Impact Of Climate Change On the Indoor Environment

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Conflicts of Interest
• Flint Hills Resources - research and consulting
• A & B sensor technologies – research
• Meda – research and speaking
• Teva – research and speaking
• Journal of Asthma – Editor in Chief

At the end of this lecture the participant will be able to:

1) Discuss the major types of climate induced indoor environmental problems
2) Explain the potential health effects related to climate change's effect on increased indoor pollutant and allergen exposure
3) Define strategies to improve or prevent climate change induced health effects in the future

Climate Change: Several Reports Discussing Relevant Health Effects

EPA Standards for Criteria Air Pollutants

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Averaging Time</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PM$_{2.5}$ (ug/m$^3$)</td>
<td>150 (24 h)</td>
<td>Annual Revoked 2006</td>
</tr>
<tr>
<td>PM$_{10}$ (ug/m$^3$)</td>
<td>35 (24 h)</td>
<td>12 (annual)</td>
</tr>
<tr>
<td>Ozone (ppm)</td>
<td>1-h Revoked 1997</td>
<td>0.075 (8 h)</td>
</tr>
<tr>
<td>NO$_2$ (ppm)</td>
<td>0.100 (1 h)</td>
<td>0.053 (annual)</td>
</tr>
<tr>
<td>SO$_2$ (ppm)</td>
<td>0.075 (1 h)</td>
<td>Annual and 24 h Revoked 2010</td>
</tr>
<tr>
<td>CO (ppm)</td>
<td>35 (1 h)</td>
<td>9 (8 h)</td>
</tr>
</tbody>
</table>

Air Quality Index (AQI) Values and Pollutant Concentration Equal to the Upper AQI Value

<table>
<thead>
<tr>
<th>AQI value</th>
<th>AQI Descriptor</th>
<th>O$_3$ (ppm)</th>
<th>PM$_{2.5}$ (24-hr avg)</th>
<th>PM$_{10}$ (24-hr avg)</th>
<th>SO$_2$ (ppm)</th>
<th>NO$_2$ (ppm)</th>
<th>CO (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-50</td>
<td>Good</td>
<td>0.059</td>
<td>12</td>
<td>34</td>
<td>35</td>
<td>50</td>
<td>4.5</td>
</tr>
<tr>
<td>51-100</td>
<td>Moderate</td>
<td>0.075</td>
<td>35</td>
<td>154</td>
<td>75</td>
<td>100</td>
<td>9.0</td>
</tr>
<tr>
<td>101-150</td>
<td>Unhealthy for Sensitive Groups</td>
<td>0.095</td>
<td>55</td>
<td>254</td>
<td>185</td>
<td>360</td>
<td>15</td>
</tr>
<tr>
<td>151-200</td>
<td>Unhealthy</td>
<td>0.115</td>
<td>150</td>
<td>304</td>
<td>364</td>
<td>644</td>
<td>30</td>
</tr>
<tr>
<td>201-300</td>
<td>Very Unhealthy</td>
<td>0.116</td>
<td>250</td>
<td>424</td>
<td>2644</td>
<td>1244</td>
<td>40</td>
</tr>
<tr>
<td>&gt;300</td>
<td>Hazardous (1-hr)</td>
<td>0.405</td>
<td>&gt;250</td>
<td>&gt;424</td>
<td>&gt;2644</td>
<td>&gt;1244</td>
<td>50</td>
</tr>
</tbody>
</table>

Source: http://www.epa.gov/airnow/aqi_tech_assistance.pdf
What is Smog?

- A term used to describe a mixture of smoke and fog.
- Occurs when high concentrations of moisture are combined with smoke (often containing oxides of sulfur and nitrogen) in the presence of high temperatures or thermal inversions and the absence of wind.
- These conditions cause polluted air to stagnate over industrial areas causing potential respiratory health hazards.
- Large coastal industrial centers with surrounding high ground are more prone to smog.
- There is often a diurnal variation in smog formation since a necessary component for its formation is sunlight.

Journal of Environmental Health; v56; p38; 1994.
Science News; v144; p306; 1993.

What are Greenhouse Gases?

- Composed of emissions from energy supply, transport, agriculture, industry, forestry, waste and commercial and residential buildings.

Summary of Studies of Impacts of Elevated [CO2] (most important GHG) on Allergic Plants

<table>
<thead>
<tr>
<th>Plant studied</th>
<th>CO2 concentration (ppm)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>C3 plants</td>
<td>500 ppm</td>
<td>Increased by 15%</td>
</tr>
<tr>
<td>C4 plants</td>
<td>1000 ppm</td>
<td>Increased by 20%</td>
</tr>
<tr>
<td>Trees</td>
<td>1500 ppm</td>
<td>Increased by 25%</td>
</tr>
</tbody>
</table>

IOM identified five major types of climate-induced indoor environmental problems

• Indoor Air Quality
• Dampness, Moisture and Flooding
• Infectious Agents and Pests
• Thermal Stress
• Building ventilation, weatherization, and energy use

Indoor Air Quality

• Indoor environments can be contaminated by chemical, organic, and particulate pollutants that migrate from outdoors
  – Also may result from gas stoves and other indoor emission sources, such as building materials, radon, and environmental tobacco smoke.
• Changes in the outdoor concentrations of a pollutant due to alterations in atmospheric chemistry or atmospheric circulation will affect indoor concentrations
• Measures to reduce energy use in buildings, such as lowering ventilation rates may cause higher exposures to pollutants emitted from indoor sources
• The expected increased use of air conditioning, if accompanied by reduced ventilation, could increase the concentrations of pollutants emitted from indoor sources
  – Power outages—caused by heat waves or other extreme weather events—could lead to the use of portable electricity generators that burn fossil fuels and emit poisonous carbon monoxide.

Dampness, Moisture and Flooding

• Extreme weather conditions associated with climate change may lead to more frequent breakdowns in building envelopes—the physical barrier between outdoor and indoor spaces—followed by infiltration of water into indoor spaces.
• Dampness and water intrusion create conditions that encourage the growth of fungi and bacteria and may cause building materials to decay or corrode, leading in turn to chemical emissions.
• Poorly designed or maintained heating, ventilation, and air-conditioning systems may introduce moisture and create condensation on indoor surfaces.
• Mold growth prevention and remediation activities also may introduce fungicides and other agents into the indoor environment.

Infectious Agents and Pests

• Weather fluctuations and climate variability influence the incidence of many infectious diseases
• Climate change may affect the evolution and emergence of infectious diseases
  – i.e., affecting the geographic range of disease vectors
• The ecologic niches for pests will change in response to climate change
  – This may lead to changed patterns of exposure and, possibly, increased use of pesticides

Thermal Stress

• Extreme heat and cold have several well-documented adverse health effects
• High relative humidity exacerbates these effects in hot conditions
• An increased frequency of extreme weather events may result in more frequent power outages that expose persons to potentially dangerous conditions indoors
  – The elderly, those in poor health, the poor, and those who live in cities are more vulnerable to both exposure to temperature extremes and the effects of exposure
  – Those populations experience excessive temperatures almost exclusively in indoor environments

Building ventilation, weatherization, and energy use

• Leaky buildings are common and cause energy loss, moisture problems, and migration of contaminants.
• Poor ventilation is associated with occupant health problems or lower productivity.
• Climate change may make ventilation problems more common or more severe by prompting the implementation of energy-efficiency (weatherization) measures that limit the exchange of indoor air with outdoor air.
• The introduction of new materials and weatherization techniques also may lead to unexpected exposures and health risks.

Action and Recommendations

• Prioritize consideration of health effects into research, policy, programs, and regulatory agendas that address climate change and buildings;
• Make prevention of adverse exposures a primary goal in designing and implementing strategies to address health effects; and
• Include collection of data to be used in making better-informed decisions in the future.

Objective: To evaluate the impact of building interventions on indoor environmental quality and pediatric asthma health care use and to conduct cost comparisons between intervention and health costs and energy savings

Methods: Employed a discrete event simulation model to simulate the effect of environmental factors, medication compliance, seasonality and medical history on indoor pollutant concentrations and asthma outcomes in low income multifamily housing. Health care use and costs at baseline were estimated and after interventions and then compared to health care costs with energy savings and intervention costs.

IOM Specific Recommendations to the EPA

• Identify populations at risk for health problems and implement measures to prevent or reduce problems.
• Develop protocols and testing standards for evaluating emissions from materials, furnishings, and appliances used in buildings.
• Facilitate research to identify circumstances in which climate change mitigation and adaptation measures may cause or exacerbate adverse exposures.
• Facilitate revision and adoption of building codes that are regionally appropriate with respect to climate-change projections to promote health and productivity of occupants.
• Develop standards for ventilation in residential buildings and improved standards for commercial buildings and schools based on health-related criteria.
• Implement a public health surveillance system to determine how outdoor conditions, building characteristics, and indoor environmental conditions are affecting occupant health.
• Educate the public on issues of climate change, the indoor environment, and health.
• Evaluate actions taken in response to climate change-induced alterations in the indoor environment to determine whether they cost-effectively enhance occupant health and productivity.
• Spearhead an effort to make indoor environment and health issues an integral consideration in climate change research and action plans.
Conclusions

- Environmental changes in homes of asthmatic patients can affect their asthma symptoms because of changes in exposure to indoor environmental pollutants
- Clinicians should take a multi-intervention approach to asthma control which includes medication and environmental interventions to reduce asthma associated pollutant exposures
- Important to implement energy saving interventions with focus on indoor environmental quality and health

Gaps in Knowledge and Recommendations for Research: Summary

- Increase understanding of current and projected impacts of climate change on respiratory health
- Augmented basic research on etiology and treatment of respiratory disease
- Identification of effective approaches for prevention and reduction of possible impacts
- Evaluation of the health impacts of policy options for reducing GHG emissions
- Research focused on particularly vulnerable populations and regions

Susceptible Subpopulations