Outline

• Air quality
• Health
• Public health’s role
• Questions and discussion
Forest fires

• Natural phenomena but have many negative consequences:
  – physical safety
  – economic costs of damaged land and homes, evacuation, and fighting fires
  – air quality
  – health
Forest fires

• Natural phenomena but have many negative consequences:
  – physical safety
  – economic costs of damaged land and homes, evacuation, and fighting fires
  – air quality
  – health
Air quality
Forest fires

• Deteriorate air quality through smoke emissions
  – release pollutants
  – reduce visibility

• Fire smoke contains\(^1\):
  – particulate matter (PM\(_{2.5}\), PM\(_{10}\))
  – nitrogen oxides (NO\(_x\))
  – carbon monoxide
  – volatile organic compounds
  – plus others

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Pollution

• Elevated PM levels measured during fires
  – 2003 fires
  – BC²: 24-hr PM$_{2.5}$ peaks of 200 µg/m$^3$
  – California³: 1-hr PM$_{10}$ peaks of 1000 µg/m$^3$

• For comparison, Canada Wide Standard for PM$_{2.5}$ (24-hr) is 30 µg/m$^3$
Smoke emissions

• Levels can be high
  – size
  – proximity
  – meteorology
  – topography

• May remain elevated for days to weeks

• Impact local, regional and global air quality
Downtown Calgary

Photo credit: Calgary Herald
Fires may continue to increase

Seasonal Fire Occurrence
(As of September 1, 2010)

- 2010
- 10-yr avg.

Number

May June July Aug. Sept

Natural Resources Canada, 2010
Health
<table>
<thead>
<tr>
<th></th>
<th>Developing countries</th>
<th>Firefighters</th>
<th>Communities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affected population</td>
<td>Women &amp; children exposed to cooking smoke</td>
<td>Healthy individuals</td>
<td>All ages, health levels</td>
</tr>
<tr>
<td>Health impacts</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Respiratory effects

• Increased hospital visits for: $^{4,5,6,7,8}$
  – asthma
  – COPD
  – upper respiratory infections
  – general respiratory problems
  – eye irritation
  – smoke inhalation
Vulnerable groups

- Greater health impacts for $^{3, 6, 9, 10}$:
  - children
  - elderly
  - individuals with pre-existing respiratory or cardiovascular disease
Cardiovascular effects

- Exposure to PM$_{2.5}$ has been linked with cardiovascular effects, including increased:
  - cardiovascular mortality
  - risk of development of cardiovascular disease
  - risk of myocardial infarction

But no studies have found evidence for increased cardiovascular-related hospital visits during forest fires
Gaps

• Nature of forest fires make them difficult to study

• Studies have only looked at short – term exposure impacts on health
Role of public health
Public health

• Inform the public
  – deteriorated air quality
  – potential health impacts
  – exposure reduction measures

• Determine need for evacuation
  – due to fire
  – due to smoke exposure
Recommendations

- Stay indoors
- Keep windows and doors closed
- Run air cleaner
- Run air conditioner
- Limit indoor sources
- Keep cool
What’s the evidence?
Staying indoors

- Are levels lower indoors versus outdoors?
- Is closing windows and doors enough?
Infiltration

Fraction of outdoor pollutants that penetrate indoors and remain suspended

Modified from Thatcher and Layton (1995)
Infiltration (cont.)

\[ F_{\text{inf}} = \frac{P \cdot a}{a + k} \]

- \( F_{\text{inf}} \) = infiltration efficiency
- \( P \) = penetration
- \( a \) = air exchange
- \( k \) = deposition
<table>
<thead>
<tr>
<th>Mean $F_{inf}$</th>
<th>Season</th>
<th>Study Location</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-A.C. = 0.86 A.C. = 0.69</td>
<td>Summer</td>
<td>Uniontown, PA</td>
<td>Suh et al., 1992</td>
</tr>
<tr>
<td>0.74</td>
<td>Summer</td>
<td>Virginia &amp; Connecticut</td>
<td>Leaderer et al., 1999</td>
</tr>
<tr>
<td>0.74</td>
<td>Spring-Summer &amp; Fall-Winter</td>
<td>Boston, MA</td>
<td>Long et al., 2001</td>
</tr>
<tr>
<td>0.70</td>
<td>Fall</td>
<td>Riverside, CA</td>
<td>Ozkaynak et al., 1996 (PTEAM)</td>
</tr>
<tr>
<td>0.66</td>
<td>Summer &amp; Winter</td>
<td>Birmingham, AL</td>
<td>Lachenmeyer and Hidy, 2000</td>
</tr>
<tr>
<td>0.65</td>
<td>Annual</td>
<td>Seattle, WA</td>
<td>Allen et al., 2003</td>
</tr>
<tr>
<td>0.62</td>
<td>Annual</td>
<td>Victoria, BC</td>
<td>Hystad et al., 2009</td>
</tr>
<tr>
<td>0.59</td>
<td>Annual</td>
<td>RTP, NC</td>
<td>Wallace and Williams, 2005</td>
</tr>
<tr>
<td>0.50</td>
<td>Winter</td>
<td>Boise, ID</td>
<td>Lewis, 1991</td>
</tr>
<tr>
<td>0.48</td>
<td>Annual</td>
<td>Los Angeles, CA</td>
<td>Sarnat S. et al., 2006</td>
</tr>
<tr>
<td>0.30</td>
<td>Winter</td>
<td>Smithers, BC</td>
<td>Allen et al., in preparation</td>
</tr>
<tr>
<td>0.61</td>
<td>Summer</td>
<td>Prince George, BC</td>
<td>Barn et al., 2008</td>
</tr>
<tr>
<td>0.27</td>
<td>Winter</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Reducing infiltration

- Staying indoors is protective but varies between buildings

- Lower $F_{\text{inf}}$ values associated with:
  - Winter season
  - Closing windows
  - Newer homes
  - Air conditioning
  - Air cleaner use
Reducing infiltration

• Staying indoors is protective but varies between buildings

• Lower $F_{\text{inf}}$ values associated with:
  – Winter season
  – Closing windows
  – Newer homes
  – Air conditioning
  – Air cleaner use

  Lower air exchange rates (AER)
Air exchange rates

• Lower AER means less of what is outside is getting indoors

• Important to ensure that levels of indoor pollutants aren’t building up

• Reduce indoor sources
Do air cleaners provide protection?

• Exposure reduction?
• Health benefits?
Air cleaners

Theoretically, cleaners reduce $F_{\text{inf}}$ by increasing deposition.
Air cleaners cont.

• Many types and models

• Indoor air is mixture of pollutants
  – indoor and outdoor sources
  – types and concentrations

• No air cleaner can remove all pollutants
## Air cleaning technologies

<table>
<thead>
<tr>
<th>Design</th>
<th>Pollutants targeted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical filters (e.g. HEPA)</td>
<td>Particles</td>
</tr>
<tr>
<td>Electronic precipitators</td>
<td>Particles</td>
</tr>
<tr>
<td>Ion generators</td>
<td>Particles</td>
</tr>
<tr>
<td>Activated carbon filters</td>
<td>Gases</td>
</tr>
<tr>
<td>Ozone generators</td>
<td>Gases</td>
</tr>
</tbody>
</table>
## Air cleaner use and outdoor-generated PM

<table>
<thead>
<tr>
<th>Study</th>
<th>Exposure</th>
<th>Air cleaner</th>
<th>Study Period</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brauner et al. 2008&lt;sup&gt;15&lt;/sup&gt;</td>
<td>Traffic</td>
<td>Portable HEPA</td>
<td>+ filter: 48hr - filter: 48 hr</td>
<td>Lower PM&lt;sub&gt;2.5&lt;/sub&gt; levels during + filter period (GM: 4.7 ± 0.8 µg/m&lt;sup&gt;3&lt;/sup&gt;) vs. - filter period (GM: 12.6 ± 1.4 µg/m&lt;sup&gt;3&lt;/sup&gt;) across homes (n= 21)</td>
</tr>
<tr>
<td>Allen et al. 2009&lt;sup&gt;16&lt;/sup&gt;</td>
<td>Wood smoke</td>
<td>Portable HEPA</td>
<td>+ filter: 7d - filter: 7d</td>
<td>Lower PM&lt;sub&gt;2.5&lt;/sub&gt; F&lt;sub&gt;inf&lt;/sub&gt; during + filter period (0.20 ± 0.17) vs. - filter period (0.34 ± 0.17) across homes (n=25)</td>
</tr>
<tr>
<td>Barn et al. 2008&lt;sup&gt;17&lt;/sup&gt;</td>
<td>Forest fire &amp; wood smoke</td>
<td>Portable HEPA</td>
<td>+ filter: 24hr - filter: 24hr</td>
<td>Lower PM&lt;sub&gt;2.5&lt;/sub&gt; F&lt;sub&gt;inf&lt;/sub&gt; on + filter days (0.13 ± 0.14) vs. - filter days (0.42 ± 0.27) across homes (n= 29)</td>
</tr>
<tr>
<td>Henderson et al. 2005&lt;sup&gt;18&lt;/sup&gt;</td>
<td>Fire smoke</td>
<td>Portable ESP</td>
<td>24 - 48hr</td>
<td>Indoor PM&lt;sub&gt;2.5&lt;/sub&gt; levels 63-88 % lower in treatment vs. matched control homes (n= 4 pairs) ; mean 24 hr indoor PM&lt;sub&gt;2.5&lt;/sub&gt; ≤ 3 µg/m&lt;sup&gt;3&lt;/sup&gt; in treatment homes vs. 5.2 – 21.8 µg/m&lt;sup&gt;3&lt;/sup&gt; in control homes</td>
</tr>
</tbody>
</table>
Air cleaner effectiveness

• Effectiveness varies among studies
  – study design: number of devices, time period, AER, air cleaner placement

• Depends on both:
  – efficiency of device at removing the pollutant
  – amount of air “cleaned” by device
• Only 1 study has looked at health benefits of air cleaners during forest fires

• Use of portable HEPA filters was associated with decreased odds of reporting respiratory symptoms (both frequency and duration)\textsuperscript{10}
  – fire near Hoopa Valley, California (1999)
  – other interventions not as effective
  – lack of exposure measurements
## Interventions

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEPA filter air cleaners (n= 98)</td>
<td>Length of use inversely related to symptom reporting</td>
</tr>
<tr>
<td>Public Service Announcements (n=238)</td>
<td>Those able to recall PSAs less likely to report symptoms</td>
</tr>
<tr>
<td>Mask use (n=100)</td>
<td>Not effective; use positively correlated with outdoor exposure</td>
</tr>
<tr>
<td>Evacuation (n=140)</td>
<td>Not effective</td>
</tr>
</tbody>
</table>
Health benefits in general

• Results are mixed

• Use of cleaners has been associated with:
  – reductions in some asthma and allergy-related symptoms\textsuperscript{19}

• Greater benefits when used with other interventions, including\textsuperscript{20}:
  – removal of sources, removal of carpets, use of impermeable bed coverings, and reduced AER
Air conditioners

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Air conditioners (ACs)

- Use has not been evaluated during forest fires

- ACs reduce AER
  - Some models may also have filters

- Linked to some health benefits but not well established
  - reduced risk of cardiovascular-related hospitalizations found in communities where AC use is prevalent\textsuperscript{21}
  - not clear if effect due to other factors (regional, socioeconomic)\textsuperscript{22}
Recommendations

• Staying indoors and using air cleaners is protective but effectiveness varies.

• Less evidence for air conditioner use for exposure reduction, but important in keeping cool.
Other community impacts
Smoke intrusion to hospitals

• Local example where rural hospital was experiencing infiltration of fire smoke
  – led to patient complaints
  – visible smoke (no measurements)

• Hospital responded by turning off HVAC system
  – Led to increase in CO$_2$

→ Best approach for hospital to take?
Important questions

• How long will conditions persist?
• What is the exposure?
• What are the health impacts? For whom?
• What can be done?
# Short-term responses

<table>
<thead>
<tr>
<th>Options</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keep HVAC <strong>on</strong></td>
<td>Hope conditions (weather, wind) change. How long is an appropriate time to wait?</td>
</tr>
<tr>
<td>Turn HVAC <strong>off</strong></td>
<td>For how long? What about indoor-generated pollutants? What about air flow in different departments?</td>
</tr>
<tr>
<td>Turn HVAC <strong>off</strong> and use <strong>air cleaners</strong></td>
<td>In all rooms or in rooms of vulnerable patients? Which type of air cleaners and how many? Purchase, maintenance, storage costs?</td>
</tr>
<tr>
<td>Evacuate</td>
<td>What is “trigger” for evacuation? Everyone or only vulnerable patients? To where (i.e. are beds available elsewhere)? Costs?</td>
</tr>
</tbody>
</table>
Long-term response

• Work with ventilation experts to design system
  – High efficiency filtering in “emergency” situations
  – Lower efficiency filtering in “normal” situations
  – Maintain necessary air flow in all departments: labs, patient rooms, surgery rooms, food prep areas
Key Points

• Forest fire are important sources of many pollutants, including PM

• Exposure to smoke is linked to respiratory health impacts; gaps exist for long-term health impacts

• Public health can inform the public about poor AQ, health impacts, and exposure reduction measures

• Current recommendations to stay indoors, and use air cleaners or air conditioners can reduce exposure to pollution and heat indoors
References

References cont.


