Air Quality, Climate, Public Health

Climate and Public Health in North Carolina: Emerging Risks and Opportunities Workshop

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Potential Mechanisms

Changes in weather, air mass patterns
- Increased temperatures
- Increased frequency of forest fires
- Increased growing seasons/pollens/mold

Air Quality

Health
The Public’s Health

Who’s Health? Vulnerable:

1) Populations
   - Children/Elderly
   - Those with asthma, COPD, CVD, diabetes, allergies, other diseases
   - Resource-poor

2) Locations
Growth in Population, Transportation Networks
Air mass patterns associated with air pollution and asthma/myocardial infarction hospital admissions

A. Hanna, K. Yeatts, Z. Zhu, A Xiu, J. Pinto, Q. Meng, Department of Epidemiology, School of Public Health & Institute for the Environment, University of North Carolina Chapel Hill
Objectives

• Characterize air mass patterns over the state of North Carolina

• Describe their relationship to air pollution
Objectives

- Examine the interrelationships among
  - Air mass patterns,
  - ozone
  - hospitalizations
    - asthma
    - myocardial infarctions

- Evaluate heat-related morbidity in a vulnerable population: children with economic disadvantage
Study Design

• Time series analyses

• Time frame, 1996-2005
Exposures

- Meteorological Data
  - The National Climatic Data Center archives, surface and upper-air data over the U.S.

- Air Masses (spatial synoptic classifications)

- Air Quality Data
  - EPA’s Air Quality System, ambient ozone concentration measurements
The Concept of Air Mass

• How is “air mass” different from basic meteorological parameters (temperature, pressure, winds, etc.)?
  – Source
  – Duration
  – Spatial coverage
Dry Tropical Air Mass
Spatial Synoptic Classification

Air mass types

• DM: Dry Moderate (mild and dry)
• DP: Dry Polar (very cold)
• DT: Dry Tropical (hottest and driest conditions at any location)
• MM: Moist Moderate (warmer and more humid than MP)
• MP: Moist Polar (cloudy, humid, and cool)
• MT: Moist Tropical (warm and very humid)
• Tr: Transition (one air mass giving way to another)
• MT+: Moist Tropical+ (upper limits of the MT)

Sheridan Spatial Synoptic Classification system (2001) (sheridan.geog.kent.edu/ssc.html)
Dry tropical trajectories, Summer

(DT 15 trajectories in Summer), Frequency trajectory clusters of 72-hour backward trajectories for Charlotte, using EDAS analysis for different air masses during the summer of years 2001, 2002 and 2003,
Health Outcomes

• Hospitalizations in North Carolina (North Carolina Center for State Health Statistics)
  – asthma (ICD9 493.x)
  – myocardial infarctions (ICD 410)
Statistical Analysis-General Linear Models

- Evaluated association of ozone with asthma and MI hospitalizations for different air masses

- Modeling strategy:
  - Joint modeling of ozone and air mass

- Assumed a Poisson distribution of the outcomes,
  - Checked for over dispersion

- Used B-spline function with 24 knots to adjust for nonlinear seasonal effect and long term trend.

- Adjusted for differences in meteorological variables (relative humidity, pressure) and day of the week.
Results

Monthly frequency of occurrence of different air masses in North Carolina based on daily weather analysis during the period 1996 to 2005.
Ozone Threshold and Air Mass Type

1996 - 2004
Ozone & Asthma Hospitalizations

Percent change (or 95% CI) in Asthma admissions per 10ppb rise in Ozone (Charlotte, Greensboro, Raleigh) Controlled for Dew point, Air mass, Ozone, and Splines (df=24, degree=4)
Ozone & Myocardial Infarction Hospitalizations

Percent change (or 95% CI) in MI admissions per 10ppb rise in Ozone (Charlotte, Greensboro, Raleigh) Controlled for Dew point, Air mass, Ozone, and Splines (df=24, degree=4)
Conclusions

• Certain air mass patterns, in conjunction with ambient ozone, were associated with increased asthma hospitalizations.
Conclusions

• The distribution of ozone concentration is different under different air masses.

  ▪ The Dry Tropical air mass was associated with highest ozone concentrations in North Carolina.

  ▪ Lag 1-day through lag 5-day ozone was positively related to asthma hospitalizations under the Dry Tropical air mass.

• Current day ozone was also associated with increased asthma hospitalizations under the Moist Tropical++ air mass.

• Lag 3-day and lag 4-day ozone was also associated with increased asthma hospitalizations under the Transition air mass.
In the Future?
Future Air Mass Predictions

For Charlotte, NC
(Hanna et al.)
Next Steps

• Use climate and air pollution models to construct projected synoptic weather classifications and air pollution for 2020-2050.

• Apply our statistical models to project asthma and MI hospitalizations for 2020-2050.
Peat Fire near Pocosin Lakes, 2008

June 11                                   June 12

Rappold et al 2011
Percent change in relative risk for ER visits

- All Respiratory
- Asthma
- COPD
- Pneumonia & Acute Bronchitis
- Upper Respiratory Infections
- All Cardiovascular
- Myocardial Infarction
- Heart Failure
- Cardiac Dysrhythmia
- Respiratory/Other Chest Pain Symptoms

Rappold et al 2011
Regional Transport & Population Growth
Regional development and Impacts on Air Pollution Emissions, Charlotte NC

Figure 5: Change in jobs 2050-2000 for Smart Growth and Business as Usual scenarios (note: total number of jobs changing is same for both scenarios)
Recommendations

• Develop North Carolina specific models and infrastructure

• Focus research efforts on
  • the effects of climate change and health in vulnerable populations
  • new adaptation strategies

• Promote new collaborations among state and local governments, universities, public and private institutions.

• Build and maintain public health surveillance, emergency preparedness, and research.

Ostry et al. 2010
Frumkin et al. 2008
# Adaptation Strategies

<table>
<thead>
<tr>
<th>Sector</th>
<th>Strategy</th>
<th>Climate change implications</th>
<th>Pathway from climate change to NCDs</th>
<th>NCD risk</th>
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<tbody>
<tr>
<td>Energy</td>
<td>Reduce household use of solid (biomass) fuels</td>
<td>Mitigation: reduce GHG emissions</td>
<td>Reduced indoor air pollution</td>
<td>Reduced CVD</td>
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<td>Reduced respiratory diseases</td>
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<td>Reduced COPD</td>
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<td>Generate cleaner electricity</td>
<td>Mitigation: reduce GHG emissions</td>
<td>Reduced outdoor pollution</td>
<td>Reduced respiratory diseases</td>
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<td>Improve household energy efficiency: provide efficient heating and cooling appliances, improve home insulation</td>
<td>Mitigation and adaptation</td>
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<td>Reduced CVD</td>
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<td>Reduced extreme temperature mortality</td>
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<td>Urban planning</td>
<td>Improve walking and cycling infrastructure</td>
<td>Mitigation: reduce GHG emissions</td>
<td>Increased active transport, physical activity</td>
<td>Reduced CVD</td>
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<td>Reduced respiratory diseases</td>
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<td>Develop and support community hubs</td>
<td>Mitigation: reduce GHG emissions</td>
<td>Increased connectivity; reduced use of fossil fuel–dependent cars; more active travel</td>
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<td>Reduce use of fossil fuel–dependent cars, supply hybrid or electric cars for fleet vehicles</td>
<td>Mitigation: reduce GHG emissions</td>
<td>Reduced urban air pollution; reduced road traffic volume</td>
<td>Reduced lung cancer</td>
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<td>Improved mental health</td>
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<td>Improve urban design, including street trees, pedestrian crossings, more footpaths, reduced distance to public transport, more urban green space</td>
<td>Mitigation and adaptation</td>
<td>More social connectivity; more shade; greater walkability and active travel</td>
<td>Reduced obesity</td>
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