Climate Change and Human Health: Risks and Responses

2008 MAWWEC

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The polar bear might not be the only threatened species

“How it threatens your health”
HEALTH EFFECTS OF CLIMATE CHANGE

Temperature Rise 1
Sea level Rise 2
Hydrologic Extremes

1 3°C by yr. 2100
2 40 cm “ “
IPCC estimates

Patz, 1998

CLIMATE CHANGE

Urban Heat Island Effect
Air Pollution & Aeroallergens
Vector-borne Diseases
Water-borne Diseases
Water resources & food supply
Mental Health & Environmental Refugees

Heat Stress
Cardiorespiratory failure
Respiratory diseases, e.g., COPD & Asthma
Malaria
Dengue
Encephalitis
Hantavirus
Rift Valley Fever
Cholera
Cyclospora
Cryptosporidiosis
Campylobacter
Leptospirosis
Malnutrition
Diarrhea
Toxic Red Tides
Forced Migration
Overcrowding
Infectious diseases
Human Conflicts
Climate Change and Human Health in Minnesota

- Heat-related mortality & morbidity
- Changes in air quality
- Water-borne diseases
- Airborne allergens
- Infectious diseases
The direct health effects of heat
Increased Mortality Risk During Heat Waves (1993, 2020 and 2050)

Sources: Kalkstein and Green (1997); Chestnut et al. (1995)

Note: Includes both summer and winter mortality. Assumes full acclimation to changed climate. Includes population growth.

GFDL Climate Change Scenario
HEAT WAVE - EUROPE

approx. 30,000 deaths over 11 days

Heat Index Summer 2003
European heat wave, 2003


<table>
<thead>
<tr>
<th>Country</th>
<th>Confirmed Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>2,091</td>
</tr>
<tr>
<td>Italy</td>
<td>3,134</td>
</tr>
<tr>
<td>France</td>
<td>14,802</td>
</tr>
<tr>
<td>Portugal</td>
<td>1,854</td>
</tr>
<tr>
<td>Spain</td>
<td>4,151</td>
</tr>
<tr>
<td>Switzerland</td>
<td>975</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1,400-2,200</td>
</tr>
<tr>
<td>Germany</td>
<td>1,410</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>29,817-30,617</strong></td>
</tr>
</tbody>
</table>
EPA’s “Excessive Heat Events Guidebook”

• “The severity and duration of summertime regional air pollution episodes are projected to increase in the Northeast and Midwest US by 2045-2052 due to climate-change-induced decreases in the frequency of surface cyclones.” (IPCC, 2007)

• By 2050, warming alone may increase by 68% the number of Red Ozone Alert days across the Eastern US. (IPCC, 2007 -Bell et al, 2006)
Climate Change and Air Quality

• Climate change will likely affect air quality (e.g., ozone) in our cities
• Climate change may make it more difficult to attain air quality standards in certain areas
• “Climate penalty” may push areas that are in attainment into non-attainment
• Additional emissions reductions may be required in the future
• Opportunity to anticipate and adapt: We have an opportunity to begin folding considerations of climate change into our planning

Forthcoming: EPA Assessment of the Implications of Climate Change for Regional Air Quality in the U.S. (Spring 2008)
‘Co-Benefits’ of GHG Reduction

Fossil Fuels are source of GHGs and local air pollutants

• Deaths from Air Pollution ranked within top 10 causes of disability

• 800,000/yr avoidable deaths due to outdoor PM air pollution (WHO, 1997)

• 3/4 of the world’s 24 megacities are in developing countries; GHG mitigation --> major ‘co-benefits’ (Cifuentes et al 2001)
For Madison, if 20% of car trips were replaced by bike trips:

1. **10 lbs (4.5 kg) lost /person/yr** (for 6.8 mi. roundtrip commute)

2. 12% fall each in **Ozone** and **NOx**: 2% drop in **PM$_{2.5}$**
   - 17,990 fewer lost-work days/yr
   - 1,906 fewer Asthma admissions/yr
   - 14,586 fewer acute respiratory cases/yr
   - $40 million saved in health costs/yr

3. **16,687 tons of CO$_2$** not emitted

The Triple Win

Grabow et al, in preparation
Climate change:
It’s not just about warming.
More Rainfall Occurring in Intense Downpours

Trends in Proportion of Annual Precipitation of Extreme Intensity (i.e., more than 2 in. per day): 1910-1995

Similar trends seen in southern Canada

(Source: Karl and Knight, 1998)
USA: Combined sewer overflows (CSOs)

1.2 trillion gal of sewage & stormwater a year discharged during combined sewer overflows – would keep Niagara Falls roaring for 18 days

Center for Water & Health, JHU Bloomberg School of Public Health
Combined Sewer Overflow in the Great Lakes Region
(Public review draft released in March 29th Federal Register Notice)

Key Questions:

- Does climate change matter to the redesign of combined sewer systems in the Great Lakes Region?

- When the climate changes, how might CSO event frequency change, and in how many cases will the four CSO events per year threshold be exceeded?

- If combined sewer systems are designed to meet the EPA’s CSO Control Policy design standard of 4 events per year, but fail to plan for climate change:
  
  - climate change may result in failure to meet the standard
  
  - there could be an average of 237 events per year above the control policy’s objectives across 182 communities
TMDLs in the Great Lakes Region
(Public review draft released in March 29th Federal Register Notice)

EPA’s TMDL program allocates pollutant loads to water bodies

Climate change could increase annual POTW treatment costs in the Great Lakes Region

- by $8-$97 million
- on impaired stream and river reaches
- further widening gap between funds needed for POTWs and funds available

Problem is manageable, but costly
Extreme Precipitation and Waterborne Disease Outbreaks in the United States, 1948-1994

Project Sponsor:
US EPA, Office of Research & Development

PI: J. Patz
Results

- **67%** of waterborne disease outbreaks were preceded by precipitation above the **80th percentile** (across a 50 yr. climate record), $p < 0.001$

- **51%** of outbreaks were preceded by precipitation above the **90th percentile**, $p < 0.002$

- Surface water-related outbreaks had strongest correlation with extreme precipitation in the month of outbreak; groundwater-related outbreaks lagged 2 months following extreme precipitation.

Global Warming's greatest threat may also be the smallest.
CLIMATE CHANGE IMPACTS ON THE UNITED STATES

**Ecosystem Models**
Maps of current and projected potential vegetation distribution for the conterminous US. Potential vegetation means the vegetation that would be there in the absence of human activity. Changes in vegetation distribution by the end of the 21st century are in response to two climate scenarios, the Canadian and the Hadley. Output is from MAPSS (Mapped Atmosphere-Plant-Soil System).

**Current Ecosystems**

**Canadian Model**

**Hadley Model**

- Tundra
- Taiga / Tundra
- Conifer Forest
- Northeast Mixed Forest
- Temperate Deciduous Forest
- Southeast Mixed Forest
- Tropical Broadleaf Forest
- Savanna / Woodland
- Shrub / Woodland
- Grassland
- Arid Lands
Relationship between temperature and malaria parasite development time inside mosquito ("extrinsic incubation period" or EIP). EIP shortens at higher temps, so mosquitoes infectious sooner.
<table>
<thead>
<tr>
<th>Disease</th>
<th>Vector</th>
<th>Population at risk (million)¹</th>
<th>Number of people currently infected or new cases per year</th>
<th>Present distribution</th>
<th>Likelihood of altered distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria</td>
<td>Mosquito</td>
<td>2,400²</td>
<td>300-500 million</td>
<td>Tropics and Subtropics</td>
<td>Highly likely</td>
</tr>
<tr>
<td>Schistosomiasis</td>
<td>Water snail</td>
<td>600</td>
<td>200 million</td>
<td>Tropics and Subtropics</td>
<td>Very likely</td>
</tr>
<tr>
<td>Lymphatic Filariasis</td>
<td>Mosquito</td>
<td>1,094³</td>
<td>117 million</td>
<td>Tropics and Subtropics</td>
<td>Likely</td>
</tr>
<tr>
<td>African Trypanosomiasis</td>
<td>Tsetse fly</td>
<td>55⁴</td>
<td>250,000 to 300,000 cases per year</td>
<td>Tropical Africa</td>
<td>Unknown</td>
</tr>
<tr>
<td>Dracunculiasis</td>
<td>Crustacean (Copepod)</td>
<td>100⁵</td>
<td>100,000 per year</td>
<td>South Asia, Arabian Peninsula, Central-West Africa</td>
<td>Unknown</td>
</tr>
<tr>
<td>Leishmaniasis</td>
<td>Phlebotomine sand fly</td>
<td>350</td>
<td>12 million infected, 500,000 new cases per year⁶</td>
<td>Asia, Southern Europe, Africa, Americas</td>
<td>Unknown</td>
</tr>
<tr>
<td>Onchocerciasis</td>
<td>Black fly</td>
<td>123</td>
<td>17.5 million</td>
<td>Africa, Latin America</td>
<td>Unknown</td>
</tr>
<tr>
<td>American Trypanosomiasis</td>
<td>Triatome bug</td>
<td>100⁷</td>
<td>18 million</td>
<td>Central and South America</td>
<td>Unknown</td>
</tr>
<tr>
<td>Dengue</td>
<td>Mosquito</td>
<td>1,800</td>
<td>10-30 million per year</td>
<td>All Tropical countries</td>
<td>Unknown</td>
</tr>
<tr>
<td>Yellow Fever</td>
<td>Mosquito</td>
<td>450</td>
<td>more than 5,000 cases per year</td>
<td>Tropical South America, Africa</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

1. Top three entries are population-prorated projections, based on 1989 estimates.
5. Ranque, personal communication.
6. Annual incidence of visceral leishmaniasis; annual incidence of cutaneous leishmaniasis is 1-1.5 million cases/yr (PAHO, 1994).

Source: Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.
A rare genotype of *Cryptococcus gattii* caused the cryptococcosis outbreak on Vancouver Island (British Columbia, Canada)


**Discussion**

Until the recent emergence of cryptococcal infection on Vancouver Island, *C. gattii* had been considered to be restricted to areas with tropical and subtropical climates (2). The identification of large-scale colonization of *C. gattii* in the environment occurring in a temperate climate zone indicates a striking change in the distribution of this species. Furthermore, the identification of the *C. gattii* genotype involved in this outbreak is consistent with a more invasive strain of Cryptococcus. Understanding where these novel genotypes occur and their source remain crucial for explaining the population dynamics of environmental *C. gattii*.
Fatal fungus spreads in Northwest

By Doug Struck
Washington Post Foreign Service
Sunday, April 8, 2007; Page D01

VICTORIA, B.C. -- The mystery emerged slowly, its clues maddeningly diverse.

Sally Lester, an animal pathologist at a British Columbia laboratory, slipped a slide under her microscope -- a tissue from a dog on Vancouver Island. Her lens focused on a tiny cell that looked like a boiled egg. It was late 1999. She had started seeing a lot of those.

On the eastern side of the island, several dead porpoises washed ashore early the next year. Scientist Craig Stephen, who runs a research center on the island, slit one open. He found its lungs seized by pneumonia and its other organs swollen by strange, flowerlike tumors.

"As climate change happens, new ecological niches will become available to organisms, and we will see this kind of thing happen again," said Karen Bartlett, a scientist at the University of British Columbia who played a central role in the search for the disease's cause.

Her investigation eventually would focus on a fungus, a member of the yeast family called Cryptococcus gattii. The microscopic fungus is normally found in the bark of eucalyptus trees in Australia and other tropical zones.
Success Story: Informing Public Health Interventions to Prevent Hantavirus Pulmonary Syndrome in the Southwestern United States

- Illustrates how ORD health-impacts assessment can ultimately lead to on-the-ground interventions to prevent disease and protect the public’s health
- 1993: HPS outbreak in SW with high death rate (>50%)
- Hypothesis: outbreak due to environmental conditions and increased rodent populations caused by unusual weather associated with 1991-92 ENSO
- EPA-sponsored study at The Johns Hopkins School of Hygiene and Public Health explored this hypothesis
- Found that high-risk areas for HPS can be predicted over 6 months in advance based on satellite generated risk maps of climate-dependent land cover.
- **Risk maps**, developed in partnership with CDC and the Indian Health Service, are already being implemented for disease prevention in the southwest by the U.S. Department of Health and Human Services.
Health Sector Assessments

• **2001 Health Sector Assessment (HSA)**
  - Examined five health outcomes
    - temperature-related morbidity and mortality
    - extreme weather events such as storms and floods
    - air pollution
    - water- and food-borne diseases
    - vector- and rodent-borne diseases

  - Overall conclusion: “…multiple levels of uncertainty preclude any definitive statement on the direction of potential future change for each of the health outcomes assessed.”

  - Also stressed the need to maintain and improve public health systems and their responsiveness to changing climate conditions

  - Identified a list of **30** research needs and knowledge gaps
Health Sector Assessments (cont.)

  - Literature published since 2001 supports HSA conclusion
  - But some improvements in understanding of potential effects
    - Refined understanding of mortality-heat stress relationship
    - Quantified impact of urban heat islands on ambient air temperatures
    - Continued development of morbidity and mortality data sets
    - Advances in epidemiologic modeling techniques have refined quantitative exposure-response relationships in various health outcome areas