Human Health Concerns as Related to the Changing Weather Patterns across Illinois

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Presentation Outline

• Quick summary: observed changes in temperature and precipitation across Illinois
• A warmer and wetter Illinois climate: Impacts human health
  – Current Understanding
  – Data Application/Analysis with PRI Resources
    • Heat Risk
    • Air Quality Concerns
    • Vector-borne Disease Risk
    • Water-borne Disease Risk
• Concluding Remarks
As Jim explained, Illinois climate has become warmer.

Illinois Historic Monthly Average Temperature Trend based on 1895-2015 (°F per Century)

Courtesy of the Midwestern Regional Climate Center

Warming has been primarily in Spring and Winter
Illinois Historic Monthly Observed Precipitation Trend based on 1895-2015 (Inches per Century)

Courtesy of the Midwestern Regional Climate Center

Increases in precipitation have primarily been during spring, summer, and late fall/early winter.
Over the last 150 years, *natural* and *anthropogenic* climate drivers have led to a warming climate

The remainder of my talk with focus on the impacts of a warmer climate regime on human health in Illinois
Atmospheric Circulation Shifts in a Warmer Climate

Global circulation and midlatitude weather systems are driven by the difference in temperature between the North Pole and the equator:

- Warmer air pushes Polar Front Jet (PFJ) stream northward into Canada.
- The PFJ stream weakens (winds slow down) due to weaker temperature difference between North Pole and Equator.
- The jet stream becomes more meridional (north to south) versus zonal (west to east).
  - More “extreme” events across the midlatitudes!
- Warmer air holds more moisture.

Image: Jones & Bartlett Learning - www.jblearning.com
A Focus on Heat Risks and Impacts to Human Health

EXTREME TEMPERATURES

*Figures from Hansen et al., 2012
There has been a 20% increase in the number of heatwaves from 1949 to 1995 for the eastern and western United States (Gaffen and Ross 1998).

The IPCC projects with strong confidence that those areas already experiencing increased heatwave events will experience events of greater intensity and magnitude through the 21st century.

- This means the Midwest!

Increased energy demand in summer to offset heat, decreased demand in winter due to projected milder temperatures.

Warmer Climate and Human Health: Heat

*Warmer temperatures greater concern than colder temperatures*

– Heat is the most prominent cause of weather-related mortalities in the US (Luber and McGeehin 2008; Harlan and Ruddell 2011)

*Consecutive nights of very warm nighttime minimum temperatures has greatest impact* (Meehl and Tebaldi, 2004)

*Most at Risk:*

– Young and elderly
– Those without air conditioning
– Pre-existing medical conditions
– Individuals taking medications that interfere with salt and water balance (Luber and McGeehin 2008)
– Those regularly working outdoors

<table>
<thead>
<tr>
<th>Location</th>
<th>July 13, 1995</th>
<th>July 14, 1995</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midway</td>
<td>$T_{max}=106$, $T_{min}=81$</td>
<td>$T_{max}=102$, $T_{min}=84$</td>
</tr>
<tr>
<td>O’Hare</td>
<td>$T_{max}=104$, $T_{min}=81$</td>
<td>$T_{max}=100$, $T_{min}=83$</td>
</tr>
<tr>
<td>Lake Villa</td>
<td>$T_{max}=102$, $T_{min}=77$</td>
<td>$T_{max}=100$, $T_{min}=81$</td>
</tr>
</tbody>
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Figure 9. Heat-related deaths, Maximum Temperature ($T_{max}$) and Heat Index (HI), Chicago, July 11-23, 1995. (As reported by the Office of the Medical Examiner.)
Heat and the Urban Environment

- Urban areas projected to see a higher, increased risk
- More than half of the world’s population now lives in cities
  - more difficult to keep cool (Luber and McGeehin 2008)
- Urban climate – exacerbates a heatwave
  - High thermal mass of concrete and blacktop
  - Low ventilation due to building density
  - Point-source heat from cars and AC units
    - All together, these feedbacks contribute to the urban heat island effect, which adds 2°F to 10°F to the ambient air temperature (Luber and McGeehin 2008; Vose, et al. 2004)
Heat Response Plan?

- Understand your city, village, town, or county’s heat risk through...
  - Demographic data
  - Location-specific climatological data
    - The Midwestern Regional Climate Center within the Illinois State Water Survey is a GREAT resource for historic climate data
      - http://mrcc.isws.illinois.edu/
      - Geospatial analysis to determine vulnerability “hotspots”

Know the criteria of the following:
- Heat Advisory
- Excessive Heat Watch:
  - Heat warning criteria likely in the next 24-72 hours
- Excessive Heat Warning:
  - Heat Index values meet or exceed warning criteria for at least 2 days (typical values: maximum daytime high $\geq 105^\circ F$ north and minimum nighttime lows $\geq 75^\circ F$)
- Air Stagnation Advisory
  - Atmospheric conditions stable enough to cause air pollutants to accumulate in a given area.
State of Illinois and Chicago Area Populations with Increased Heat Risk

Labeled Cities are those with Population of 20,000 or greater

Selection Criteria:
1) Poverty (Number of homes within census block at or below poverty level in the last 12 months for family of four)
2) Age (greater than or equal to 50)
3) Median Age of Dwelling (built prior to 1981)

*Census Block Group Data 2007-2011: https://www.census.gov/geo/maps-data/data/tiger-data.html

BRACE Illinois provides detailed county-level social vulnerability maps here:
https://braceillinois.uic.edu/summer-heat-toolkit/heat-addenda/
Shift in Mean Storm Track

- Polar jet stream (i.e. “storm track”) projected to shift north
  - Less midlatitude cyclones across Midwest
  - Reduced ventilation of air from cities such as Chicago (Mickley, et al. 2004; Jacob and Winner 2009; Ramsey et al. 2014)
    - Allergies, Asthma, respiratory diseases, & air pollution/air quality all impacted

Particulate Matter Concentrations

- Contributors to increased PM 2.5 levels:
  - Increased humidity
  - Increased stagnation events
  - Increased biogenic emissions

- Contributors to decreased PM 2.5 levels:
  - Increased precipitation
  - Enhanced atmospheric mixing, and other factors could decrease PM 2.5 levels.

- More variability is projected for these climate variables in a warmer climate
  - No consensus yet on net increase or decrease in PM 2.5 levels in the United States from climate fluctuations, just a increase in the severity of events

*From Fann, et al., 2016.
Projected Changes in Temp., O$_3$, and O$_3$-Related Premature Deaths in 2030 compared to 2000 (from Balbus et al., 2016)

Each year (2000 and 2030) is represented by 11 years of modeled data for May through September, the traditional ozone season in the United States.

Moderate Emissions (RCP 6.0)

Higher Emissions (RCP 8.5)
Primary Impacts of Climate Change

- Increased levels of CO2, warmer temperatures, and increased rainfall have extended the length of the growing season
  - Increases in the amount of allergenic pollens
  - Increases the potency of the allergenic pollens
  - Expands the spatial distribution of allergenic pollens
    - See Albertine et al., 2014; Beggs 2004; Bielory et al., 2012

Ragweed pollen season length increased by as much as 11 to 27 days (1995-2011) in parts of the US and Canada because of warmer temperatures. Increases in the length of the pollen season are also correlated with increases in the number of days before the first frost. Image from the 3rd National Climate Assessment.
FAVOURABLE CLIMATE FOR BREEDING

With climate change, increases in temperature and rainfall are expected. This may result in vectors thriving in new locations and maturing faster.

Ticks and Mosquitoes

VECTOR-BORNE DISEASE RISK

Warmer Climate and Human Health: Vector Diseases

- Blacklegged ticks: Lyme Disease
  - Tick is sensitive to temperature and moisture
  - Climate suitability expands north and west as climate warms and precipitation patterns shift
  - Suitability decreases in the far south due to temperatures
  - Tick presence also dependent on (and not included in the model):
    - physical environment (forests and sandy soils)
    - its host (such as white-tailed deer)

Projected distribution of climate-based habitat suitability for *Ixodes scapularis* during three future time periods. The simulation is based on climate change predictions using the Canadian Global Coupled Model (CGCM1) integration forced with anticipated increases in both greenhouse gas and sulfate aerosols, was overlaid on the current predicted distribution.

from Brownstein et. al, 2005
Warmer Climate and Human Health: Vector Diseases

• Just last week, CDC expressed concern of an “epidemic of Lyme disease” that has occurred over the past 2 decades.
  – 95% of Lyme disease cases reported in 2015 came from 14 NE and Midwestern states

• NE expected to be hit hard again this year, due to a large crop of acorns dropping nearly two years ago
  – Acorns = more mice = more infected ticks = more infected humans

• Acorn production impacted by temperatures or precipitation, sometimes both variables
  – White Oaks: spring is warmer than normal in late-April, followed by a cool stretch in early May (Sharp and Sprague 1996)
  – Some evergreen Oak varieties: precipitation one or two years prior (Koenig et al., 1996)


1996-2015 temperatures versus 1895-2000 long-term average
Warmer Climate and Human Health: Vector Diseases

- Mosquitoes: West Nile, Zika, Chikungunya, and Dengue viruses
  - Relationships between vector and climate are highly complex
  - No concrete findings have been found

Example: West Nile Virus

<table>
<thead>
<tr>
<th>Climate Variable</th>
<th>Impact on WNV Spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature, Positive Correlation</td>
<td>- viral replication rates\n- seasonal phenology of mosquito host population\n- growth rates of vector populations\n- viral transmission efficiency to birds\n- geographical variation in human case incidence</td>
</tr>
<tr>
<td>Temperature, Negative Correlation</td>
<td>- interval between blood meals\n- incubation time from infection to infectiousness in mosquitoes</td>
</tr>
<tr>
<td>Precipitation (above average, floods)</td>
<td>- leads to higher mosquito abundance (excess water), but also flushes drainage channels used by larvae\n- positive correlation to potential disease outbreak in humans</td>
</tr>
<tr>
<td>Precipitation (below average, droughts)</td>
<td>- “Rich” water (less water = more concentrated) attracts certain mosquitoes and birds. Increases the bird-mosquito interaction and accelerates the episodes cycling and amplification of WNV within these populations</td>
</tr>
<tr>
<td>Relative humidity (positive correlation)</td>
<td>- vector population dynamics\n- human morbidity</td>
</tr>
</tbody>
</table>

(adapted from Table 1, Paz 2015)
Warmer Climate and Human Health: Vector Diseases

Example: Dengue (from Morin et al., 2013)

Diagram of biophysical influences on DENV ecology showing the interactions between climate variables, vectors, and the virus. Numbers identify relationships between variables. Habitat availability for mosquito larvae is influenced by temperature through evaporation and transpiration (1) and incoming precipitation (2). Temperature is a major regulator of mosquito development (3), viral replication within infected mosquitoes (4), mosquito survival (5), and the reproductive behavior of mosquitoes (6). Habitat availability is required for immature mosquito survival (7) and reproduction of adult mosquitoes (8). Faster mosquito development and increased survival will accelerate mosquito reproduction (9 and 10). Increased mosquito reproduction enhances the likelihood of transmission by increasing the number of blood feedings (11), whereas faster viral replication increases transmission by shortening the extrinsic incubation period (12). Last, increased survival of the adult mosquito increases the amount of viral replication (13).
Warmer Climate and Human Health: Vector Diseases

- Key factors increasing risk of infection in a warmer, wetter climate:
  - Population density
  - Poverty
  - Housing quality
  - Stagnant/ponding water
- **Topographic Wetness Index (TWI)**

- Best way to manage risk?
  - Conduct outreach in the most vulnerable neighborhoods!

**TWI**: a land-surface index that predicts areas susceptible to saturation, and areas that have the potential to produce overland flow

Clayton Ballerine, of the Illinois State Water Survey CHAMP group is a great resource for more information!
Warmer Climate and Human Health: Vector Diseases

• An additional resource:
  – Midwestern Regional Climate Center and West Nile Virus
    • Contact: Nancy Westcott (nan@illinois.edu)
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.

Flooded materials in homes, schools, and businesses can cause molds to grow and be inhaled.

Climate change increases heavy downpours.


WATER-BORNE DISEASES
Warmer Climate and Human Health: Increases in Areal and Urban Flooding, Flash Flooding

- Water ponding and stagnation on saturated soils
  - Increased probability of vector-borne disease
- Urban Flooding
  - Exceedance of storm drainage capacity
    - Combined sewage overflows
    - Contaminated water supplies and water-born diseases
- Areal Agricultural Flooding
  - Nutrient and pesticide runoff into waterways
  - Animal waste runoff into waterways
  - Both = increased risk of contaminated water supplies, vector-born, and water-born diseases

Annual number of days with precipitation greater than 2 inches for 1900–2014, averaged over 5-year periods (Figure: NCEI State Climate Summaries, 2017)
Impacts of Climate Change to Human Health: Summary

- **Warming Global Temperatures**
  - Midlatitude storm track shifts northward
  - Midlatitude/Polar front jet stream weakens

- **Changes in Precipitation**

- **Changes in Temperature**

- **Less Mixing of Atmosphere over Midwest**

- **Health Impacts**
  - Flooding from increased extreme precipitation events
  - Combined Sewage Overflows
    - Contaminated drinking water supplies/water quality
  - Flooded basements
    - Mold
    - Sewage
  - Stagnant water
    - vector-borne diseases
  - Agricultural Runoff
    - Vector-borne and water-borne diseases, water quality

- **Warmer temperatures**
  - Increase in heat-wave type events
    - Young, elderly, and impoverished most at risk
    - Increased risk for cardiac events in elderly
  - Ozone and other pollution concentrations increase
  - Insects
    - Impacts life cycle and migration – serve as vectors to disease
  - Plants
    - Impacts life cycle, seed spread, & plant migration – allergies
  - Water and food-born disease transmission
    - Changing aquatic habitats with changes in water temperatures
    - Increase in food-born illness such as salmonella

- **More Stagnant Airmasses**
  - Ozone and other pollution concentrations increase
    - Increased respiratory problems
  - Plants
    - Increased concentrations of pollen, allergens
How to Build Resiliency

- Heavy rainfall events, heat waves, and vector populations are not predicted well by global climate models
  - This results in risk uncertainty
- Build resiliency through education that addresses/explains human health concerns via different risk perceptions (i.e. speak to people, not at people)
  - Risk as a hazard (has a level of threat)
    - “which risks should we rank?”
  - Risk as a probability
    - “What is the risk of basements flooding?”
  - Risk as a consequence
    - “What is the risk of not maintaining the AC unit?”
  - Risk as a potential adversity or threat
    - “How great is the risk of getting a tick bite if wearing shorts?”
- Build and maintain strong relationships with National Weather Service forecast offices, emergency management, local critical facilities, and community leaders for optimal response and mitigation
- Build and maintain strong relationships with researchers that study climate variability and climate change impacts in their field of specialty