Health Effects of Climate Change

Kacey C. Ernst, PhD MPH

kernst@email.arizona.edu

Educational Series
Disclosure

All Faculty, CME Planning Committee Members, and the CME Office Reviewer have disclosed that they have no financial relationships with commercial interests that would constitute a conflict of interest concerning this CME activity.
Educational Objectives

1. Provide an overview of what climate change is and isn’t
2. Review the data on the impact of climate on health
3. Discuss the change in disease patterns associated with climate change
4. Present effective interventions to ease the health impact of climate change.
Climate Variability vs. Climate Change

- **Climate Change**:  
  - persistent change or trend in mean atmospheric conditions  
  - current changes unprecedented in human history

- **Climate Variability**:  
  - day-to-day (weather) or relatively short term (seasonal) changes in atmospheric conditions  
  - effects on disease patterns most easily analyzed, and used in forecasts
What is climate change? Climate variability?

Unchanging Average, Unchanging Extremes

Average Trend (solid line)

Actual Measure (dashed line)

From Wilson, ML. Presented at NCAR
Unchanging Average, *Increasing* Extremes

**Average Trend** (solid line)

**Actual Measure** (dashed line)

From Wilson, ML. Presented at NCAR
Increasing Average, Unchanging Extremes

Average Trend (solid line)

Actual Measure (dashed line)

From Wilson, ML. Presented at NCAR
Increasing Average, Greater Extremes

Average Trend (solid line)

Actual Measure (dashed line)

From Wilson, ML. Presented at NCAR
Increasing Rate of Increasing Average, Greater Extremes
The Scenarios

- Why multiple scenarios?
- Based on different projections of
  - Investment in mitigation strategies (i.e. reductions in emissions) both development and dissemination
  - Globalization vs. regionalization
  - Population growth
  - Economic growth vs. environmental growth

What will our world look like?
Emissions Estimates by Scenario

Source: http://www.narccap.ucar.edu/about/emissions.html
“Until mid-century, projected climate change will impact human health mainly by exacerbating health problems that already exist (very high confidence). Throughout the 21st century, climate change is expected to lead to increases in ill-health in many regions and especially in developing countries with low income, as compared to a baseline without climate change (high confidence)”.

IPCC Fifth Assessment Report
What diseases are the most climate sensitive?

- heat stress
- effects of storms
- air pollution effects
- asthma
- zoonotic
- vector-borne diseases
- water-borne diseases
- food-borne diseases
- sexually-transmitted diseases
Pathways of Climate Change and Health

Figure 3.1. Pathways by which climate change affects human health (modified from reference 2)

- Human exposures
  - Regional weather changes
    - Heatwaves
    - Extreme weather
    - Temperature
    - Precipitation
- Contamination pathways
- Transmission dynamics
- Changes in agro-ecosystems, hydrology
- Socioeconomic and demographic disruption
- Modulating influences
- Health effects
  - Temperature-related illness and death
  - Extreme weather-related health effects
  - Air pollution-related health effects
  - Water and food-borne diseases
  - Vector-borne and rodent-borne diseases
  - Effects of food and water shortages
  - Mental, nutritional, infectious and other health effects

Source: IPCC Third Climate Assessment Report
Extreme heat (and cold*) associated with increased mortality

- Heatstroke
- Heart attacks*
- Stroke

Number of deaths spike in Paris during a sweltering heat wave in 2003. **Credit:** University of Hawaii at Mānoa/Benedicte Dousset
Extreme Heat Projections

- Very high confidence
- Lower emissions scenarios project over 129 days of heat over 100 in southern AZ
- Higher emissions scenario across broader area

Extreme Heat - Adaptation

- Urban Design/land use change (e.g.
- Targeted warnings
- Community-based programs (e.g. cooling centers)
- Public health education
- Public assistance (e.g. Air conditioner repair services in Maricopa County)
Future changes in fire probability from 16 climate models

- Very high confidence
- Increase fire-related injury
- Excess particulate matter
Climate Disaster Mortality

Figure 2: Global Death and Death Rates Due to Extreme Weather Events, 1900–2010

Very high confidence
Better
- Monitoring
- Forecasts
- Lead times for warnings
- Dissemination
- Response

Note: this is mortality not injury

Note: For the last period, 2000–2010, annual deaths and death rates are based on an 11-year average.
Waterborne Disease Impact

- Very high confidence
- Human action – improper disposal
- Weather – flooding
- Rainfall -> transport and dissemination of infectious agents
- Temperature -> growth survival and persistence
- Alterations in non-human hosts for waterborne zoonosis can also indirectly be influenced
Climate Change: Waterborne & Foodborne

Source: Report on 1st annual nat. science and policy research consensus conference on health and climate change – Ottawa, 13 TO 15 MARCH, 2001, and implications for infections diseases
Waterborne disease relationships

- Cholera most well-studied
- Strong associations with temperature and rainfall

Waterborne – Adaptation/ Mitigation

- Similar to current conditions (figure)
- Enhance detection of pathogens
- Improve containment and removal
Food-borne disease

- Very high confidence
- Foodborne illnesses particularly
  - Salmonella
  - Campylobacter
- Strong correlation with season and warm weather

**Figure 1**

Observed and expected laboratory confirmed cases of *Salmonella Enteritidis* infections since 2002 in the Netherlands

Respiratory Diseases

• Climate change impacts on air pollutants uncertain – low confidence
  • ozone increase most likely but unknown impact on health

• Longer growing seasons, long-term climate changes may alter pollen burden
  • Aeroallergens may increase

• May alter incidence or exacerbate
  • Asthma, other acute allergic reactions
Respiratory Disease - Adaptation

- Adaptive Measures
  - early warning systems
  - public education

- Generally impact non-infectious respiratory diseases although can compromise lung function
Vector-borne

- Multiple aspects of vector-borne diseases may change with climate change
  - Change in vectors geographic range
  - Change in generation time of vector and pathogen
  - Change in suitability of habitat for vector (rainfall, temperature etc.) increase intensity and range
Changing precipitation - Vector

- Vector
  - Increase larval habitat and thus vector density
  - Too much -> wash out
  - Low rainfall rivers dry up and create pools
  - Increased water storage
  - Increased humidity increased survival

Source: *Environmental Health Perspectives*
Volume 111, Number 12, September 2003

The bane of Bangladesh. Government attempts to deal with disease-carrying mosquitoes have been criticized as ill-conceived and inappropriate.
Temperature Effects - Vector

• Vector
  • Survival ↓↑ depending on species
  • Decrease size
  • May decrease activity
  • Population growth – ↓ time of development

<table>
<thead>
<tr>
<th>Vector</th>
<th>Pathogen</th>
<th>Threshold (Min Temp) for Biological Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anopheles Mosquito</td>
<td>P. falciparum malaria</td>
<td>8-10ºC</td>
</tr>
<tr>
<td>Triatome bugs</td>
<td>T. Cruzi</td>
<td>20ºC (2-6ºC survival)</td>
</tr>
<tr>
<td>Aedes Mosquito</td>
<td>Dengue virus</td>
<td>6-10ºC</td>
</tr>
<tr>
<td>Ixodes Ticks</td>
<td>Borrelia burgdorferi, Babesia microti</td>
<td>5-8ºC</td>
</tr>
<tr>
<td>Pulex irritans flea</td>
<td>Yersinia pestis</td>
<td>10-12ºC</td>
</tr>
</tbody>
</table>

Source: Patz and Olson 2006
Temperature Effects - Pathogen

- Pathogen
  - ↓ Extrinsic incubation period
    - Incubation period for vector: time to acquire, develop, multiply, reach site
  - ↓ Viral replication

Source: Reeves et al. 1994
Food security and nutrition

• Droughts predicted to increase (high conf.)

- Drought
  - Reduce water and vegetation
  - Reduce livestock and food stuffs
  - Malnutrition
    - Increased susceptibility to infections for animals and humans

Palmer Drought Severity Index, PDSI: below -4 is extreme drought. The 2030-39 scenario, via *Climate Progress*
Livestock vulnerability to climate change – US example

Southern states cull cattle in 2011

Texas and Oklahoma herds shrink by most, Nebraska and western states expand net change in total cattle over 2011

- Texas
- Oklahoma
- Kansas
- New Mexico
- Virginia
- Wyoming
- Florida
- Colorado
- California
- Nebraska

NOTE: Jan 1, 2012 vs Jan 1, 2011
Source: USDA
Scale of Change

• Spatial variability: How will climate change impact the geographic distribution of disease?
  • Global ---- local
• Temporal variability: How will climate change impact distribution of disease over time?
  • Century ---- annual
• Spatial-temporal variability
Early Warning Systems - indicators

- An integral part of the epidemic preparedness plan (national and district-based)
- Aim: predict the timing and severity of an epidemic.
- Use three groups of indicators
  - Vulnerability indicators
  - Transmission risk indicators
  - Early detection indicators
EWS: Vulnerability indicators

- Existence of a large number of vulnerable persons, likely to be infected and develop clinical illness is a prerequisite to epidemic occurrence
- Vulnerability expresses the degree of susceptibility of populations
- Predict the severity of impact, rather than the timing of an increase in disease
EWS: Transmission risk indicators

- Meteorological/weather data, when routinely collected and analysed in specific locations can provide a warning signal in predicting timing of malaria epidemics several months in advance

- Examples
  - Heavy rainfall after an unusually dry period
  - Unexpected higher temperature and/or humidity for a given altitude
  - Unusual flooding – epidemics in cities
### Early Warning Systems – Fine Temporal Resolution

Understand, anticipate and manage the impact of seasonal climate fluctuations (Source: Earth Institute, Columbia University)
Source: WHO Malaria Early Warning Systems - Concepts, Indicators and Partners
Determining vulnerability

- Global change but local impacts dependent on
  - Current climate
  - Current disease status
  - Capacity to respond
  - Infrastructure
  - Political stability

Source: Samson et al. 2011
Overall adaptation strategies

• Most effective strategies reduce current vulnerability
• Improve basic public health
  • Clean water
  • Sanitation
  • Health care (vaccination, child health)
• Develop disaster preparedness infrastructure
• Alleviate poverty
Summary

“In view of these impacts, and those that we have projected for the future, no one on this planet is going to be untouched by climate change,” Rajendra Pachauri, the chairman of the IPCC, said in the press conference announcing the report’s conclusions.
References