Where There’s Fire, There’s Smoke: Will Wildfires Rage Alongside the Pandemic in 2020?

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Outline

• Wildfire
• Climate Change
• What’s in wildfire smoke
• Health effects
• Public health messaging
• Prevention
• COVID-19 and wildfires
Wildfire
Sonoma-Napa Wildfires – Oct. 2017
Carr, Mendocino Complex, and Camp Fires - 2018
Acres Burned in Wildland Fires 1985-2013

Source: National Interagency Fire Center
2017 and 2018 were Bad Wildfire Years - Why?

- The wildfire season in California typically ends in October when autumn rains begin
- 5 years of drought 2011-2016; many dead trees
- *El Nino* winter of 2017 brought lots of rain, ending the drought
- Increased growth of vegetation in spring
- Normally dry and very hot summer weather generating lots of fuel
- Lack of rain in fall
Climate Change and Increase in Wildfires

Source of data: Westerling and Bryant, "Climate change and wildfire in and around California: Fire modeling and loss modeling" (2006), www.climatechange.ca.gov
Australian Bush Fires

- 31 million acres have burned (16 times what burned in California in 2018)
- Fires are in populated areas with more than 2500 homes destroyed
- Poor air quality in Sydney, Melbourne, Canberra, and New Zealand
- Climate-forcing emissions = 9 months from man-made sources
Wildfire emissions and related health impacts

Youssouf et al. Atmospheric Environment 2014;97:239-251
Emissions from Wildfires

**Primary air pollutants**
- Particulate Matter (PM)
- CO
- NO\(_2\)
- Polycyclic aromatic hydrocarbons (PAHs)
- Volatile organic compounds (VOCs)

**Secondary air pollutants**
- Particulate Matter (PM)
- Ozone
Camp Fire – Nov. 9, 2018
When Buildings and Vehicles Burn

• Structural fire smoke contains other toxic air contaminants, including
  – HCN, HCl, phosgene, metals
  – toluene, styrene, dioxins

• The Sonoma-Napa, Thomas, and Camp fires caused many buildings and motor vehicles to burn
  – Local residents exposed to more than wood smoke
Poor Air Quality in Bay Area

- Nov. 15, 2018 – PM$_{2.5}$ goes over 200 μg/m$^3$ in San Francisco and stays high for 10 days
- PM$_{2.5}$ even higher closer to the fire – over 300 μg/m$^3$ in Sacramento and over 400 μg/m$^3$ in Yuba City
Acute health impacts of short-term community wildfire smoke exposures
Clear evidence of an association between wildfire smoke and respiratory health

- Asthma exacerbations significantly associated with higher wildfire smoke in nearly every study
- Exacerbations of chronic obstructive pulmonary disease (COPD) significantly associated with higher wildfire smoke in most studies
- Growing evidence of a link between wildfire smoke and respiratory infections (pneumonia, bronchitis)
Cardiovascular effects
Victoria, Australia - Dec 1, 2006 - Jan 31, 2007

Out-of-Hospital Cardiac Arrest (OHCA)

Ischemic Heart Disease (IHD) Hospitalizations

Haikerwal et al. 2015 J Am Heart Assoc
• Wildfire-PM$_{2.5}$ associated with heart attacks and strokes for all adults, particularly for those over 65 years old

• Increase in risk the day after exposure:
  - All cardiovascular, 12%
  - Heart attack, 42%
  - Heart failure, 16%
  - Stroke, 22%
  - All respiratory causes, 18%
  - Abnormal heart rhythm, 24% (on the same day as exposure)

Slide credit: Wayne Cascio

Wettstein Z, Hoshiko S, Cascio WE, Rappold AG et al. JAHA April 11, 2018
Other Health Outcomes

• Adverse birth outcomes
  – Low birth weight, ? preterm birth
• Mental health
• ? Chronic effects from recurrent exposures based on the PM$_{2.5}$ literature
  – Metabolic outcomes
  – Cognitive decline
  – Child neurodevelopment
  – Health of pregnant mothers
Wildland Firefighter Health Effects

- Cross-shift changes in lung function, urinary biomarkers of exposure, and blood biomarkers of inflammation
- Pre-post season changes in lung function, airway responsiveness, and airway inflammation
- Do the fire season-associated changes persist?
Environmental Research

Wildland firefighter smoke exposure and risk of lung cancer and cardiovascular disease mortality


• Estimated the daily dose of wildfire smoke PM$_{2.5}$
• The daily dose for firefighters working 98 days per year of PM$_{2.5}$ ranged from 0.30 mg to 1.49 mg
• For career durations (5–25 years), wildland firefighters had an estimated increased risk of lung CA (8 percent to 43 percent) and CVD (16 percent to 30 percent) mortality
Improved planning and readiness on the part of the public health infrastructure and health care providers are necessary to reduce morbidity and mortality due to wildland fire smoke exposure.
Public Health Advisories

Based on the U.S. EPA’s Air Quality Index:
“Good” 0-50
“Moderate” 51-100
“Unhealthy for sensitive groups” 101-150
“Unhealthy” 151-200
“Very Unhealthy” 201-300
“Hazardous” >300
Public Education

• Stay indoors – shelter-in-place
• Building and room filtration
• Respiratory protective gear
  – Outdoor workers
  – General public
  – Persons with preexisting heart and lung disease
  – Children
CalOSHA Emergency Standard

- If feasible, provide an enclosed location with filtered air so that employee exposure to PM2.5 is less than an AQI of 151.
- Provide N95 respirators if employers cannot reduce workers' exposure to PM2.5 to an AQI of 150 or lower.
Wildland forest fire smoke: health effects and intervention evaluation, Hoopa, California, 1999

Joshua A Mott, Pamela Meyer, David Mannino, Stephen C Redd

- Large fire burned for 2 months with poor air quality (high PM$_{10}$)
- CDC investigators documented increased health care utilization for lower respiratory illness
- Recollection of public service announcements was associated with a reduced odds of reporting adverse respiratory health effects

West J Med 2002;176:157-162
Wildland forest fire smoke: health effects and intervention evaluation, Hoopa, California, 1999

Joshua A Mott, Pamela Meyer, David Mannino, Stephen C Redd

- Increased duration of the use of HEPA air cleaners was associated with a reduced odds of reporting adverse respiratory health effects
- No protective effects were observed for use of masks or duration of evacuation

West J Med 2002;176:157-162
Post-Wildfire Problems

• Post-traumatic stress
• Housing shortage, especially for low-income, immigrant renters
• Post-fire structural building clean-up
  – Much of the work done by day workers
Fire suppression has increased fuel availability
Increased Development - Wildland Urban Interface
Prevention

• Most of the U.S. Forest Service wildfire budget goes to suppression activities, leaving precious little for necessary forest-maintenance activities.
  – The 2013 Rim Fire started in Yosemite but mostly burned in the Stanislaus National Forest – why?

• Dead trees and excessive undergrowth need to be removed from our forests

• Communities near National Forests resist prescribed burns
Community Protection

- At-risk communities can do more to prepare for wildfires
  - Bulldoze fuel breaks around neighborhoods
  - Install new smoke-detection cameras and sensors
  - Remove vegetation around homes
  - Improve escape routes in subdivisions
  - Train residents in initial fire suppression methods (i.e., watering down roofs)
How Might Outdoor Pollution (e.g., Wildfire Smoke) Worsen COVID-19?

1. Acute Effects
   • Does the **current** outdoor pollution level affect risk of COVID-19 infection, hospitalization or death?

2. Chronic Effects
   • Does **long-term** exposure to outdoor pollution increase risk of worse outcomes with COVID-19 infection?
Acute Effects of Pollution on Respiratory Infection

- Controlled exposure\(^1\) to NO\(_2\), O\(_3\) and/or fine particulate matter (PM\(_{2.5}\)) worsens viral proliferation and severity of infection by other viruses:
  - Influenza
  - Rhinovirus
  - RSV

- Mechanisms of increased severity of viral infection:
  - Impaired ciliary function (first line defense of upper airways)\(^2\)
  - Oxidative stress and production of free radicals, causing local damage\(^1\)
  - Reduced ability of macrophages to phagocytose\(^1\)


Gowdy et al. *Particle and Fibre Toxicol* 2010

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DE=Diesel exhaust

Viral Titers in Mouse Lung
Daily PM Linked to Flu & Pneumonia Hospitalization

Lag 0–1 concentrations of PM$_{2.5}$ and hospital admissions for flu-like illness during flu season in Beijing, 2008-2014

3-day moving average (lag 0–2) concentrations of PM$_{2.5}$ and hospital admissions for pneumonia in 184 cities in China, 2014–2017
Pollution Exposure and COVID-19 Count in China

Generalized additive models of daily moving averages of pollutant exposure and Covid-19 count in 120 Chinese cities Jan-Feb 2020, controlling for meteorology

Suspended Particles May Spread Virus

- Particulate matter pollution may be platforms for viruses to spend more time in the air and travel longer distances
- In Italy\(^1\) and China\(^2\), COVID-19 mortality greatest in most polluted areas
- SARS-COV-2 RNA has been found on outdoor particulate matter in

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PM\(_{10}\) Levels Feb 10-29, 2020

Covid-19 Fatalities Feb 10-29, 2020
Outdoor Pollution and Mortality from SARS (a coronavirus) in China

\[
\text{Case Fatality} = -0.063 + 0.001 \times \text{API} \\
\text{Correlation Coefficient} = 0.8568
\]

Coal Pollution and 1918 Spanish Flu

All-Age Mortality from Spanish Flu (High vs Low Coal Pollution)

Clay K. Economics and Human Biology. 2019
Several reports note higher COVID-19 mortality in more polluted areas of Western Europe, California and China\textsuperscript{1,2,3}

These case reports do not control for confounders (e.g., timing of initial COVID-19 outbreak, population density, SES, age, co-morbidities)

\textsuperscript{1}Ogen. Sci Total Environ. 2020; \textsuperscript{2}Bashir et al. Environ Res. 2020. \textsuperscript{3}Frontera et al. J Infect. 2020
Exposure to air pollution and COVID-19 mortality in the United States: A nationwide cross-sectional study

- Examined county-level long-term PM2.5 and Covid-19 mortality in 3,000 U.S. counties (~98% of the population)

- A $1 \mu g/m^3$ higher in PM$_{2.5}$ (averaged for 2000 to 2016) associated with an 8% increase in the COVID-19 death rate (95% CI 2%, 15%)

- April 24, 2020 revision: data until April 22, 2020, adjusts for timing of the epidemic's spread, timing of the social distancing policies and population age distribution

Wu et al. medRxiv 2020.
Emerging Data Show Racial Disparities in COVID-19 Infection and Mortality

<table>
<thead>
<tr>
<th></th>
<th>Non-hospitalized</th>
<th>Non-fatal hospitalized</th>
<th>Known to have died</th>
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<tbody>
<tr>
<td>Black/African American</td>
<td>335.5</td>
<td>271.7</td>
<td>92.3</td>
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<tr>
<td>Hispanic/Latino</td>
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<td>White</td>
<td>190.4</td>
<td>114.5</td>
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<tr>
<td>Asian</td>
<td>95.1</td>
<td>82.2</td>
<td>34.5</td>
</tr>
</tbody>
</table>

Similar disparities noted across the country

Source: NYC.gov
COVID-19 and Wildfires in 2020

• Bad wildfire season predicted
• Should prescribed burns be used?
• How can evacuations be done safely?
• How do we fight wildland fires?
• How do we protect the public?
Summary

• The duration of the wildfire season is longer and catastrophic wildfires are increasing in frequency due to climate change
• Acute respiratory effects are well documented, but new studies suggest acute cardiovascular effects
• Long-term effects of high and/or recurrent exposures need further study
• Need to invest heavily in forest management and community resilience
• Risk of COVID-19 may be increased by wildfire smoke and complicates wildland firefighting
Thank you