Climate Change and Human Health

George Luber, PhD

Asthma outbreak hits kids
RISKS OF THE ‘RED ZONE’

Heat stalks city elderly

Deaths climb; officials warn risk not over
 Thousands hit by power outages

Aedes aegypti mosquito, the primary transmitter of yellow fever and other important arboviral diseases. CDC photo by Eric L. Takacs.

The many faces of climate change and its impacts on human health. Images from CDC, NASA, and CDC's National Center for Health Statistics. CDC photo by Eric L. Takacs.
Intergovernmental Panel on Climate Change (IPCC)
2007 Landmark Reports
Climate Change is Happening Now

- Warming is unequivocal; most of the warming of the past 50 years is very likely (90%) due to increases in greenhouse gases.

- Physical and biological systems on all continents and oceans already affected by climate changes.

- Already committed to more warming (next few decades); choices about emissions affect the longer term more and more. (IPCC2007)
Worldwide Effects of Global Warming

- Evidence of global destabilization of natural systems:
  - Ice cap & glacier melting
  - Early arrival of Spring
  - Oceans warming
  - Rising sea levels
  - Extreme weather patterns
  - Coral reef disintegration
Polar ice cap shrinkage, 1979-2005

A Smaller Ice Cap

The ice covering the Arctic Ocean shrunk to its smallest size in a century this summer, continuing a trend of decades.

EXTENT OF SUMMER SEA ICE
In millions of square miles

Sources: William Chapman and John Walsh (left); National Snow and Ice Data Center (above)
Chacaltaya Glacier, Bolivia (1940 – 2005)
Some Projections of Future Changes in Climate (IPCC 2007)

- Very likely that **heat waves**, will become more intense and frequent. [> 90% probability]
- Very likely that **heavy precipitation events** will become more frequent. [> 90% probability]
- Likely that **tropical cyclones** will become more intense, with larger peak wind speeds and more heavy rainfall [> 66% probability]
- Likely increase in areas affected by **drought**. [> 66% probability]
- Likely increase in incidence of **extremely high sea level** [> 66% probability]
Temperature Projections using Scenario A1B

Warming in the US is projected to vary by region.

Curriero et al. 2002
Extremes impact people more than mean.

Peterson et al., 2007b
Some occurrences will be well beyond historical experience

European heat wave of 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>

from Schär et al., 2004

Climate Change and Urban “Built” Environments

- Cities and climate are coevolving to place more populations at risk:

- Increase in vulnerable populations:
  - Today, more than half of the world’s population lives in cities, up from 30% in 1950.
  - By 2100 there will be 100 million more people > 65 years old (relative to 2000) (Ebi et al. 2006).

- Intensification of exposures: Urban heat islands
Urban Heat Island can add 7° – 12° F

Thermal Satellite Image of Phoenix, AZ Night Surface Temperature
Heat Island Impacts on Air Pollution

Maximum Daily Ozone Concentrations vs. Maximum Daily Temperature

Atlanta

New York
Heat Island and CO$_2$ Dome impact on Urban Aeroallergens

- Ragweed
- ↑ CO$_2$ and temperature → ↑ pollen counts, longer growing season

**Something in the Air**
Researchers at the U.S. Dept. of Agriculture planted ragweed in and around Baltimore in 2001 to test how the plant responds to different concentrations of CO$_2$. The results:

<table>
<thead>
<tr>
<th>Area</th>
<th>Urban</th>
<th>Suburban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period of collection</td>
<td>July 30-Sept. 7</td>
<td>Aug. 6-Sept. 10</td>
<td>Aug. 15-Sept. 17</td>
</tr>
<tr>
<td>Average CO$_2$ level, parts per million in the air</td>
<td>600</td>
<td>400</td>
<td>200</td>
</tr>
<tr>
<td>Pollen count, grains per cubic meter of air</td>
<td>12,138</td>
<td>3,262</td>
<td>2,294</td>
</tr>
</tbody>
</table>

Source: Lewis Ziska, U.S. Dept. of Agriculture

Poison Ivy

- *Toxicodendron radicans*
- ↑ CO$_2$ leads to
  - ↑ photosynthesis
  - ↑ water use efficiency
  - ↑ growth
  - ↑ biomass
  - More allergenic urushiol
- Greater CO$_2$ stimulation than most other woody species

Climate projections:  
*Heavy Precipitation*

**Facts from Climate Models and Theory**

- Increasing levels of greenhouse gases warm the climate and lead to increases in *very heavy* precipitation events.

**Why:** Increasing air temperatures result in a greater amount of water vapor in the air.
Extreme Precipitation Events

- ↑ frequency of more intense rainfall → ↑ severe floods, landslides, and debris and mud flows.

On July 26-27, 2005, 37+ in. of rain fell in Mumbai, leading to 1,000+ deaths.

Sources: Cruz et al., 2007; Image: Peterson et al., 2007b; news.bbc.co.uk
Extreme Precipitation and Waterborne Disease Outbreaks in the US: 1948 -1994

• **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 correlated with heavy precip in the month of outbreak; groundwater-related outbreaks lagged 2 months following extreme precipitation.

Hydrologic Extremes and Water-borne Disease:

Milwaukee 1993

Cryptosporidiosis epidemic
405,000 cases, 54 deaths

Preceded by heaviest rainfall in 50 years (Curriero et al., 2001)

$31.7 million in medical costs
$64.6 million in lost productivity (Corso et al., 2003).
Direct Effects of Hydrologic Extremes

↑ drier climates → forest fires and smoke

Vulnerable Populations:
- Young Children
- Elderly
- Pregnant Women
- People with Preexisting Respiratory and Cardiac Diseases

Source: Ziska et al., *J Allerg Clin Immunol* 2003;111:290-95; Graphic: www.abcnews.net/au
Harmful Algal Blooms (Red-tides)

Enhanced by:
- Increased water temps
- nutrient runoff

Figure 2. Distribution of the CyanoHAB, *Cylindropermopsis raciborskii*, in Florida (Williams 2001, Fristachi et al. 2007). *C. raciborskii*, which produces potent hepatotoxins (Table 2), was originally found only in tropical areas but has recently spread to cooler regions.
Tropical Cyclones

- ↑ sea-surface temperatures
- → ↑ tropical cyclone intensity and ↑ the height of storm surges

Sources: Ali, 1999; Images: NOAA.gov; www.weatherunderground.com
Secondary Effects of Hydrologic Extremes

- **Droughts encourage:**
  - Aphids
  - Locusts
  - Whiteflies
  - Aspergillus flavus (aflatoxin)

- **Floods encourage:**
  - Mold
  - Fungi
  - Nematodes

Sources: Rosenzweig et al., 2001; Images: entemology.ucdavis.edu
Prediction:
Because of Climate Change, Vector distributions will increase in latitude and altitude
Deadly dengue fever surging in Mexico

Mosquito-control teams dispatched to springtime tourist areas

The deadly hemorrhagic form of dengue fever is increasing drastically in Mexico, and experts predict a surge throughout Latin America fueled by climate change, migration and faltering mosquito eradication efforts.

Overall dengue cases have increased by more than 600 percent in Mexico since 2001, and worried officials are sending special teams to tourist resorts to spray pesticides and remove garbage and standing water where mosquitoes breed ahead of the peak Easter Week vacation season.

The Intergovernmental Panel on Climate Change, made up of the world's leading climate scientists, predicted in March that global warming and climate change would cause an upsurge in dengue. In Mexico, officials say longer rainy seasons already are leading to more cases.

"It used to be seasonal, in the hottest, wettest months, and now in some regions we are seeing it practically all year," said Joel Navarrete, an epidemiologist with the Mexican Social Security Institute.
Reported Cases of Dengue 1980-1999

Climate is one determinant of vector-borne disease incidence
Distribution of Lyme Disease, 1991-2000 and 2020

Tick abundance at model equilibrium

Potential Health Effects of Climate Change

**Climate Change:**
- Temperature rise
- Sea level rise
- Hydrologic extremes

**HEAT**
- Heat stress, cardiovascular failure

**SEVERE WEATHER**
- Injuries, fatalities

**AIR POLLUTION**
- Asthma, cardiovascular disease

**ALLERGIES**
- Respiratory allergies, poison ivy
- Malaria, dengue, encephalitis, hantavirus, Rift Valley fever
- Cholera, cryptosporidiosis, campylobacter, leptospirosis

**VECTOR-BORNE DISEASES**
- Malnutrition, diarrhea, harmful algal blooms
- Anxiety, despair, depression, post-traumatic stress
- Forced migration, civil conflict

**WATER-BORNE DISEASES**
- Evaporation, dryness
- Air pollution
- Allergies
- Vector-borne diseases
- Water and food supply
- Mental health

**WATER AND FOOD SUPPLY**
- Malnutrition, diarrhea, harmful algal blooms
- Anxiety, despair, depression, post-traumatic stress
- Forced migration, civil conflict

**MENTAL HEALTH**
- Anxiety, despair, depression, post-traumatic stress
- Forced migration, civil conflict

Adapted from J. Patz
Other Considerations

- There will be significant **regional variation** in the effects of climate change

- There will be significant **variation in the demographic groups** effected by climate change
Now the bad news...

- Despite existing breadth of organizations and sectors with initiatives on climate change
- Despite the likelihood of anticipated health effects of climate change

Public health effects of climate change remain largely unaddressed
TOWARD A PUBLIC HEALTH FRAMEWORK FOR ADDRESSING CLIMATE CHANGE

Guiding principles, both practical and ethical:

- Public Health Prevention Framework
- Co-Benefits and synergies
- Environmental Justice
- Complexity/Ecosystems thinking
A PUBLIC HEALTH FRAMEWORK FOR ADDRESSING CLIMATE CHANGE

Guiding principles:

Public Health Prevention Framework:

- Primary prevention: aims to prevent the onset of injury or illness
  - Corresponds with mitigation—efforts to slow, stabilize, or reverse climate change by reducing greenhouse gas emissions.

- Secondary and Tertiary Prevention: aims to diagnose disease early in order to control its advance and reduce the resulting morbidity
  - Corresponds with adaptation—efforts to anticipate and prepare for the effects of climate change, and thereby to reduce the associated health burden.
Public Health role in Primary prevention (mitigation)

Mitigation efforts will largely occur in sectors other than health, however public health can:

- Reduce GHG emissions in our own operations (health care settings)
- Assess health implications of various mitigation strategies
- Educate the public and policymakers on health benefits of mitigation approaches.
Public Health role in Secondary Prevention (Adaptation)

Correspond closely to conventional public health practices.

These can include:

- Track and monitor disease (surveillance)
- Enhance emergency response capacity
- “Weatherize” communities
A PUBLIC HEALTH FRAMEWORK FOR ADDRESSING CLIMATE CHANGE

Guiding principles:

**Co-benefits and synergies**

- Efforts to mitigate or adapt to the effects of climate change frequently yield other health benefits, both direct and indirect.
Air pollution \( \downarrow \) CO\( _2 \) emissions \( \downarrow \) Depression

Physical activity \( \uparrow \)

Injuries \( \downarrow \)

Infraestructure costs \( \downarrow \)

Osteoporosis \( \downarrow \)

Social capital \( \uparrow \)

And by the way…
<table>
<thead>
<tr>
<th>Health &amp; Climate Change Adaptation Synergies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat wave plans using “buddy systems”</td>
</tr>
<tr>
<td>↑ social capital,</td>
</tr>
<tr>
<td>↑ community resiliency</td>
</tr>
<tr>
<td>↓ vehicular travel</td>
</tr>
<tr>
<td>↓ car crashes, ↓ air pollution</td>
</tr>
<tr>
<td>↑ fuel efficiency</td>
</tr>
<tr>
<td>↓ air pollution</td>
</tr>
<tr>
<td>Locally grown food</td>
</tr>
<tr>
<td>↓ pesticide loading, ↓ fuel</td>
</tr>
<tr>
<td>Energy-efficient buildings</td>
</tr>
<tr>
<td>↓ operating costs</td>
</tr>
<tr>
<td>Alternative energy sources</td>
</tr>
<tr>
<td>Business opportunities</td>
</tr>
</tbody>
</table>
A PUBLIC HEALTH FRAMEWORK FOR ADDRESSING CLIMATE CHANGE

Guiding principles:

Environmental Justice

Climate change will disproportionately threaten certain populations, especially poor people and members of ethnic and racial minority groups.
The United States emits one quarter of the world's gases that cause global warming.
Persons killed by disasters: 1975 - 2004

Those who are most affected are least responsible for the greenhouse gas emissions that cause the problem
Low-income people typically lack insurance to replace possessions lost in storms. Only 25 percent of renters have renters insurance.
A PUBLIC HEALTH FRAMEWORK FOR ADDRESSING CLIMATE CHANGE

Guiding principles:

*Complexity and Ecosystems thinking*

- OBESITY EPIDEMIC
- DEPRESSION
- PEAK PETROLEUM
- CLIMATE CHANGE
- POPULATION GROWTH
- POVERTY
- AIR POLLUTION
- SUBURBAN SPRAWL
- LOSS OF GREENSPACE
- SEDENTARY LIFESTYLES

OBESITY EPIDEMIC

PEAK PETROLEUM

CLIMATE CHANGE

POPULATION GROWTH

POVERTY

AIR POLLUTION

SUBURBAN SPRAWL

LOSS OF GREENSPACE

SEDENTARY LIFESTYLES
Adaptation strategies for health

Track diseases and trends related to climate change
CDC’s National Environmental Public Health Tracking Program
Adaptation strategies for health

Investigate infectious water-, food-, and vector-borne disease outbreaks
got ciguatera?
Have you ever become sick from eating fish caught offshore in Texas? If you answered YES, contact us at 1-888-474-5929. We'd like to talk with you about your symptoms. E-mail us for more information at ciguatera@cdc.gov or visit www.cdc.gov/nceh/ciguatera.

Ciguatera Fish Poisoning on Texas Coast Oil Rigs
Adaptation strategies for health

Communicate effectively on climate change
Climate Change Scenarios Scare, and Motivate, Kids

By Darragh Johnson
Washington Post Staff Writer
Monday, April 16, 2007; Page A01

The boy has drawn, in his third-grade class, a global warming timeline that is his equivalent of the mushroom cloud.

"That's the Earth now," the 9-year-old says, pointing to a dark shape at the bottom. "And then," he says, tracing the progressively lighter stripes across the page, "it's just starting to fade away.

How we're damaging the environment is more of a worry to you than getting a girl or boyfriend, says a survey.

The results showed three quarters of 11 to 14-year-olds worry about climate change, compared to 41% who are worried about going out with someone.

And it looks like you lot aren't just all talk - 63% turn off the lights when you leave a room, 82% of you recycle, and 75% say we should recycle more.

The survey quizzed 1,554 kids on their views on the
CAUTION

THIS SIGN HAS
SHARP EDGES

DO NOT TOUCH THE EDGES OF THIS SIGN

ALSO, THE BRIDGE IS OUT AHEAD

Image courtesy of Jonathan Patz.
Adaptation strategies for health

Partnerships with private sector, civic groups, NGOs, faith community, etc.

Heat wave and severe storm response plans; focus on the most vulnerable

Adaptation strategies for health
Risk for Hyperthermia: Thermal & Census Model

Legend
- Death from Hyperthermia (Primary Cause)
- Risk as Predicted from Neural Network
  - Low
  - Moderate
  - High

Death Locations are in Assigned Census Tracts but are Randomly Offset to Protect Privacy
Adaptation strategies for health

Public health workforce prepared to respond
Priority health actions for climate change

Promote workforce development by ensuring the training of a new generation of competent, experienced public health staff to respond to the health threats posed by climate change.
Strategies for Climate Change

- Develop region and city-specific strategies
  - Focus on vulnerable populations in urban areas

- Enhanced surveillance integrating environmental and health data
  - Climate change indicators?

- Identify Co-Benefits
Conclusions

- Climate change is now a mainstream issue
- Climate change must also be framed as a public health issue
- Opportunity costs of not taking action are high
Thank You

Contact:
George Luber, PhD
Associate Director for Global Climate Change
National Center for Environmental Health

gluber@cdc.gov
Tel: 770-488-3429