.S. Environmental Protection Agency. Heat Island Effect. U.S. Environmental Protection Agency 2005. (Accessed at http://www.epa.gov/heatisland/index.htm.)

5. Vose RS, Karl TR, Easterling DR, Williams CN, Menne MJ. Impact of land-use change on climate. Nature 2004;427:213–4.
6. U.S. Environmental Protection Agency. Excessive Heat Events Guidebook 2006. (Accessed at http://epa.gov/heatisland/about/pdf/EHEguide_final.pdf.)
7. Peterson T, Zhang X, Brunet-India M, Vázquez-Aguirre J. Changes in North American extremes derived from daily weather data. Journal of Geophysical Research 2008;113.
8. Haines A, Kovats RS, Campbell-Lendrum D, Corvalan C. Climate change and human health: Impacts, vulnerability and public health. Public Health 2006;120:585–96.
9. Argaud L, Ferry T, Le Q-H, et al. Short- and long-term outcomes of heatstroke following the 2003 heat wave in Lyon, France. Archives of Internal Medicine 2007;167:2177–83.
10. Meehl GA, Tebaldi C. More intense, more frequent, and longer lasting heat waves in the 21st century. Science 2004;305:994–7.
11. Ziska L, Gebhard D, Frenz D, Faulkner S, Singer B, Straka J. Cities as harbingers of climate change: common ragweed, urbanization, and public health. Journal of Allergy and Clinical Immunology 2003;111:290–5.
12. Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, and Hanson CE, eds. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press 2007. (Accessed at http://www.ipcc.ch/ipccreports/ar4-wg2.htm.)
13. Patz JA, Vavrus SJ, Uejio CK, McLellan SL. Climate change and waterborne disease risk in the Great Lakes Region of the U.S. American Journal of Preventive Medicine 2008;35:451–8.
14. Perciasepe R. Combined sewer overflows: where are we four years after adoption of the CSO control policy? EPA Office of Wastewater Management. Washington DC 1998.
15. Curriero FC, Patz JA, Rose JB, Lele S. The association between extreme precipitation and waterborne disease outbreaks in the United States, 1948–1994. American Journal of Public Health 2001;1194–9.
16. Monis J, Lewin P, Smith CW, Blake P, Schneider R. Ciguatera fish poisoning: epidemiology of the disease on St. Thomas, U.S. Virgin Islands. American Journal of Tropical Medicine and Hygiene 1982;31:574–8.
17. Williams C, Burns J, Pawlowicz M, Carmichael W. Assessment of Cyanotoxins in Florida's lakes, reservoirs, and rivers. Palatka, FL: St. Johns River Water Management District 2001.
18. Gage KL, Burkot TR, Eisen RJ, Hayes EB. Climate and vectorborne diseases. American Journal of Preventive Medicine 2008;35:436–50.
19. Gubler D, Reiter P, Ebi K, Yap W, Nasci R, Patz J. Climate variability and change in the United States: potential impacts on vector- and rodent-borne diseases. Environmental Health Perspective 2001;109:223–33.
20. Ogden NH, Maarouf A, Barker IK, et al. Climate change and the potential for range expansion of the Lyme disease vector Ixodes scapularis in Canada. International Journal for Parasitology 2006;36:63–70.
21. Frumkin H, McMichael AJ, Hess JJ. Climate change and the health of the public. American Journal of Preventive Medicine 2008;35:401–2.