Climate change and
Vulnerability in the Elderly

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Presentation outline

• Overview on climate change
  – Definitions
  – The greenhouse effect
  – Global warming
  – Health Impacts of Climate Change

• Examples of research in this area
Definitions

- **Weather** is what you get
- **Climate** is what you expect
  - Based on 30-year averages
- **Climate variability**
  - Short-term fluctuations around the average weather
- **Climate change**
  - Operates over several decades or longer
Climate Change

• Climate change is a significant and lasting change in the distribution of weather patterns over periods ranging from decades to millions of years.

• Climate change includes major changes in temperature, precipitation, wind patterns, and extreme events, that occur over several decades or longer.
Why is Climate Changing?

- IPCC: Warming of the climate system is caused by increasing concentrations of greenhouse gases in the atmosphere produced by human activities such as:
  - deforestation
  - burning of fossil fuels

- Global mean temperature increased around 0.8 °C (1.4 °F) since 1980s.

- CO₂ increased 280 ppm to 390 ppm since mid-1900s
What will an increase in temperature do?

- An increase in global temperature will cause:
  - sea levels to rise
  - oceans become warmer and more acidic
  - change the amount and pattern of precipitation
  - probable expansion of subtropical deserts.

- More frequent occurrence of extreme-weather events
  - heat waves, droughts and heavy rainfall, species extinctions, changes in crop yields.

- Changes will vary from region to region around the globe

- As these and other changes become more pronounced in the coming decades, they will likely present challenges to our society and our environment.
• **Climate models** produce projections of future Global mean surface temperature

• Simulations of future climate depend on the path of socio-economic development.

IPCC, 2007
Pathways by Which Climate Change Affects Health

**Driving forces**
- Population dynamics
- Unsustainable economic development
- Natural causes
- Greenhouse gases (GHG) emissions

**Adaptive capacity**

**Mitigative capacity**

**Mitigation measures**

**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

**Regional weather changes**
- Heatwaves
- Extreme weather
- Temperature
- Precipitation

**Microbial contamination pathways**

**Transmission dynamics**

**Agro-ecosystems, hydrology**

**Socioeconomics, demographics**

**Health-specific adaptation measures**

**Research needs**

**Evaluation of adaptation**
Drivers of Health Issues

- Population growth
- Urbanization
- Scientific developments
IPCC: Potential Health Impacts of Climate Change

- Any increase in climate extremes (storms, floods, cyclones) increase the risk of infectious disease epidemics, particularly in developing countries.
- Increase in heat waves, often exacerbated by increased humidity & urban air pollution.
- Increase in the geographic range of potential transmission of malaria & other vector-borne diseases.
- Increase in water- and food-borne diseases.

The severity of impacts will depend on the capacity to adapt & its effective deployment.
Indicators of Vulnerability to Heat Events

- Age and disease profile, including obesity
- Low level of fitness
- Dehydration from reduced food and liquid intake
- Use of drugs affecting temperature regulation
- Socioeconomic status
- Housing conditions
- Prevalence of air conditioning
What Can You Do to Protect Yourself?

• Know how is the weather and if there is a cold spell or a heat wave
  – television, radio, newspaper and on the internet
• Air conditioning and water during a heat wave
• Stay in warm heated room during a cold patch.
• Offer/get help from neighbors, friends and families
• Local community organizations offer help to vulnerable people such as shelter, air conditioning, or water
Specific research questions

• How many people become ill or die during hot or cold weather?
• Do cause-specific admissions or mortality increase with increasing temperature?
• Does vulnerability differ by
  – co-morbid conditions?
    heat-related; diabetes; cardiovascular; respiratory; neurological
  – individual characteristics?
    race, gender, age, public vs. private hospital
  – city-wide characteristics?
    % poverty, % with college education, % non-white, air conditioning prevalence, % green space, housing characteristics, air pollution concentrations, weather variability, city preventive programs
Climate Change Epidemiology

- Apply methods developed for air pollution epidemiology to address climate change
- Quantify climate change effect on health
  - Extremes, average temperature, temperature variability
  - Effects depend on location, exposure period
- Characterize shape of exposure-response
- What factors contribute to susceptibility and vulnerability?
  - Evaluate effect modification
Findings in climate change epidemiology studies

1. Short-term effect of weather parameters on mortality focusing on susceptibility

2. Long-term increases in temperature variability may elevate the risk of mortality in different subgroups of susceptible older populations
Study population
Individual MEDICARE records (age 65+)
135 U.S. cities (1985-2006)

National Oceanic and Atmospheric Administration (NOAA) Weather data
2000 Census data
2001 National Land Use Cover dataset

U.S. Energy Information Administration climate zones. CDD: cooling degree days, HDD: heating degree days.
Susceptibility to Mortality in Weather Extremes: Effect Modification by Personal and Small Area Characteristics In a Multi-City Case-Only Analysis

- Identify which susceptibility and vulnerability factors were modifiers of the effect of weather parameters and temperature extremes on the risk of dying.

Susceptibility factors/ modifiers

• **Medical condition**: having cause of admissions prior to death:
  • Myocardial infarction; Congestive heart failure; Atrial fibrillation; Diabetes
  • Chronic obstructive pulmonary disease; Pneumonia
  • Alzheimer’s disease; Parkinson’s disease; Dementia

• **Personal characteristics**: sex and race

• **ZIP code area level modifiers**:
  • proportion of land with green space
  • proportion of land with water
  • poverty level
  • proportion of non-white population
  • population density
  • proportion of population with college degree
Methods

• Case-only analysis
  ✓ 1st stage: city specific
  ✓ 2nd stage: random effects meta-analysis

• We examined all deaths within Medicare hospitalizations

Outcome:

• Presence or absence of the modifier.

Exposure:

– Mean temperature, water-vapor pressure
– Extremely cold days (temperature ≤ 1st percentile in that city).
– Extremely hot days (temperature ≥ 99th percentile in that city).
**Descriptive: over 7 millions deaths**

<table>
<thead>
<tr>
<th>Previous admission for:</th>
<th>% of total deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alzheimer’s disease</td>
<td>5.1</td>
</tr>
<tr>
<td>Parkinson’s disease</td>
<td>2.8</td>
</tr>
<tr>
<td>Dementia</td>
<td>6.5</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>16.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Individual level modifiers:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-white race</td>
<td>14.0</td>
</tr>
<tr>
<td>Female</td>
<td>57.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zip code area level modifiers:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low % Green Space</td>
<td>35.4</td>
</tr>
<tr>
<td>Low % Water</td>
<td>24.2</td>
</tr>
<tr>
<td>High % Poverty</td>
<td>29.2</td>
</tr>
<tr>
<td>High % No High School Diploma</td>
<td>27.3</td>
</tr>
<tr>
<td>Low % College Degree</td>
<td>20.2</td>
</tr>
</tbody>
</table>
Relative odds of dying on an extreme hot and cold temperature day (defined at 1\textsuperscript{st}, 99\textsuperscript{th} % temperature) for persons who had the condition compared with persons who did not have the condition.

Alzheimer's Parkinson's Dementia Atrial fibrillation Non-white race Low % green space High % poverty High % no High School Medical conditions Individual modifiers Zipcode level modifiers
Relative odds of dying for an increase in warm month (7.7 °C) and decrease in cold month temperature (8.6 °C)

<table>
<thead>
<tr>
<th>Medical conditions</th>
<th>Zipcode level modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold months</td>
<td>Cold months</td>
</tr>
<tr>
<td>Warm months</td>
<td>Warm months</td>
</tr>
<tr>
<td>Alzheimer's</td>
<td>Parkinson's</td>
</tr>
<tr>
<td>Dementia</td>
<td>Atrial fibrillation</td>
</tr>
<tr>
<td>Non-white race</td>
<td>Low % green space</td>
</tr>
<tr>
<td>High % poverty</td>
<td>High % no High School</td>
</tr>
<tr>
<td>Individual modifiers</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

• In this study we identified several subpopulations particularly susceptible to average temperature and temperature extremes.

• Recognition of subpopulations that are particularly vulnerable to temperature extremes is of public health relevance, especially because these subpopulations are growing proportions of the population.

• This knowledge may contribute to establishing health programs that would better protect the vulnerable.
Summer temperature variability and long-term survival among elderly people with chronic disease

- We investigated whether the standard deviation of summer (June-August) temperatures were associated with survival in four cohorts of persons with predisposing diseases in 135 US cities.

Cohorts

- Persons hospitalized with:
  1. Myocardial infarction (MI, ICD-9: 410)
  2. Chronic obstructive pulmonary disease (COPD, ICD-9: 490-496, except 493)
  3. Diabetes (ICD-9: 250)
  4. Congestive heart failure (CHF, ICD-9: 428)

- Follow-up periods: calendar years (January – December) until the year in which they die or until December 2006 (censoring).
Methods

- Cox’s proportional hazard model
  Adjusting for: year of follow up, season, Individual risk factors, wintertime SD temperature.

✓ 1st stage: city and cohort specific analysis
✓ 2nd stage: random effects meta-analysis

Outcome:
- Mortality

Exposure:
- Standard deviation (SD) of mean daily summertime (June-August) temperature in each city
- Daily 8-hour mean ozone (U.S. EPA AQSTTN)
Susceptibility factors/ modifiers

- **Personal characteristics:**
  - Sex, age and race

- **ZIP code area level modifiers:**
  - proportion of land with green space
  - proportion of land with water
  - poverty level
  - proportion of non-white population
  - population density
  - proportion of population with college degree
## Descriptive

<table>
<thead>
<tr>
<th></th>
<th>CHF</th>
<th>MI</th>
<th>DIABETES</th>
<th>COPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total events</td>
<td>1,939,149</td>
<td>1,454,928</td>
<td>3,364,868</td>
<td>3,749,096</td>
</tr>
<tr>
<td>Deaths %</td>
<td>60.9</td>
<td>41.9</td>
<td>43.0</td>
<td>49.8</td>
</tr>
<tr>
<td>Gender %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>41.2</td>
<td>50.9</td>
<td>41.6</td>
<td>46.4</td>
</tr>
<tr>
<td>Female</td>
<td>58.8</td>
<td>49.1</td>
<td>58.4</td>
<td>53.6</td>
</tr>
<tr>
<td>Race %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>82.1</td>
<td>87.3</td>
<td>75.5</td>
<td>86.4</td>
</tr>
<tr>
<td>Black</td>
<td>13.1</td>
<td>7.9</td>
<td>17.1</td>
<td>9.1</td>
</tr>
<tr>
<td>Other</td>
<td>4.8</td>
<td>4.8</td>
<td>7.3</td>
<td>4.5</td>
</tr>
<tr>
<td>Mean Age</td>
<td>79</td>
<td>77</td>
<td>76</td>
<td>77</td>
</tr>
</tbody>
</table>
Hazard Ratio (HR) and 95% Confidence Intervals (CI) per 1°C increase in yearly summer temperature standard deviation: 135 U.S. cities by cohort

<table>
<thead>
<tr>
<th>Condition</th>
<th>Summer (June-August)</th>
<th>Adjusting for ozone</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HR</td>
<td>95% CI</td>
</tr>
<tr>
<td>COPD</td>
<td>1.048</td>
<td>1.029</td>
</tr>
<tr>
<td>Diabetes</td>
<td>1.055</td>
<td>1.035</td>
</tr>
<tr>
<td>MI</td>
<td>1.050</td>
<td>1.030</td>
</tr>
<tr>
<td>CHF</td>
<td>1.038</td>
<td>1.024</td>
</tr>
</tbody>
</table>
Hazard Ratio and 95% CI for 1 °C increase in the standard deviation of summer temperature. Modification of the standard deviation of summer temperature-mortality association estimated at the 25th (low) and the 75th (high) percentile of the effect modifier.
Hazard Ratio and 95% CI for 1 °C increase in the standard deviation of summer temperature: modification of the effect by age

<table>
<thead>
<tr>
<th>Age</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>65-75</td>
<td>CHF</td>
</tr>
<tr>
<td>&gt;75</td>
<td>COPD</td>
</tr>
<tr>
<td>65-75</td>
<td>DIAB</td>
</tr>
<tr>
<td>&gt;75</td>
<td>MI</td>
</tr>
</tbody>
</table>
Conclusions

- High day to day variability in summer temperatures shortens life expectancy.
- Based on these increases in mortality risk, greater summer temperature variability could result in more than 10,000 additional deaths per year.
- The mortality risk was 1% to 2% greater for those living in poverty and for African Americans.
- Some adaptation measures, such as green space, may ameliorate this effect.
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