Smoke Signals: Epidemiologic Evidence of Wildfire Toxicity

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• No relevant financial relationships with a commercial interest
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At the end of this talk, I hope you will be able to:

• Describe the reasons for recent increases in wildland fire activity in the U.S.
• Identify respiratory effects of wildfire exposure
• Recognize likely cardiovascular effects of wildfire exposure among elderly

Increase in Acres Burned in U.S.

Wildland fires contribute to more than a third of the total annual burden of PM$_{2.5}$

Image Source: October 12 2017 NASA Satellite images
EPA Federal Emissions Inventory 2014

PM$_{2.5}$ Air Quality Improved 1988-2016 Except in Wildfire-Prone Areas

McClure and Jaffe. Proc Natl Acad Sci. 2018

Wildfire PM$_{2.5}$ Often Exceeds Standards

<table>
<thead>
<tr>
<th>Air Quality Index (AQI) Values</th>
<th>Levels of Health Concern</th>
<th>Health Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 50</td>
<td>Good</td>
<td>Little or no risk</td>
</tr>
<tr>
<td>51 to 100</td>
<td>Unhealthy for Sensitive Groups</td>
<td>General Public not likely affected</td>
</tr>
<tr>
<td>101 to 150</td>
<td>Unhealthy</td>
<td>All may experience some effects</td>
</tr>
<tr>
<td>151 to 200</td>
<td>Very Unhealthy</td>
<td>All may experience more serious effects</td>
</tr>
<tr>
<td>201 to 300</td>
<td>Hazardous</td>
<td>Emergency conditions</td>
</tr>
<tr>
<td>301 to 500</td>
<td>&gt;250 µg/m$^3$</td>
<td></td>
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</tbody>
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Public health and OSHA advisories
Key Drivers of Wildland Fire Activity

More Acres Burned
- Drier conditions (climate change explains ~55% increase in aridity 1979-2015 in Western U.S.)
- Many more prescribed fires (300% ↑ in acres/yr in past 10 years)

More Loss of Life & Property
- Years of fire suppression (biomass accumulation)
- Wildland-urban interface

2. Data from John Hall, Director, Joint Fire Science Program

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

Wildfire-Associated PM$_{2.5}$ and Respiratory ED Visits

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

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

>2 days with wildfire-PM$_{2.5}$ >37µg/m$^3$ associated with 7.2% (95% CI: 0.35%, 15%) increase in respiratory admissions (but not CV admissions)

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

- More admissions for:
  - Asthma (34% increase during heavy smoke)
  - Acute bronchitis
  - Pneumonia
  - COPD
  (not CV admissions)

- 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 PM²

2. DeFlorio-Barker et al. JEPH. 2019

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, wheezing)
  - 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 symptoms²


Wildland Firefighters

- Volunteer and professional (e.g. USFS firefighters)
- No approved respirator!
- Few studies of health effects due to research challenges
- Using exposures and PM dose-response functions,¹ firefighters with 5-25 yr career have:
  - 8-43% higher risk of lung cancer mortality
  - 16-30% higher risk of CV mortality

1. Navarro et al. Environ Res. 2019

Elderly Likely at Risk for Acute Cardiovascular Effects of Wildfire Smoke

- Wildfire PM₂₅ associated with hypertension, myocardial infarction, arrhythmia, and heart failure, particularly >65 years old

1. California 2015 Wildfire Study
2. All Cardiovascular Admissions

Wettstein et al. JAH 2018
Conclusion

• 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 and respiratory admissions, and likely CV admissions among elderly

• Chronic health effects of repeated smoke exposure to communities and firefighters are not well-described