Health Effects of Wildfires

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California Climate Action Team
Public Health Workgroup (CAT-PHWG)
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Disclosures

• No conflicts of interest

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2018 November

The Camp Fire is now the most destructive fire in California history.

Multiple and fast spreading fires, easily jumped what would normally serve as a fire break, 6-lane Highway 101.

https://www.youtube.com/watch?v=opVz7HZAXLo
While thousands of residents were under evacuation orders, hospitals threatened by fires were also having to evacuate patients.
Particulate matter

PM$_{10}$: inhalable particles, with diameters that are generally 10 micrometers and smaller.

PM$_{2.5}$: fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller.
Current AQI (Combined PM and O₃)
Monday, October 09, 2017 11:00 AM PDT

Santa Rosa
Vacaville
Elk Grove
Woodland
San Rafael
Antioch
San Francisco
Oakland
Livermore
San Jose

Generated: 2017-10-09 11:30:13Z
Air-quality impacts extend hundreds of miles => distant urban areas

- Forest fires in Quebec, Canada, 2002
- Baltimore, Maryland, nearly 1,000 miles downwind
- 30-fold increase in airborne fine particle concentrations

Source: Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on the Terra satellite, Land Rapid Response Team, NASA/GSFC
Global mortality attributable to wildfire smoke: Estimated to be 339,000 persons

Johnson FH et al. 2012

URL: lance-modis.eosdis.nasa.gov/cgi-bin/imagery/firemaps.cgi
Increasing Wildfire Risk in the U.S.

Acreage Burned in the U.S. Annually

Radeloff et al. 2005
Adapted from https://www.nifc.gov/fireInfo/fireInfo_stats_totalFires.html
Drought -- 129 Million Dead Trees
Increasing Wildfire Risk to Human Populations: Wildland–Urban Interface ("WUI")

- 38% of U.S. housing units near wildland

headwaters.economics.org/wildfire/homes-risk/northern-california-homes-and-cost-of-wildfires
Fires from Agricultural and Prescribed (controlled) Burns

Agricultural fires and prescribed burns account for 70% of total number of fires in U.S.

CO₂ emissions increasing

NASA 2012
Wildfire smoke is a complex mixture of gases and particles. Depends on fuel & combustion conditions.

**Gases**
- Combustion products
  - Carbon monoxide
  - Nitrogen monoxide
  - Carbon dioxide
- Products of secondary photochemical processes
  - Ozone
  - Nitrogen dioxide

**Particles**
- Organic compounds
  - Polycyclic Aromatic Hydrocarbons
  - Organic acids: carboxylic acids
  - Aldehydes, formaldehyde
- Inorganic materials, trace elements:
  - K, Mg, P, Mn
- Free radicals – mainly organic
Wildfires increasing ambient air pollution

Wildfires contributed 20% of the particulate matter in ambient air pollution, 2012

• *Important to remember that not everyone exposed to wildfire smoke will have health problems.*

*Duration & level of exposure, age, individual susceptibility, pre-existing lung or heart disease, etc.*
Wildfire particulate matter

- Penetrates deeply into the alveolar region of the lung
- Damage to cilia
- Loss of epithelial cells
- Crosses into the bloodstream

Health effects known or suspected to be caused by wildfire smoke

• Eye irritation, sore throat, wheeze & cough
• Asthma & COPD exacerbations
• Bronchitis & pneumonia
• Cardiovascular outcomes
• Adverse birth outcomes
• All-cause mortality
Respiratory morbidity

*Very consistent evidence from a large number of studies*
Reviewed by Reid et al 2016.

**Asthma**
- Very consistent evidence from a large number of studies
- Most commonly studied, most clearly affected outcome, based on hospitalization and ED visits
- Also studies on medication use, physician visits

**COPD**
- Very consistent associations (fewer studies than asthma)

**Respiratory infections**
- Associated (fewer studies than asthma)

**Infectious conditions - pneumonia and bronchitis**
- Associated (fewer studies than asthma)
Cardiovascular morbidity

• Often mixed / inconclusive / null
  - 16 evaluations of cardiovascular morbidity overall – generally null
    (Reid et al 2016)

• Not as many studies looked at cardio compared to respiratory

• CV events much rarer than respiratory, e.g. asthma
  – harder to study

• Too broad a category?
  - relatively few studies look at separate endpoints within cardiovascular
Cardiovascular effects
Victoria, Australia - Dec 1, 2006 - Jan 31, 2007

Out-of-Hospital Cardiac Arrest (OHCA)

Percentage change (95% CI)

- OHCA Total
- >65 years
- Men

Ischemic Heart Disease (IHD) Hospitalizations

Percentage change (95% CI)

- IHD
- >65 years
- Women
Natural disasters → Psychological impacts

**WILDFIRES**

- **Spain:** ↑ anti-anxiety RX use in months following wildfires
- **Greece:** depression, paranoia, psychopathology
- **Los Angeles fire victims:** sleep disturbances, nightmares
Vulnerable populations

- Young and old are susceptible
- Pre-existing conditions, e.g.
  - respiratory
  - cardiovascular
  - diabetic
- Outdoor workers
## Wildfire Susceptible Populations
### NHANES 2007-2010

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<th>N</th>
<th>Percent (95% CI)</th>
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<td>7135</td>
<td>73.0 (71.4, 74.6)</td>
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<td>Respiratory only</td>
<td>642</td>
<td>6.4 (5.5, 7.2)</td>
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<td>2.6 (2.3, 2.9)</td>
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<tr>
<td>&gt;65 years only</td>
<td>1713</td>
<td>10.9 (10.1, 11.8)</td>
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<tr>
<td>Respiratory and cardiovascular</td>
<td>136</td>
<td>1.0 (0.7, 1.3)</td>
</tr>
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<td>Respiratory and &gt;65 years</td>
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<td>1.6 (1.3, 1.8)</td>
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<tr>
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<td>3.8 (3.3, 4.3)</td>
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<tr>
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NHANES = National Health and Nutrition Education Survey
Wildfire Susceptible Populations
NHANES 2007-2010

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27% fall into at least one susceptible group

NHANES = National Health and Nutrition Education Survey
Vulnerable Populations: Indigenous vs. Non-indigenous

COPD Hospital admissions Australia

Adjusted Odds Ratios, 95% Confidence Interval, per 10μg/m³ increase in PM10

General population: ~20% increase in COPD

Vulnerable Populations:
Indigenous vs. Non-indigenous

COPD
Hospital admissions
Australia

Adjusted Odds Ratios,
95% Confidence Interval,
per 10ug/m³ increase in PM10

General population:
~20% increase in COPD

Indigenous population:
~200% increase in COPD (log scale)

San Diego 2007 Wildfire Research Study:
Collaboration with San Diego County, Michigan Tech Research Institute

California
- 9,000 separate wildfires
- >1,000,000 acres burned

San Diego
- Medi-Cal population
- San Diego firestorm
  - 500,000 evacuated
  - Multiple school & road closings
Daily PM$_{2.5}$

Average
Daily average PM$_{2.5}$ (by zip)
US EPA 24hr PM standard
(35µg/m$^3$)

PM$_{2.5}$ (µg/m$^3$)

0 - 200 - 400 - 600 - 800 -

17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 1 2 3 4 5

October 2007 | November 2007

Day 1-5
Day 6-10
Day 11-15
Respiratory and cardiovascular visits
San Diego County during 2007 fire period

Visit Type
- Emergency Presentations
- Inpatient Hospitalizations
- Outpatient Visits
Respiratory visits

- Asthma
- Upper Respiratory Infection
- Respiratory Symptoms
- Acute Bronchitis
- Bronchitis (not specified)
- Pneumonia
- COPD

Visit Type:
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Respiratory visits

Asthma
Upper Respiratory Infection
Respiratory Symptoms
Acute Bronchitis
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Pneumonia
COPD

Visit Type
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Respiratory visits, by age group
Respiratory visits, by age group
## Air Quality Index (AQI)

### Odds Ratios (ORs), conditional logistic regression of respiratory emergency department visits

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<th>AQI categories</th>
<th>OR (95% CI) Same day</th>
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<th>OR (95% CI) 2-day lag</th>
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<tr>
<td>PM$_{2.5}$ (µg/m$^3$)</td>
<td></td>
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<tr>
<td><strong>Good (0 - 12)</strong></td>
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<td></td>
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<tr>
<td><strong>Moderate (12.1 - 35.4)</strong></td>
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<td><strong>Unhealthy for Sensitive Groups (35.5 - 55.4)</strong></td>
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<td><strong>Unhealthy (55.5 - 150.4)</strong></td>
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<td><strong>Hazardous (≥ 250.5)</strong></td>
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Temperature

Relative humidity

AIC
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Odds Ratios (ORs), conditional logistic regression of respiratory emergency department visits

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<td>Moderate (12.1 - 35.4)</td>
<td>1.20 (0.91-1.59)</td>
<td>1.11 (0.84-1.47)</td>
<td>0.80 (0.59-1.08)</td>
</tr>
<tr>
<td>Unhealthy for Sensitive Groups (35.5 - 55.4)</td>
<td>1.43 (0.96-2.13)</td>
<td>1.73 (1.18-2.53)*</td>
<td>1.51 (1.00-2.28)*</td>
</tr>
<tr>
<td>Unhealthy (55.5 - 150.4)</td>
<td>1.27 (0.97-1.67)</td>
<td>1.79 (1.30-2.23)*</td>
<td>1.50 (1.13-1.98)*</td>
</tr>
<tr>
<td>Very unhealthy (150.5 - 250.4)</td>
<td>1.68 (1.00-2.83)</td>
<td>1.58 (0.93-2.68)</td>
<td>1.87 (1.07-3.27)*</td>
</tr>
<tr>
<td>Hazardous (≥ 250.5)</td>
<td>2.41 (1.39-4.18)*</td>
<td>1.28 (0.70-2.36)</td>
<td>1.74 (1.00-3.03)*</td>
</tr>
<tr>
<td>Temperature</td>
<td>1.00 (0.99-1.01)</td>
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<td>1.00 (0.99-1.00)</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>1.01 (1.00-1.01)*</td>
<td>1.01 (1.00-1.01)*</td>
<td>1.01 (1.00-1.01)*</td>
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<tr>
<td>AIC</td>
<td>5233.2</td>
<td>5228.9</td>
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CARDIOVASCULAR EFFECTS & WILDFIRE SMOKE 2015 WILDFIRES

CDPH Collaborative Research

Number of Smoky Days per County:

May 1 through September 30, 2015

Cardiovascular and other ER visits
↑ Risks from light, medium and dense smoke -- Adults 65+

No consistent relationship seen with younger adults.
SmokeSense Mobile App:

A collaborative citizen science research project developed by US EPA

The California Department of Public Health with support from the American Lung Association is collaborating with US EPA to analyze data from SmokeSense.
Resources

USEPA – AirNow
https://www.airnow.gov/

Nixle: Sign up to get up-to-date local public safety and school info
http://www.nixle.com/

Download SmokeSense EPA Citizen Science Project Mobile App

Supported in part by the American Lung Association

Public Health Guidance Resource:
Wildfire Smoke: A guide for public health officials
https://www3.epa.gov/airnow/wildfire_may2016.pdf
Resources

USEPA – AirNow
Fires and Your Health

Fires and Your Health

Smoke is made up of a complex mixture of gases and fine particles produced when wood and other organic materials burn. The biggest health threat from smoke is from fine particles. These microscopic particles can get into your eyes and respiratory system, where they can cause health problems such as burning eyes, runny nose.


Particle Pollution and Your Patients' Health

Evidence-based Training for Healthcare Professionals

- Wildfire Smoke for Public Health Officials
- How Smoke Can Affect Your Health
- Particle Pollution: Your Health
- Other Air Pollution Topics

Exit AirNow

Before a Wildfire

Informed patients can use the Air Quality Index to protect their health.

https://www.epa.gov/pmcourse/continuing-education-particle-pollution-course

USEPA – CME Education

This course is designed for family medicine physicians, internists, pediatricians, occupational and rehabilitation physicians, nurse practitioners, nurses, asthma educators, pulmonary specialists, cardiologists, and other medical professionals.

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Environmental Health Investigations Branch
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Occupational Health Branch

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