Current Effects of Climate on ID

- Cryptococcus gattii
- Vibrio vulnificus
- Tick-borne Encephalitis
- Shortened respiratory syncytial virus (RSV) season in northern climates

Cryptococcus gattii, a tropical pathogen emerging in a temperate climate zone

The Lancet 2001; 358(9275):16
Amplification of warming in Arctic has global implications for bird populations

- Advancement in species’ phenology over past 30-60 years
  - Migration: 1.3-4.4 days earlier per decade
  - Breeding: 1.9-4.8 days earlier per decade

- Poleward shifts of range margins
  - 18.9 km average range movement northward over 20-year period

Alterations in Habitat and Food Availability

- Increased competition for nest sites for those species that do not migrate early

- Mismatch between the peak in insect availability and the peak food demands
Changes in climate have been associated with:

- Population declines in Costa Rica
- Breeding phenology in Great Britain
- Physiological changes in female toads, leading to increased female mortality rates and decreased fecundity in survivors
- Widespread amphibian extinctions
- Temperatures at many highland localities shifting towards the growth optimum of fatal fungus, chytrid *Batrachochytrium dendrobatidis*
- Unusual climatic conditions can alter development and increase frog susceptibility to various pathogens.
- Environmental stressors that can cause declines include loss of habitat, disease, pollutants, climate change
Natural Earth Cycles and Wobbles

![Graph showing natural Earth cycles and wobbles]

- Present Mammals
- Present
For 650,000 years, atmospheric CO₂ has never been above this line … until now.
Climate Change is Happening Now

- Warming is unequivocal
- Physical and biological systems on all continents and oceans are already affected by climate changes
- Overall the earth has warmed 0.85°C from 1880-2012
- Arctic sea ice is disappearing at a rate of up to 50,000 km² per year
- Antarctic ice sheets are losing 159 billion tons of ice each year

IPCC 2007
Health and Climate Change: Policy Responses to Protect Public Health. 2015 The Lancet
Nasa – Projected U.S. Temperature Changes by 2100

https://www.youtube.com/watch?v=39cBqY1sszy#action=share
Temperature Changes in Nebraska

- Nebraska has experienced an overall warming of about 1°F since 1895, with warming trends that are highest in winter and spring and for the nighttime lows than for daytime highs.
- Since 1895, the length of the frost-free season has increased by 5 to 25 days across Nebraska.
- Projected temperature changes for Nebraska range from an increase of 4-5°F (low emission scenarios) to 8-9°F (high emission scenarios) by the end of the twenty-first century.

Source: Understanding and Assessing Climate Change: Implications for Nebraska, September 2014
New NASA Satellite Survey Reveals Dramatic Arctic Sea Ice Thinning

Source: IPCC

www.nasa.gov

Since 1979, more than 20 percent of the polar ice cap has melted away.

Source: IPCC
Extreme Weather

- Globally, the number of reported weather-related natural disasters has more than tripled since the 1960s.

- Every year, disasters result in over 60,000 deaths, mainly in developing countries.

- By the 2090s, climate change is expected to widen the area affected by drought, double the frequency of extreme droughts, and increase their average duration six-fold.

- Health Hazards associated with extreme weather events:
  - Death, injury, or disease
  - Negative effects on physical, mental, and social well-being
  - Exacerbation of existing medical conditions

Source: WHO. http://www.who.int/mediacentre/factsheets/fs266/en/
Global sea level has risen by about 8 inches since reliable record keeping began in 1880. It is projected to rise another 1 to 4 feet by 2100.

A 2°C increase in global temperature is inevitable even if we take dramatic action.

Even if countries meet their current non-binding pledges to reduce carbon emission, we will still be on course to reach 3°C by the end of this century.
Climate Change Affects Human Health in Two Ways

1. Changing the severity and frequency of health problems that are already affected by climate and weather factors

2. Creating unanticipated health problems or health threats in places where they have no previously occurred.
Figure 1: An overview of the links between greenhouse gas emissions, climate change, and health
The causal links are explained in greater detail in the section about climate change and exposure to health risks.

www.thelancet.com  Published online June 23, 2015  http://dx.doi.org/10.1016/S0140-6736(15)60854-6
Climate Change and Health

**Climate Drivers**
- Increased temperatures
- Precipitation extremes
- Extreme weather events
- Sea level rise

**Exposure Pathways**
- Extreme heat
- Poor air quality
- Reduced food & water quality
- Changes in infectious agents
- Population displacement

**Health Outcomes**

<table>
<thead>
<tr>
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**Non-Climate Stressors**
- Land-use change
- Ecosystem degradation
- Infrastructure condition
- Geography
- Agricultural production & livestock use

**Social Determinants**
- Age & gender
- Race & ethnicity
- Poverty
- Housing & infrastructure
- Education
- Discrimination
- Access to care & community health infrastructure
Climate Change and Health

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Heat-Related Death and Illness

• Hotter than normal or colder than normal days can compromise the body’s ability to regulate temperature.

• In the presence of extreme heat, loss of temperature control can result in heat cramps, heat exhaustion, heatstroke, hyperthermia, and worsening of already present chronic conditions.

• The elderly, children, people working outdoors, and economically disadvantaged groups are at an increased risk of death during a heat wave.

• Between the years 2030 and 2050, climate change is expected to cause an additional 38,000 deaths per year due to heat exposure in the elderly.

Source: WHO. http://www.who.int/mediacentre/factsheets/fs266/en/
European Heat Wave

• The summer 2003 European heat wave caused more than 30,000 excess deaths.

• Hottest summer in Europe since 1500 AD.

Sources:
WHO. http://www.who.int/mediacentre/factsheets/fs266/en/
South Carolinians are struggling to recover from historic Midlands rainfall recorded in parts of the state. USA TODAY

Running dry: How the drought is forging a new California

By Carolyn Lochhead | June 12, 2015 | Updated: July 24, 2015 3:24pm

Californians are living through a slow-motion natural disaster, a four-year drought that is combining with record heat to challenge the state in unprecedented ways.
Tropical Cyclones

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

Indian Ocean and SW Pacific Category 4 and 5 Hurricanes

Ali, 1999
Images: NOAA.gov; www.weatherunderground.com
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

SCruz et al., 2007; Image: Peterson et al., 2007b; news.bbc.co.uk
Cost of Natural Disasters

In 2014, the United States spent $25 billion for the economic and insured losses incurred from natural disasters.

Image: NOAA, 2015
Climate Change and Health

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Heat-related Illness
Cardio-pulmonary Illness
Vector-borne Disease
Water-borne Disease
Food-borne Disease & Nutrition
Mental Health
Climate change implication for air quality and respiratory illness

Modified weather patterns influence the level and location of outdoor air pollutants such as ground-level ozone and fine particulate matter.

Droughts also tend to exacerbate respiratory illnesses through reduced air quality:

- Soil drying
- Loss of vegetation
- Airborne particulate matter
- Dust storms
- Wildfires

Figure 2. Projected change in average daily maximum temperature, seasonal average maximum daily 8-hr ozone, and ozone-related premature deaths in 2030.
Direct Effects of Hydrologic Extremes

↑ drier climates → forest fires and smoke

Vulnerable Populations:
- Young Children
- Elderly
- Pregnant Women
- People with pre-existing respiratory and cardiac diseases

Ziska et al., *J Allerg Clin Immunol* 2003;111:290-95
Image: www.abcnews.net/au
Greater Pollen Counts

- Pollen and other aeroallergen levels are higher in extreme heat.
- Longer growing seasons under a warmer climate allow for bigger ragweed plants that produce more pollen later into the fall.
- More airborne allergens could mean more asthma attacks.
- Asthma affects around 300 million people worldwide.

Sources:
WHO. http://www.who.int/mediacentre/factsheets/fs266/en/
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Global Warming's greatest threat may also be the smallest.
The Impact of Climatic Factors on Vectorborne Zoonotic Diseases

• Climatic factors (e.g., temperature, moisture) affect the distribution and abundance of vectors and vector-borne pathogens

• Climatic factors affect disease transmission efficiency (vector competence)

• Climatic variables and perturbations can affect disease occurrence patterns
Changes in Lyme Disease Case Distribution, United States

Climatic perturbations can affect disease occurrence patterns

Plague Trophic Cascade Model

Increased rodent food sources

Increased rodent survival and reproduction

High rodent densities favor epizootic spread

Cool summer, 15–18 mos after first wet winter (Major effect)

Widespread epizootics

Increased human plague risks

Increased soil moisture and available hosts

Increased flea survival and reproduction

Cool temperatures favor survival of infected fleas

Effects of Increased Precipitation
Feb. – March (Major effect)
July – Aug (Minor effect)
Feb. – March (Minor effect)

Enscore et al. 2002 AJTMH 66: 186-196
BECFORE 1970
Cold temperatures caused freezing at high elevations and limited mosquitoes, mosquito-borne diseases and many plants to low altitudes

TODAY
Increased warmth has caused mountain glaciers to shrink in the tropics and temperate zones

DENGUE FEVER OR MALARIA
MOSQUITOES
PLANTS

Some mosquitoes, mosquito-borne diseases and plants have migrated upward
Studies suggest climate change could expose an additional 2 billion people to dengue transmission by 2080.


Estimated Population at Risk for Dengue Fever in 1990 (A) and 2085 (B) Based on Climate Data from 1961 to 1990

[Dr. Simon Hales](http://image2.thelancet.com/extras/0186/111/75web.pdf)/The Lancet
Projected Effects of Climate Change: Malaria

- Small, Goetz and Hay (2003) – Incidence in Africa would increase in some areas and decrease in others
- Tanser, Sharp and le Sueur (2003) – 16-28% increase in person-months of exposure
  - Little latitudinal change in risk, most change occurs in existing areas or with altitude
- Reiter et al. (2004) – Stressed local effects and other factors that could be confounded with climate effects
- Hay et al. (2002) – No association between long-term meteorological trends and malaria outbreaks in East Africa
- Dev (2007) – No association between rainfall and annual incidence of malaria in India.
Tropical Disease Burden
(Diseases Transmitted by Insects)

Data from the World Health Organization (2004)

<table>
<thead>
<tr>
<th>Disease</th>
<th>DALYs (Thousands)*</th>
<th>Deaths (Thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria</td>
<td>46,486</td>
<td>1,272</td>
</tr>
<tr>
<td>Lymphatic filariasis</td>
<td>5,777</td>
<td>0</td>
</tr>
<tr>
<td>Afr. Trypanosomiasis</td>
<td>1,525</td>
<td>48</td>
</tr>
<tr>
<td>Leishmaniasis</td>
<td>2,090</td>
<td>51</td>
</tr>
<tr>
<td>Onchocerciasis</td>
<td>484</td>
<td>0</td>
</tr>
<tr>
<td>Chagas disease</td>
<td>667</td>
<td>14</td>
</tr>
<tr>
<td>Dengue</td>
<td>616</td>
<td>19</td>
</tr>
<tr>
<td>TOTAL</td>
<td>57,643</td>
<td>1,404</td>
</tr>
</tbody>
</table>

* Disability Adjusted Life Years - the number of healthy years of life lost due to premature death and disability. Numbers reflect an overall 12% increase in DALYs and 20% mortality increase since 2001.
Droughts

Reducing water quantity can reduce water quality from increased pollutant concentration, stagnation, and higher temperatures than can encourage pathogen growth.

Drought has also increased the incidence of West Nile virus disease.

- During droughts mosquitos find the remaining water sources and transmit the virus to other species

Droughts followed by periods of heavy rainfall have been associated with an increase in rodent populations

- Could potentially increase prevalence of hantavirus
Climate Change and Health

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Water-Related Illnesses

Water-related illnesses can be caused by pathogens, such as:

- Bacteria, virus, and protozoa
- Toxins produced by harmful algae and cyanobacteria
- Chemical introduced into the environment by humans

Increasingly variable rainfall patterns are likely to affect the supply of freshwater.

Lack of safe water can compromise hygiene and increase the risk of diarrheal disease, which kills almost 600,000 children under 5, every year.

Between the year 2030 and 2050, climate change is expected to cause an additional 48,000 deaths per year due to diarrhea.

Diarrhea kills more children than malaria, measles, and AIDS combined. Proportional distribution of cause-specific deaths among children under five years of age, 2012 (excluding neonatal deaths).

Sources:
1. WHO. http://www.who.int/mediacentre/factsheets/fs266/en/
2. CDC. http://www.cdc.gov/healthywater/global/diarrhea-burden.html
Elevated Sea Surface Temperatures

Elevated sea surface temperatures associated with climate change will increase human exposure to water contaminants in food.

Warmer water in Alaska from 1997-2004 was associated with an outbreak of *Vibrio parahaemolyticus* in 2004.

Warmer waters associated with Cholera outbreaks

Heavy Downpours Are Increasing Exposure to Disease

Streams and rivers rise, which contributes to flooding of homes, businesses, and critical infrastructure like sewer and storm water systems.

Floodwaters can become contaminated with agricultural waste, chemicals, raw sewage, and other pollutants.

Floodwaters can contain disease-causing bacteria, viruses, and parasites.

Sewage overflow from treatment plants, septic fields, and municipal lines can back up into people’s homes.

Climate change increases heavy downpours.
Hydrologic Extremes and Waterborne Disease

Milwaukee 1993:
- Cryptosporidiosis epidemic
- 405,000 cases, 54 deaths
- Preceded by heaviest rainfall in 50 years (Curriero et al., 2001)
- $31.7M in medical costs
- $64.6M in lost productivity

Corso et al., 2003
Intense Rainfall is Increasing in the Great Plains

Increases the risk of failure of, or damage to, water infrastructure for drinking water, wastewater, and stormwater, thus increasing risk of exposure to water-related pathogens, chemicals, and algal toxins.

Source: http://nca2014.globalchange.gov/highlights/overview/overview
Water Contamination & Impairment
Nebraska – NDEQ website 2014

Source: Scott Holmes, Lincoln Lancaster County Health Department
Harmful Algal Blooms (Red Tides)

Enhanced by
- Increased water temps
- Nutrient runoff
- Upwelling events

Figure 2. Distribution of the CyanoHAB, *Cylindrospermopsis 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.
Bioaccumulation of Methylmercury

Elevated water temperatures may lead to higher concentrations of methylmercury (a form of mercury that can be absorbed into the bodies of animals, including humans)

Methylmercury exposure can affect child development, particularly if exposed in-utero

Sources:
2. Gonzalez-Estecha, M., and Coauthors, 2014: [The effects of methylmercury on health in children and adults; national and international studies].
Nebraska Fish Consumption Advisories – 2013
Primarily Due to Mercury Contamination

92 Lakes and Streams in Nebraska

Source: Scott Holmes, Lincoln Lancaster County Health Department
Climate Change and Health

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Rising Temperatures Can Decrease Food Safety

Rising temperatures and changes weather extremes is expected to intensify pathogen and toxin exposure, increasing the risk and incidence of foodborne illnesses.

Some pathogens thrive in warm, humid conditions
- *Salmonella*
- *Escherichia coli (E. coli)*
- *Campylobacter*

Foodborne illnesses peak in the summer
- Warmer weather
- Food preparation outdoors
- Leaving food outside at picnics and BBQs

*Salmonella* on raw chicken will double in number approximately every hour at 70°F, every 30 minutes at 80°F, and every 22 minutes at 90°F.

Sources:
2. Oscar, T., 2009: Predictive model for survival and growth of Salmonella Typhimurium DT104 on chicken skin during temperature abuse. *Journal of Food Protection*
Food Nutrition

- Increases in CO2 will likely increase carbohydrate content in food, while at the same time decreasing the protein and essential mineral content.

- “Hidden Hunger” is the sufficient or excessive intake of calories but insufficient intake of one or more micronutrients, such as vitamin A, iron, iodine, and zinc.

- Micronutrient deficiencies adversely affect metabolism, the immune system, cognitive development and maturation, and can be a factor in the prevalence of obesity.

- Aquaculture
  Climate change is altering fish distribution and productivity of marine and fresh water species
Pest Distribution

• Climate change will also alter the distribution of pests, parasites, and microbes, which will lead to increases in the use of pesticides

• Increased human exposure to chemical contaminants in the food chain.
Extreme Weather Can Decrease Food Security

Extreme weather events can contribute to pathogen transmission, multiplication, survivability, and growth, increasing risk of food contamination.

Example: Runoff or flood water that may carry partially untreated sewage or other wastes can contaminate ground water and surface water used for irrigation, harvesting and washing of food.

Chemical contaminants in floodwater following Hurricane Katrina included spilled oil, pesticides, heavy metals, and hazardous waste.

Source: Manuel, J., 2006: In Katrina’s Wake. Environ Health Perspectives
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Mental Health and Well-Being

Mental health consequences of exposure to disasters
- Post-traumatic stress disorder (PTSD)
- Depression
- General anxiety

Virtually everyone is exposed to the threats of climate change and to events attributed to climate change through frequent media coverage.

High risk groups
- Children
- Elderly
- Pregnant and post-partum women
- People with pre-existing mental illness,
- Low-income persons and homeless
- First-responders
The Impact of Climate Change on Physical, Mental, and Community Health

**CLIMATE IMPACTS**

- [Sun] Changes in fitness and activity level
- [Fire] Heat-related illness
- [Allergies]
- [Water] Increased exposure to waterborne and vectorborne illness

**Medical and Physical Health**

- [Family]
- [Older Person]

**Mental Health**

- [Brain]
  - Stress, anxiety, depression, grief, sense of loss
  - Strains on social relationships
  - Substance abuse
  - Post-traumatic stress disorder

**Community Health**

- [Earth]

  - Increased interpersonal aggression
  - Increased violence and crime
  - Increased social instability
  - Decreased community cohesion
A 2°C Temperature Increase Can Make People Angrier

- Spikes in temperature and precipitation can increase the risk of personal violence and social upheaval
- While climate is not the sole or primary cause of violence, it undeniably exacerbates existing social and interpersonal tension in all societies, regardless of wealth or stability.

http://wattsupwiththat.com/2013/08/01/claim-2c-temperature-increase-will-make-people-angry/
“Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen.”

“Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide that are unprecedented in at least the last 800,000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century.”

- IPCC Climate Change 2014 Synthesis Report Summary for Policymakers

**The Report:**
- 1 scoping meeting to outline 30 chapters
- 217 author nominations representing 92 nationalities
- 242 lead authors and 66 review editors from 70 countries
- 436 contributing authors from 54 countries
- Over 12,000 scientific references cited

**Total Reviews:**
- 50,492 comments
- 1729 expert reviewers from 84 countries
- 49 governments

**The WGII Approval Session**
- 25-29 March 2014, Yokohama, Japan
- The Summary for Policymakers was approved line-by-line and accepted by the Panel, which has 195 member Governments
“Climate change is a problem which can no longer be left to future generations.”

- Pope Francis
Public Health Response to Climate Change

• Enhanced surveillance
  • Human cases in previously disease-free areas
  • Introduction of new vectors, hosts, or pathogens
  • Changing transmission patterns recognition and response
  • Identify potential vulnerable populations

• Strengthen public health infrastructure to improve measures to reduce the spread of disease or disease vectors and hosts

Average annual increase in Lyme disease, selected U.S. counties, 1992-2006

*Counties reporting average of >5 cases annually
Public Health Response to Climate Change

• Modeling and long-term ecological and epidemiological research on influence of environmental changes on disease cycles
• Preparedness: Review, evaluate and prepare adaptive countermeasures (temperature triggers, vaccines, therapeutic agents, insecticides, etc.)
• Training & Education: PH workforce
Challenges

- Communicating uncertainty
- Climate change must be framed as a public health issue
- The costs of not taking action are high
- Linking meteorologic science with health – “new demands on science and services”
CLIMATE SUMMIT

WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?

- ENERGY INDEPENDENCE
- PRESERVE RAINFORESTS
- SUSTAINABILITY
- GREEN JOBS
- LIVABLE CITIES
- RENEWABLES
- CLEAN WATER, AIR
- HEALTHY CHILDREN
- ETC. ETC.
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