Effects of climate change on respiratory health & Aerosol’s role in ozone depletion

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Outline

Effects of climate change on respiratory health


Metered dose inhalers and the Montreal Protocol

Montreal Protocol On Substances that Deplete the Ozone Layer 2014 REPORT OF THE UNEP MEDICAL TECHNICAL OPTIONS COMMITTEE

Exemplar: asthma hotspots and the built environment

Keddem S, Barg FK, Glanz K, Jackson T, Green S, George M Mapping the urban asthma experience: Using qualitative GIS to understand contextual factors affecting asthma control. Sci Med. 2015 Sep;140:9-17
**EFFECTS OF CLIMATE CHANGE ON RESPIRATORY HEALTH**

Greenhouse gases (GHGs)

Gases that contribute to the greenhouse effect by absorbing infrared radiation (trap heat in the atmosphere)

- Water vapor (H₂O)
- Carbon dioxide (CO₂)
- Methane (CH₄)
- Nitrous oxide (N₂O)
- Ozone (O₃)
- Chlorofluorocarbons (CFCs)
- Hydrofluorocarbons (incl. HCFCs and HFCs)

Higher CO2 levels increase:
- the volume of allergenic plant growth
- the speed of growth
- the amount of pollen produced and released
- the plants’ range
- the length of the pollen-producing season

Higher Co2 implicated in higher prevalence of allergic asthma and anaphylaxis
Climate change and pediatric asthma

Developing lung is very susceptible to damage when exposed to pollutants
- children have smaller lungs and airways
- children have immature immune systems

Children have greater exposure to pollutants and allergens:
- breathe more rapidly
- have higher rates of mouth breathing with exercise
- play outdoors more
- play closer to the ground

GHGs cause

1. Increases in average temperature
2. More extreme weather
3. Changes in precipitation patterns and rising sea levels
INCREASES IN TEMPERATURE

Increases in average temperatures

Days hotter than average seasonal temperatures in the summer cause increases in ground level ozone (O₃), outdoor air pollutants and CO₂
Triple threat: Asthma, heat and outdoor pollution

Particulate matter and ozone have inflammatory effect on the airways, allowing easier airway penetration of aeroallergens that produce respiratory effects.

Triple threat: COPD, heat and indoor pollution

Temperature may modify the effect of indoor pollution on patients with COPD who spend the majority of their time indoors.

- Increasing morbidity and mortality
MORE EXTREME WEATHER

Extreme weather

More severe and more frequent wildfires and dust storms due to drought and desertification have the potential to transport high concentrations of PM thousands of miles from their source.

Dust storms have the potential to carry bacteria, fungi, and influenza across vast distances.
Extreme natural events will become more frequent

Thunderstorm asthma

Columbia University School of Nursing
Heatwaves

Heat stress, outdoor and indoor air pollution, and respiratory infections will increase death rates in asthma and COPD

35,000 died in a 2003 European heat wave
- co-existing respiratory conditions 3rd leading cause of death

CHANGES IN PRECIPITATION PATTERNS AND RISING SEA LEVELS
Precipitation increases HPS infections

More flooding linked to spikes in indoor and outdoor microbes and mold

El Niños will be more common and more powerful in coming years; higher rates of hantavirus pulmonary syndrome occur during El Niño years

Heat and humidity increase respiratory infections

Supports the reproduction, transmission, survival and virulence of bacterial, viral and fungal infections, vectors, and host responses
Heat and humidity increase respiratory infections.

Increase zoonotic and waterborne bacterial respiratory infections

- **Legionella** (2018 in NYC)

<table>
<thead>
<tr>
<th>Disaster, Year</th>
<th>Reference</th>
<th>Location</th>
<th>No. cases</th>
<th>Fungal organism</th>
<th>Type of infection</th>
<th>Outcome</th>
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<tbody>
<tr>
<td>Tomato, 2011</td>
<td>Nebelt Fanfurt et al. (4)</td>
<td>USA</td>
<td>13</td>
<td>Apophysomyces trapeziformis</td>
<td>Soft tissue</td>
<td>36% all-cause mortality</td>
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<td>Great East Japan Earthquake and Tsunami, 2011</td>
<td>Kawakami et al. (7)</td>
<td>Japan</td>
<td>1</td>
<td>Aspergillus fumigatus</td>
<td>Pulmonary; multi-organ dissemination</td>
<td>Death</td>
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<tr>
<td></td>
<td>Nakamura et al. (6)</td>
<td>Japan</td>
<td>1</td>
<td>Sporosporium apiospermum</td>
<td>Lung and brain abscesses</td>
<td>Death</td>
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<tr>
<td></td>
<td>Igusa et al. (7)</td>
<td>Japan</td>
<td>1</td>
<td>Pathogen not identified</td>
<td>Sinusitis and meningitis</td>
<td>Death</td>
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<td>Hurricane Ike, 2008</td>
<td>Riddell et al. (8)</td>
<td>USA</td>
<td>3</td>
<td>Unspecified agent of chromoblastomycosis</td>
<td>Soft tissue</td>
<td>Recovery</td>
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<tr>
<td>Hurricane Katrina, 2005</td>
<td>Rao et al. (9)</td>
<td>USA</td>
<td>1</td>
<td>Cladosporium sp.</td>
<td>Pulmonary</td>
<td>Resolved without treatment</td>
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<tr>
<td>Indian Ocean Tsunami, 2004</td>
<td>Petri et al. (10)</td>
<td>Thailand</td>
<td>2</td>
<td>Cladothallus mangiferae</td>
<td>Soft tissue</td>
<td>Recovery</td>
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<td></td>
<td>Garzoni et al. (11)</td>
<td>Thailand</td>
<td>2</td>
<td>Sporosporium apiospermum</td>
<td>Spondylothesis, 1; brain abscess, 1</td>
<td>Recovery</td>
</tr>
<tr>
<td></td>
<td>Gunaratne et al. (12)</td>
<td>Colombo, Sri Lanka</td>
<td>6</td>
<td>A. fumigatus</td>
<td>Meningitis</td>
<td>50% all-cause mortality</td>
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<tr>
<td></td>
<td>Andersen et al. (13)</td>
<td>Sri Lanka</td>
<td>1</td>
<td>Apophysomyces elegans</td>
<td>Soft tissue</td>
<td>Not specified</td>
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<td></td>
<td>Snell and Tavakoli (14)</td>
<td>Thailand</td>
<td>1</td>
<td>A. elegans</td>
<td>Soft tissue</td>
<td>Recovery</td>
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<tr>
<td></td>
<td>Maguerie et al. (15)</td>
<td>Southeast Asia</td>
<td>1</td>
<td>Fusarium sp.</td>
<td>Soft tissue, sepsis</td>
<td>Death</td>
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<tr>
<td>Earthquake, 1994</td>
<td>Schneider et al. (16)</td>
<td>USA</td>
<td>203</td>
<td>Coccidioides immitis</td>
<td>Pulmonary: 6 (3.7%) disseminated</td>
<td>1.5% all-cause mortality</td>
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<tr>
<td>Volcano, 1985</td>
<td>Patillo et al. (17)</td>
<td>Colombia</td>
<td>8</td>
<td>Rhizopus arrhizus</td>
<td>Soft tissue</td>
<td>80% all-cause mortality</td>
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<tr>
<td>Dust storm originating near Bakersfield, California, 1977</td>
<td>Flynn et al. (18)</td>
<td>USA</td>
<td>115</td>
<td>C. immitis</td>
<td>Pulmonary: 16 (14%) disseminated</td>
<td>7% all-cause mortality</td>
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<tr>
<td></td>
<td>Williams et al. (19)</td>
<td>USA</td>
<td>16</td>
<td>C. immitis</td>
<td>Pulmonary: 4 (22%) disseminated</td>
<td>5.5% all-cause mortality</td>
</tr>
</tbody>
</table>

Asthma Educators’ role is to decrease risks associated with climate change

- Practice
to assess patient’s risk and educate

- Policy
to join public health efforts to reduce carbon footprint and mitigate effects of climate change

- Research
to understand vulnerability and healthy adaptive behaviors

METERED DOSE INHALERS AND THE MONTREAL PROTOCOL
Montreal Protocol on Substances that Deplete the Ozone Layer

International treaty designed to protect the ozone layer by phasing out the production of substances responsible for ozone depletion

Chlorofluorocarbons (CFCs) Phase-out

First universally ratified treaty in UN history

Ratified by 197 parties in 1987 only 14 years after hole discovered

Respiratory and non-respiratory diseases use inhalational therapy

Technically possible by modulating particle size through inhaler design, and by adjusting excipients and propellants
Carbon footprint

Carbon footprint is the amount of CO₂ and other carbon compounds emitted by a particular person, group, or product.

CFCs had a larger carbon footprint.
HFAs have a much smaller carbon footprint.

Metered dose inhalers and the Montreal Protocol

In 2008 CFCs were replaced with HFAs (HFCs).
95% use HFC-134a.
5% use HFC-227ea.
Amounts of CFCs exempted, used, on hand at the end of each year (tons), 1996-2014

Particle Size of ICS

 Courtesy R. Pleasants
**Metered dose inhalers and the Montreal Protocol**

HFAs are CFC-free but are GHGs

- HFA MDIs are estimated at 0.03 percent of global GHGs
- 8% of NHS total carbon footprint

**Why not go with only DPIs or develop HFA-free propellants?**

- 10-20% will never be able to use DPIs
- Transition from CFC to HFC took 20 years and cost industry $2 billion

**Are there other options?**

- Companies looking to decrease size of metering chamber by 25-50%

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**Asthma Educators’ role is to decrease carbon footprint of products**

- Practice
  
  to consider adding the idea of propellant-free options for patients to consider when selecting devices
Proportions of doses delivered by MDIs and DPIs in different regions, 2012

Sweden is 90% DPI

Estimated relative carbon dioxide emissions of everyday items compared with asthma inhalers
Estimates by IPAC of carbon footprints of respiratory devices and treatment methods

<table>
<thead>
<tr>
<th>Respiratory devices and treatment methods</th>
<th>Carbon footprint Per 200 actuations (Grams CO₂-eq.)</th>
<th>Carbon footprint Per dose (Grams CO₂-eq.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFC MDI</td>
<td>150,000-200,000</td>
<td>1,500-2,000</td>
</tr>
<tr>
<td>HFC-134a MDI</td>
<td>20,000-30,000</td>
<td>200-300</td>
</tr>
<tr>
<td>HFC-227 MDI</td>
<td>60,000-80,000</td>
<td>600-800</td>
</tr>
<tr>
<td>Dry Powder Inhaler</td>
<td>1,500-6,000</td>
<td>&lt;20</td>
</tr>
<tr>
<td>Tablets</td>
<td>1,500-5,000</td>
<td>&lt;20</td>
</tr>
</tbody>
</table>

Montreal Protocol

Now three assessment panels

1. Science
2. Environmental effects
3. Technical and Economics (TEAP)

6 standing TEAP Committees

- Flexible and Rigid Foams (FRFTOC)
- Halons (HTOC)
- Methyl Bromide (MBTOC)
- Refrigeration, A/C and Heat Pumps (RAHTO)
- Chemicals (CTOC)
- Medical (MTOC)
EXEMPLAR: ASTHMA HOTSPOTS AND THE BUILT ENVIRONMENT

Keddem, Barg, Glanz, Jackson, Green & George M
Sci Med. 2015 Sep;140:9-17

West Philadelphia
Freelisting and salience scores

List of all the things you can think of that make it hard to take care of your asthma.

- not having medicine
- stress
- weather
- physical ailments
- dirt/dust
- not following directions
- not enough physical exercise

Environmental triggers:
- forgetting medicine
- not using medicine
- too much physical exercise

Figure 1: Selected Neighborhood Criteria Variables in West Philadelphia

Figure 3.
Weighted Composite Map of Perceived Risk to Asthma Control

Perceived Risk to Asthma Control

High
Low
0 1 2 3 4 Miles

Figure 4.

Earth on the Verge of Melting