Climate Change, Air Quality and Respiratory Health

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Earth, Wind and Fire: a One Medicine Approach to Climate Change
11 December 2008
Disclaimers & Acknowledgements

• Neither my spouse nor I have any financial interests in any products or companies related to this talk

• “Climate change and allergic disease” September 2008 Drs. Truckner, Weber and Peden coauthors.
Health Impacts of Climate Change

Direct Impacts
- Heat-related
- Storm-related
- Food-borne Infections
- Water-borne Infections
- Vector-borne Disease
- Air Quality-related

Indirect Impacts
- Food Insecurity
- Water Insecurity
- Sea Level Rise
- Forced Migration
- Political Instability
# Climate-Related Health Stressors in the USA by regions

## Table ES.2 Summary of Regional Vulnerabilities to Climate-Related Impacts

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<th>United States Census Regions</th>
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1 Based on impacts identified in the published peer-reviewed literature and expert opinion.

[http://climatescience.gov/Library/sap/sap4-6(final-report)](http://climatescience.gov/Library/sap/sap4-6(final-report))
Climate Change and Air Quality

- Ozone
- Air Pollution
- Aeroallergens
- Wildfires
Ozone and Climate Change

Up Temperature
Up Climate Change
Up Urban Heat Islands
Up NOx
Up Fossil Fuels
Up VOCs
Up Fossil Fuels
Up Vegetation enhanced by higher CO₂

http://www.epa.gov/air/ozonepollution/basic.html
Ozone and Health

Ground-level ozone

↑ Frequency/severity of asthma attacks
   (strong evidence)
   ↑ Use of rescue medications
   ↑ ER visits
   ↑ Hospitalizations
   ↑ Mortality

↑ Incidence
   (some evidence with heavy exposure)

March 2008, 8-hr ozone standard lowered to 0.075 ppm
Direct Cost of Ozone

Estimated Number of Respiratory Hospital Admissions due to Ozone in NC\(^1\)

- Excess respiratory hospital admissions, Summer 1997 = 1900\(^2\)
  (4.6% of total respiratory admissions)
- Average charge/respiratory admission, $10,051\(^3\)
- Total hospital charges = $19,097,587

1. OEEB/DPH: Luanne Williams and Rick Langley, memo to Div. of Air Quality, DENR. April-October 1997
2. Extracted from regional data, Abt Associates, Inc.
3. NC State Center for Health Statistics

Slide by J Engel, NC State Epidemiologist, State Energy Conference 2007
Predicting the future?

MULTI-MODEL AVERAGES AND ASSESSED RANGES FOR SURFACE WARMING

Global surface warming (°C)

Year

IPCC AR4
50 cities A2 (BAU) Scenario

Increase in 1-Hr Max Ozone 1990 to 2050

Hospital Admissions
- Respiratory
  - Average +0.8-2.1%
  - Highest +1.7-4.5%
- Asthma
  - Average + 2.1% (0.6, 3.5)
  - Highest +4.7% (1.4, 8.1)

Excess CVD/Pulm Mortality
- Average +0.18% (0.09, 0.28)
- Highest +0.42% (0.20, 0.62)

Bell. Climate Change 2007;82:61ff, Fig 1
Air Pollution and Climate Change

65% of SOx from Coal
Much of Hg from Coal

↑ Fossil fuel pollution
↑ Population
↑ Demand

↑ PM, NOx, SOx, VOCs
↓ Lung growth
↑ Respiratory infections
↑ Asthma attacks
↑ All age, all cause mortality
↑ Miscarriages, preterm & low birth weight births

↑ Mercury
↑ Neurodevelopmental damage

Phillip J. Redman, USGS
Particulates and Climate Change

- Robust associations between PM, morbidity and mortality

- 8 yr study of 1700 10 yr olds in southern Calif
  - Clinically and statistically significant decrements in FEV1, regardless of asthma status
  - same magnitude as effect of maternal smoking
    (Gaudernam, NEJM 2004;351-1057)

- “Too few data yet exist for PM to draw firm conclusions about the direction or magnitude of climate impacts.”
  (SAP 4.6, US Climate Change Science Program)
% Annual Excess Morbidity & Mortality in USA Attributable to CO₂

- Annual air pollution related deaths in US increase 1000 (350-1800) per 1°C rise in fossil fuel CO₂–induced temperature, (additionally 20-30 more cancers annually)

Who is at risk?

Vulnerable Groups

- Intrinsic characteristics
  - Age
  - Health Status
  - Genetics

- Extrinsic characteristics
  - SES
  - Geography
  - Education
  - Occupation
  - Culture
  - Access to Health Care
How many Americans at risk?

- 2 out of 5 Americans (125 million) live in areas unhealthful for ozone* or PMs
  - 1 in 10 (30.4 M) live where ozone, short term and year round PM are too high
  - Asthma
    - $O_3$: 2.2 million children, 5.5 million adults
    - PM short term: 1.9 M children, 5 M adults
    - PM year round: 1.2 M children, 3 M adults
  - Extremes of Age
    - $O_3$: 24 million children, 10.2 million seniors
    - PM short term: 20.6 M children, 9.4 M seniors
    - PM year round: 13 M children, 5.5 M seniors
  - COPD, CVD, DM

*old standard

State of the Air 2008 based on 2004-2006
EPA air quality  http://www.stateoftheair.org/
## North Carolinians?

<table>
<thead>
<tr>
<th>Condition</th>
<th>Population</th>
</tr>
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<tbody>
<tr>
<td>Children under 18</td>
<td>1,591,183</td>
</tr>
<tr>
<td>Seniors 65 and up</td>
<td>710,565</td>
</tr>
<tr>
<td>Pediatric Asthma</td>
<td>146,664</td>
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<tr>
<td>Adult Asthma</td>
<td>327,387</td>
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<tr>
<td>Chronic Bronchitis</td>
<td>295,582</td>
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<tr>
<td>Emphysema</td>
<td>85,973</td>
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<tr>
<td>CV Disease</td>
<td>1,582,031</td>
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<tr>
<td>Diabetes</td>
<td>363,308</td>
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<tr>
<td><strong>Total State Population</strong></td>
<td><strong>6,450,074</strong></td>
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CC & Atopy, Allergy, Asthma

- **Direct Effects**
  - T & CO₂ on Allergens
    - Quantitative
    - Qualitative
  - Extended Seasons
  - Altered Ranges
  - Exotic/Invasive Species
- **Indirect Effects**
  - Potentiation
    - Ozone effects
    - Other air pollutants
Examples of Recent Changes

- Flowering time of 385 British plant species over past decade
  - Average 4.5 days earlier
  - 16% were 15 days earlier
  - 3% flowered later
  
  Fitter, Fitter Science 2002;296:1689-91

- More oak pollen now being measured in warmer Mediterranean sites
  - Models suggest 50% increase by 2100

Gracia-Mozo Ann Agric Environ Med 2006;362
CC & Atopy, Allergy, Asthma
Quantitative Impact of CO\textsubscript{2} on Aeroallergens

Ziska, World resources review, 2000, 12:449-457
Early Spring and Pollen Counts

- Simulated early spring
  - Plants taller, heavier
  - More flowers
  - 54.8% more pollen
- Higher CO$_2$
  - 55% higher pollen for latest simulated spring
- Both early spring and higher CO$_2$ increase pollen count, but early spring has stronger effect

Ragweed Pollen

![Graph showing estimated pollen production over dormancy release stages for different CO$_2$ levels.

Rogers. EHP 2004:114:865]
Cities are Harbingers of CC

Temperature
• +1.8-2.0° C urban vs rural

Atmospheric CO₂
• + 30% urban vs rural

Ragweed grew earlier, bigger and released more pollen in cities (no qualitative differences)

Ziska. JACI 2003;111:290

FIG 2. Time course of ragweed pollen production for 4 sites along an urban transect for 2001 as a function of day of year. Values are numbers of pollen grains per cubic meter of air.
Duration of Allergy Season
Quantitative Impact of CC on Aeroallergens

- Length of pollen season increasing significantly
- Seeking medical consultation
  - OR 2.69 (1.32-5.52) day of high pollen counts
  - OR 2.48 (1.26-4.88) 5 days after high pollen counts

CC and Allergenicity
Qualitative Impact of CO$_2$ on Allergens

• Poison ivy
  – Grows faster and bigger
  – Increased photosynthesis and water use
  – MORE ALLERGENIC
    • Higher unsaturated urushiol congeners

• Possible with aero-allergens too?

Mohan PNAS (2006)103:9086
Ozone and Ragweed Occurrence in the Continental United States

110 Million Americans live where both ozone and ragweed are problems!

Source: US Environmental Protection Agency, US Department of Agriculture, Global Biodiversity Information Facility

*Allergy and Asthma Foundation of America, Asthma Capital 2007

http://www.nrdc.org/globalwarming/sneezing/map.pdf
Who and How Many at Risk?

1 in 5 Americans have some sort of allergy

Maybe 60 million sneezing, wheezing, sleep deprived, cranky citizens missing work and school will create some serious political will for change!
Drought and Fire

Impacts on health, agriculture, air and water quality

U.S. Drought Monitor

December 2, 2008
Valid 8 a.m. EST

Wildfire, NPS

http://drought.unl.edu/dm/monitor.html
Climate-Related Health Stressors in the USA by regions

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Climate Change and Wildfires

• Sudden uptick in western wildfires during mid 1980s
• Mostly mid-elevations, Northern Rockies
  – Land use and management issues minimal
  – Correlates increased spring and summer temperatures
    (Spearman 0.78, p<0.001) and early snowmelt (stream flows)
  – Longer fire seasons, longer burning fires
• Consistent with predictions of IPCC for 21st Century

Characteristics of Wildfire Smoke

- Components
  - PM
  - CO
  - CO₂
  - NOx
  - O₃
  - VOCs
  - HAPs

- Modifiers
  - Fuel type
  - Weather (wind)
  - Topography

- Generally acute exposures
  - Studies variable

California Wildfire Smoke Guide for Health Professionals, 2008
Health Impacts of Wildfires

- Southern California Wildfires Fall 2003
- PM measured directly and by satellite light extinction
- Exposure analysis by interpolation to zipcode level
- PM$_{2.5}$ increased average of 70 ug/m$^3$
- Increased asthma admissions (2 day lag)
  - 10% in $\geq$ 65 yrs
  - 8.3% in 0-4 yo
- Also increases in acute bronchitis, pneumonia and COPD related admissions

Delfino. OEM on line 18 Nov 2008
NC Experience

NASA
Who’s at risk?

- Individual characteristics
  - The usual suspects
    - Extremes of age
    - Medically infirm
    - Poor
    - Outdoor workers

- Geography
  - Adjacent to fires
  - Distant transport
    - Florida fires affecting NC air quality
    - Coastal fires affecting Triangle air quality
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<th>Drought</th>
<th>Tropical Storms</th>
<th>Extreme Rainfall with Flooding</th>
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Standard Advice -- Adapt

- Learn to use air quality index and pollen counts
- Avoid exposures
  - Don’t exercise on bad air days
  - Stay inside
  - Close houses and use AC
  - Consider hepa filter
- Optimize medications

Use more Energy → Emit more GHG → Exacerbate CC → Inc Health Risk
Standard Advice -- Adapt

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Use more Energy → Emit more GHG → Exacerbate CC → Inc Health Risk
Choose a Better Future -- Mitigate

• Everyone’s Responsibility
  – CO₂ is the main problem
  – Biggest US Sources: Cars, Coal, Cuisine

• Action must be individual to international

• Options vary greatly
  – By regional climate
  – By level of development
  – By institutional organization

• Good for health!
  – Health professionals natural leaders
## Health Co-Benefits of Mitigation

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<thead>
<tr>
<th></th>
<th>↓ Fossil Fuel Use</th>
<th>Preserve Forest Sinks</th>
<th>↓ Urban Heat Island</th>
<th>Sustainable Urban Design</th>
<th>Improve Mass Transit</th>
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<tr>
<td>CVD</td>
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<tr>
<td>Respiratory Diseases</td>
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<tr>
<td>Obesity-Related</td>
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</table>

+++ very good evidence, ++ good evidence, + some evidence

Patz. 2008 AnnRevPubH
• 45% average per capita carbon footprint is individual activity – under personal control – 60% in the US

• Mitigation in USA and developed countries– contraction, transition to low/no-carbon energy – AND technology transfer

• Mitigation in developing countries – “climate proofing” with clean energy and sustainable development UP FRONT
Find the Win-Win Choices

- “Burn calories instead of carbon”
  - More active transport cleans the air and fights obesity
    (muscle power is carbon neutral - on the right diet)
- Social time instead of “screen” time
  - More interactive family and group time combats isolation and depression
- Eat fresh, local and lower on the food chain
  - Supports local farms/economy, improved nutritional quality, lower risk of chronic diseases
- Energy efficient homes and offices save money
  - Wealth supports health
Win-Win-Win: Triple Bottom Line

1. Sustainable Communities (Planet)
2. Strong Economy (Profit)
3. Health (People)
   - Alternative Energy – Wind, Wave, Solar
     1. Carbon Neutral
     2. New Green Jobs, Keep Energy Dollars Local
     3. Clean Air
   - Green Buses, More Bikes
     1. Reduced Cars and Emissions
     2. New “Green Jobs”
     3. Clean Air, Fewer Accidents, More Physical Activity
A way forward – Make Changes

• Personal Choices MATTER
  – Calculate your carbon footprint
  – Reduce it iteratively and tell the stories

• Professional Choices MATTER
  – Green your office and institution
  – Educate and innovate

• Political Choices MATTER
  – Make change locally (Cool Cities, Mayor’s Challenge, etc)
  – Educate decision makers
  – Vote, speak out, write, run for office

www.healthandenvironment.org/?module=uploads&func=download&fileId=418
Simultaneous and Urgent Action

GOAL – ADAPT

“Manage the Unavoidable”

- Public Health Infrastructure
- Focus on vulnerable groups and local conditions

ADAPTATION ~ SECONDARY PREVENTION

GOAL – MITIGATE

“Avoid the Unmanageable”

- Dramatic sea level rise & massive extinctions
- Limit temperature rise to 1-2°C this century

MITIGATION ~ PRIMARY PREVENTION

“Individual and collective actions can succeed”

Dr. R.K. Pachauri, Chair IPCC
Achim Steiner, the Executive Director of the UNEP after Bali

• “…unless people care about what is written in [the IPCC report], political leaders cannot move, and it is only citizens …who ultimately will bring the political will to bear upon negotiations….So, yes, this is a complex document…look for people who can interpret some of this in the world that we live in, because unless people care about what this IPCC has given us, there will not be the level of political action [needed]. It depends ultimately on citizens who elect their governments.”
What are we **DOING** to Restore the Future?

Our Legacy, by Victor Cauduro Rojas, from The Millennium Series