Pulmonary Health Effects and Clinical Implications of Wildfire Smoke

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Objectives of this Talk

• Describe the reasons for recent increases in wildland fire activity in the U.S.

• Identify respiratory effects of wildfire exposure

• Discuss clinical interventions for high risk patients
2 Types of Wildland Fire

Wildfire

Prescribed Fire

Photos from Kathleen Navarro
More Heavy Metals and PAHs in Flaming Smoke

Key Drivers of Wildland Fire Activity

More Acres Burned

• Drier conditions (climate change explains ~55% increase in aridity 1979-2015 in Western U.S.\(^1\))

• Many more prescribed fires (300% ↑ in acres/yr in past 10 years)\(^2\)

More Loss of Life & Property

• Years of fire suppression (biomass accumulation)

• Wildland-urban interface

2. Data from John Hall, Director, Joint Fire Science Program
Hot, dry conditions increase risk of large destructive wildfires

U.S. Wildfires

- Australian Bush Fires 2020
- Camp Fire, California 2018
- Siberian Megafire, 2020
PM$_{2.5}$ Air Quality Improved 1988-2016 Except in Wildfire-Prone Areas

McClure and Jaffe. *Proc Natl Acad Sci.* 2018
Wildland fires contribute to more than a third of the total annual burden of PM$_{2.5}$.
Smoke from wildfires in #NovaScotia has travelled into New England. Air quality will go from good to moderate across Central & Southern Mass, with hazy skies anticipated this evening.
Wildfires are “Natural” Experiments

• **Acute** respiratory health effects have been identified in many studies comparing rates of respiratory visits & admissions before, during and after smoke events

• **Chronic** respiratory health effects of repeated exposure to regional wildfire smoke are not well-studied
Wildfires increase respiratory admissions

Wildfire-Specific PM$_{2.5}$ and Respiratory Hospitalization of Medicare Patients

Wildfire-specific PM$_{2.5}$ was estimated using a global chemical transport model.

% Increase in Respiratory Admissions on Smoke Wave (SW) Days

- $>20$
- $>23$
- $>28$
- $>37$

>2 days with wildfire-PM$_{2.5} > 37$µg/m$^3$ associated with 7.2% (95% CI: 0.25%, 15%) increase in respiratory admissions

Liu et al. *Epidemiology*. 2017
Many Studies Find Increases in Asthma Admissions & Treatment During Wildfires

- 34% increase in asthma admissions during heavy smoke
- COPD, acute bronchitis, pneumonia also higher

- Wildfire PM may be more toxic for asthmatics than PM from other sources: 6.7% vs 1.3% increase in Medicare asthma hospitalization per 10 µg/m³ of wildfire vs non-wildfire PM

Wildfire-PM and Rescue Inhaler Dispensation

6% higher RR (95% CI: 4 – 7%) of inhaler dispensation per 10 µg/m³ higher wildfire PM

Elliott et al. Environ Health. 2013
Respiratory Symptoms in Children

- Children’s Health Study (ages 6-7 & 17-18)\(^1\) found wildfire smoke associated with:
  - Upper respiratory symptoms (nose, eyes, throat irritation)
  - Lower respiratory symptoms (cough, bronchitis, wheeze)
  - Medication use for above symptoms
  - Greater symptom increases among asthmatics
  - 63% increase in asthma attacks

- Among non-asthmatic children, airway size (MMEF:FVC) associated with greater susceptibility to respiratory symptoms\(^2\)

Wildland Firefighters are the Most Exposed

• Volunteer and professional (e.g. USFS firefighters)

• No approved respirator!

• Few studies of health effects due to research challenges
Flaming > Smoldering Smoke Causes Acute Neutrophilic Inflammation in the Lung

Major research needs:
• What is the toxicity of smoke from different fuel sources and burn types?
• Is PM2.5 the best index to use to measure health effects of wildland fires?
• What are respiratory health consequences of repeated, long-term wildfire smoke exposure?
Systems for Providing Protection from Inhalation Hazards Should Extend to the Public and Broader Groups of Workers, Says New Report

News Release | February 10, 2022
## Personal Air Quality Interventions

<table>
<thead>
<tr>
<th>Tier in Hierarchy of Controls</th>
<th>Exposure Control Action</th>
<th>Estimated Exposure Reduction</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Elimination</td>
<td>Relocation</td>
<td>100%</td>
<td>Stress of relocation may be harmful, especially for vulnerable populations. Exposure to air pollution and other unsafe conditions while in transit may not have feasible places to go.</td>
</tr>
<tr>
<td>2. Engineering</td>
<td>Reduce indoor infiltration by closing doors and windows Filter air with portable air filters, central air filters, or air conditioners in recirculation mode</td>
<td>20-80%</td>
<td>Effectiveness varies greatly with ventilation and filtration rates. Portable HEPA filters generally more effective, if properly sized and used. Central forced-air filtration is generally less effective due to lower-efficiency filters and shorter run times. Upfront costs, but may provide year-round benefit by reducing indoor PM from other sources.</td>
</tr>
<tr>
<td>3. Administrative</td>
<td>Stay indoors</td>
<td>~50% on average, but varies widely</td>
<td>Without added filtration, the building envelope limits infiltration to a widely variable extent depending on tightness. Especially important for outdoor activity. Pulmonary ventilation rates may increase 10- to 20-fold during heavy exertion. If temporary, little risk of harmful reduction in beneficial physical activity.</td>
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<td></td>
<td>Avoid heavy or prolonged physical activity</td>
<td>Lowers inhaled dose of pollutants</td>
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<td>4. Personal protective equipment</td>
<td>Wear a NIOSH-approved N95 or P100 filtering facepiece respirator</td>
<td>90% or greater, depending on quality of fit. Near 0% if poorly fitted</td>
<td>Should be used only when outdoor activity cannot be avoided. Performance depends on fit. Fit testing and medical clearance are not generally available. Physiological stress due to increased work of breathing, heat, discomfort. Populations vulnerable to wildfire PM may also be more vulnerable to adverse effects of wearing a respirator.</td>
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</tbody>
</table>
Household HEPA Air Cleaners

• Reduce indoor PM$_{2.5}$ by 20-80%$^1$ (but modest if any effect on gaseous pollutants)

• Appear to reduce asthma morbidity$^2$

• Appear to reduce adult respiratory symptoms during wildfire events$^3$

Respirators (e.g. N95)

• Reduce exposure to PM but not gas pollutants, which also have health effects

• May mitigate short-term physiological effects of PM (evidence limited to healthy adults)

• None approved for children (NIOSH certifies N95s)

• Safety of prolonged use not evaluated in adults with severe heart or lung disease

Shi et al. Environ Health Perspect. 2017

Source: FEMA
Conclusions

• Wildland fires are a major source of PM exposure, and air quality has worsened in wildfire-prone areas in US

• Wildfire smoke is associated with asthma attacks, respiratory infection and respiratory admissions

• Air purification and respirator use reduces PM exposure / inhalation

• There is a need for clinical effectiveness research to warn and protect high risk patients
Thank you

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- David Rosse

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Support, by Lorenzo Quinn. Venice, Italy.
How Smoke May Interact with Viral Life Cycle

Rebuli et al. JACI. 2021.