



# Where There's Wildfire, There's Smoke: An Epidemiological Perspective

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# Outline

- Wildfire
- Climate change
- What's in wildfire smoke
- Community health effects
- Wildland firefighter health issues

# Sonoma-Napa Wildfires – Oct. 2017



# Southern CA Wildfires – Dec. 2017



Thomas fire

Rye fire

Creek fire

Los Angeles

# Carr, Mendocino Complex, and Camp Fires - 2018



# 2017 and 2018 were Bad Wildfire Years

## - Why?

### Sierra Snowpack

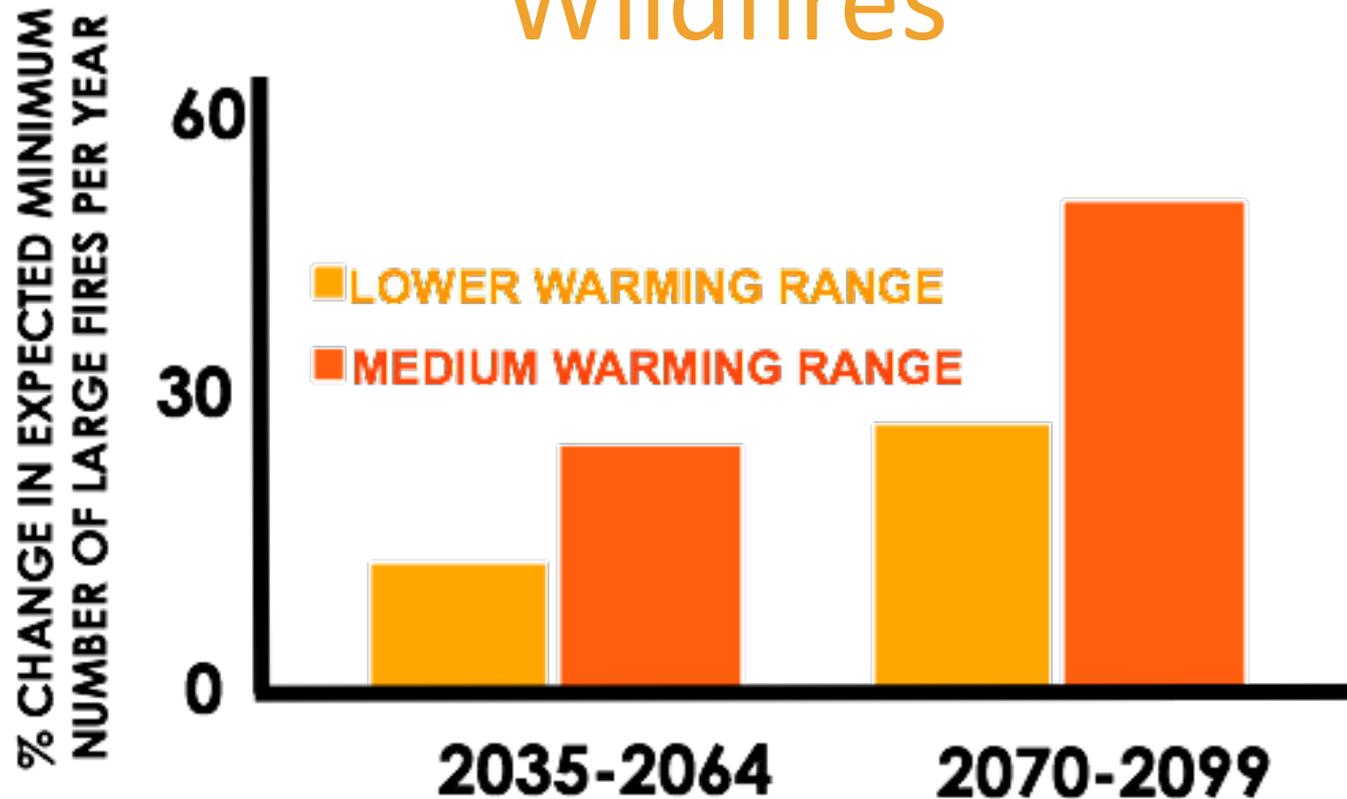


January 2013

January 2014

- 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



# Emissions from Wildfires

## Primary air pollutants

- Particulate Matter (PM)
- Carbon monoxide (CO)
- Nitrogen dioxide (NO<sub>2</sub>)
- Polycyclic aromatic hydrocarbons (PAHs)
- Volatile organic compounds (VOCs)

## Secondary air pollutants

- Particulate Matter (PM)
- Ozone



# Coffey Park neighborhood burning

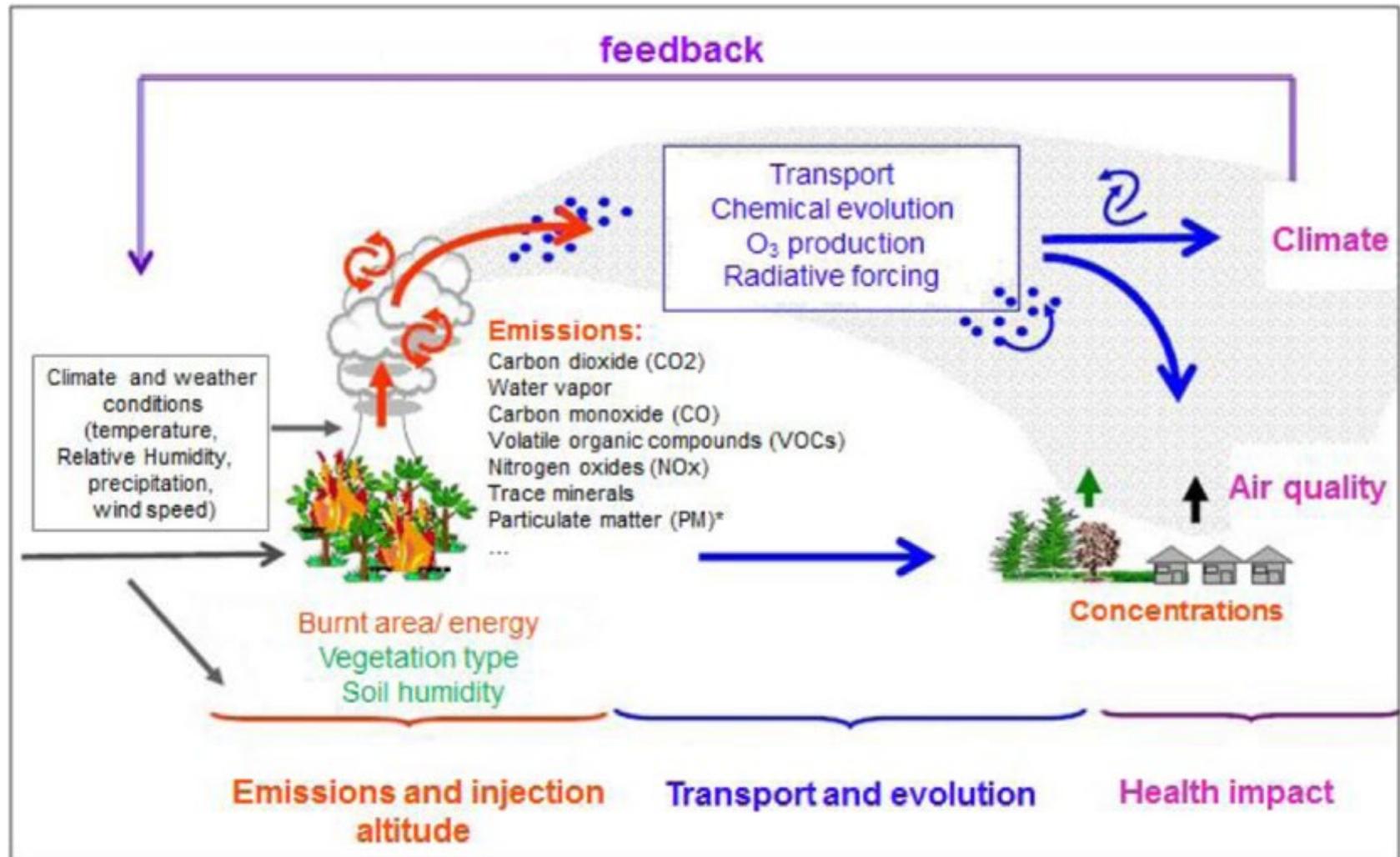


# When Buildings and Vehicles Burn

- Structural fire smoke contains other toxic air contaminants, including
  - Hydrogen cyanide (HCN), hydrochloride (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
- The plumes that travelled to the San Francisco Bay Area and Greater Los Angeles were almost entirely wood/biomass smoke

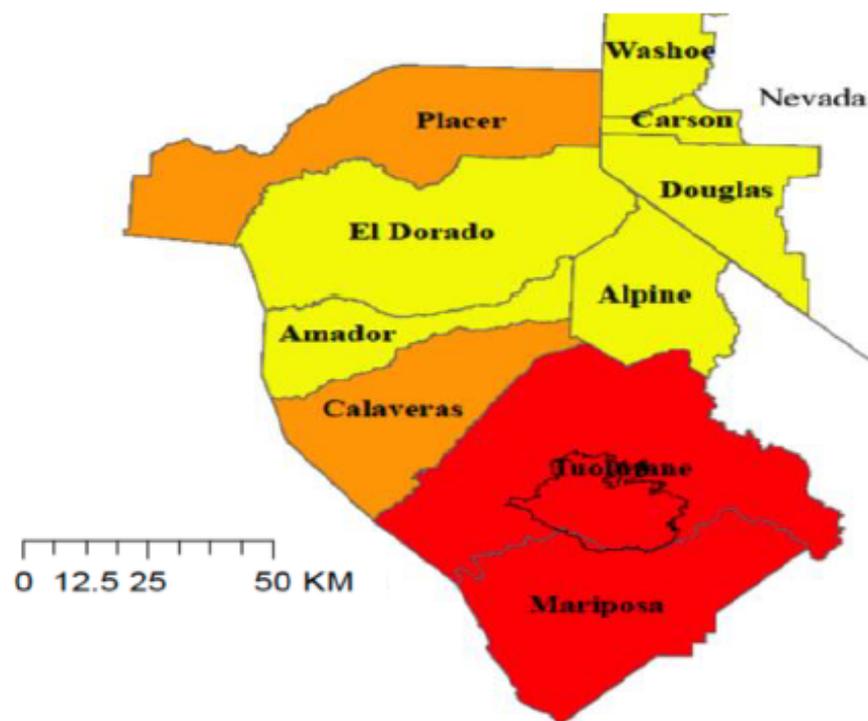


# Wildfire emissions and related health impacts

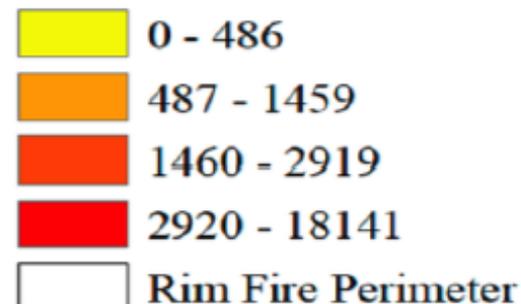


## Air-Quality Impacts and Intake Fraction of PM<sub>2.5</sub> during the 2013 Rim Megafire

Kathleen M. Navarro,<sup>†</sup> Ricardo Cisneros,<sup>\*,‡</sup> Susan M. O'Neill,<sup>§</sup> Don Schweizer,<sup>‡</sup> Narasimhan K. Larkin,<sup>§</sup> and John R. Balmes<sup>†</sup>



### Daily Mass Intake $\mu\text{g PM}_{2.5}$ per person



**Higher (RED) exposures levels are**

**500 times the 24-hour National Ambient Air Quality Standard**

**Reference:**

**EPA 24 hr PM<sub>2.5</sub> standard = 35 $\mu\text{g}/\text{m}^3$**

# Camp Fire – Nov. 9, 2018

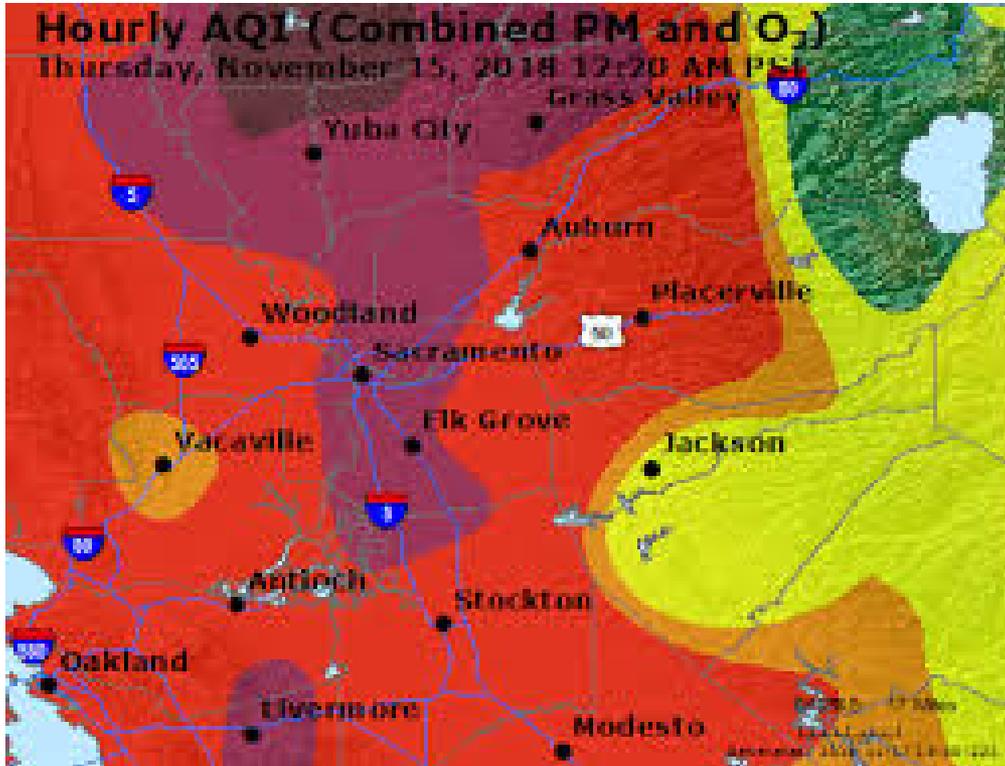


# Poor Air Quality in Bay Area



- Nov. 14, 2018 –  $\text{PM}_{2.5}$  goes over  $200 \mu\text{g}/\text{m}^3$  that Thurs. evening and is projected to stay high for days
  - UC Berkeley cancels classes, but does not close campus
  - UC Berkeley postpones the “Big Game” with Stanford scheduled for Sat. Nov. 16

# Even Poorer Air Quality Closer to Fire



Nov. 15, 2018 – PM<sub>2.5</sub> goes up to 250  $\mu\text{g}/\text{m}^3$  in Sacramento and over 300  $\mu\text{g}/\text{m}^3$  in Yuba City

# Acute health impacts of short-term community wildfire smoke exposures

## Critical Review of Health Impacts of Wildfire Smoke Exposure

*Colleen E. Reid,<sup>1,2</sup> Michael Brauer,<sup>3</sup> Fay H. Johnston,<sup>4,5</sup> Michael Jerrett,<sup>1,6</sup> John R. Balmes,<sup>1,7</sup> and Catherine T. Elliott<sup>3,8</sup>*



# Clear evidence of an association between wildfire smoke and respiratory health

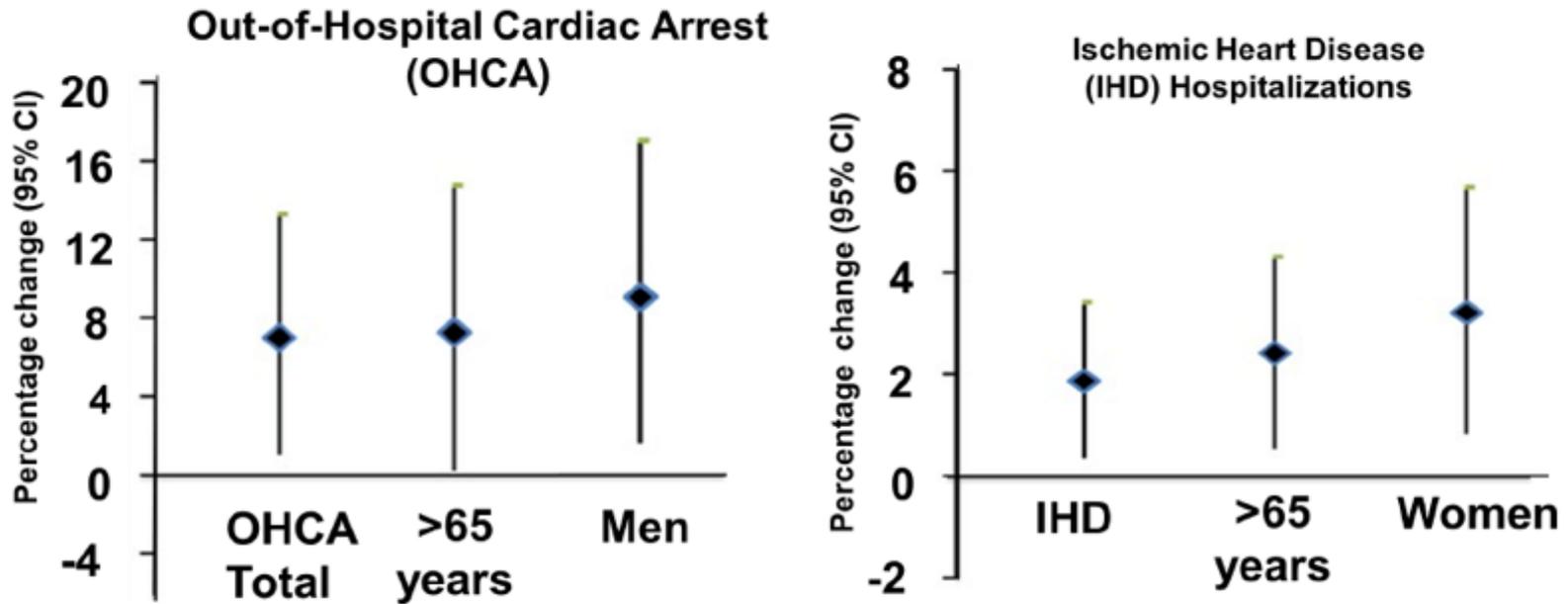
- Asthma exacerbations significantly associated with higher wildfire smoke *in nearly every study*
- Exacerbations of chronic obstructive pulmonary disease (COPD) significantly associated with higher wildfire smoke in most studies
- Growing evidence of a link between wildfire smoke and respiratory infections (pneumonia, bronchitis)





## Cardiovascular effects

Victoria, Australia - Dec 1, 2006 - Jan 31, 2007

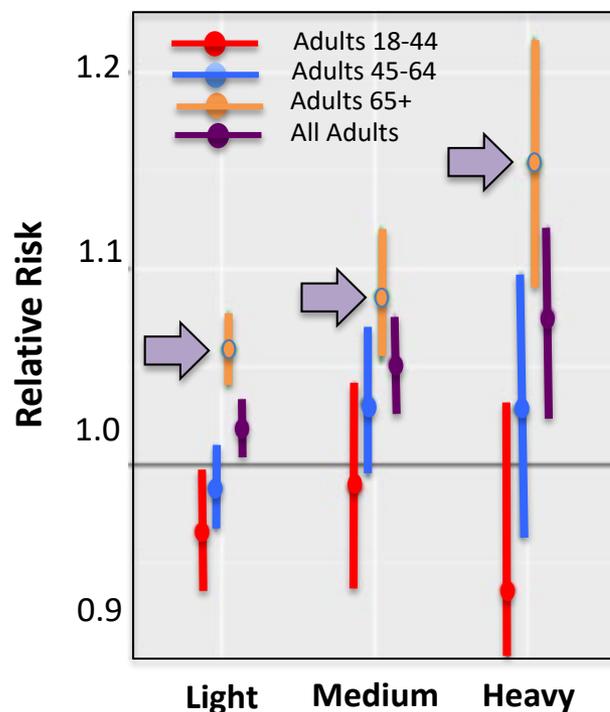




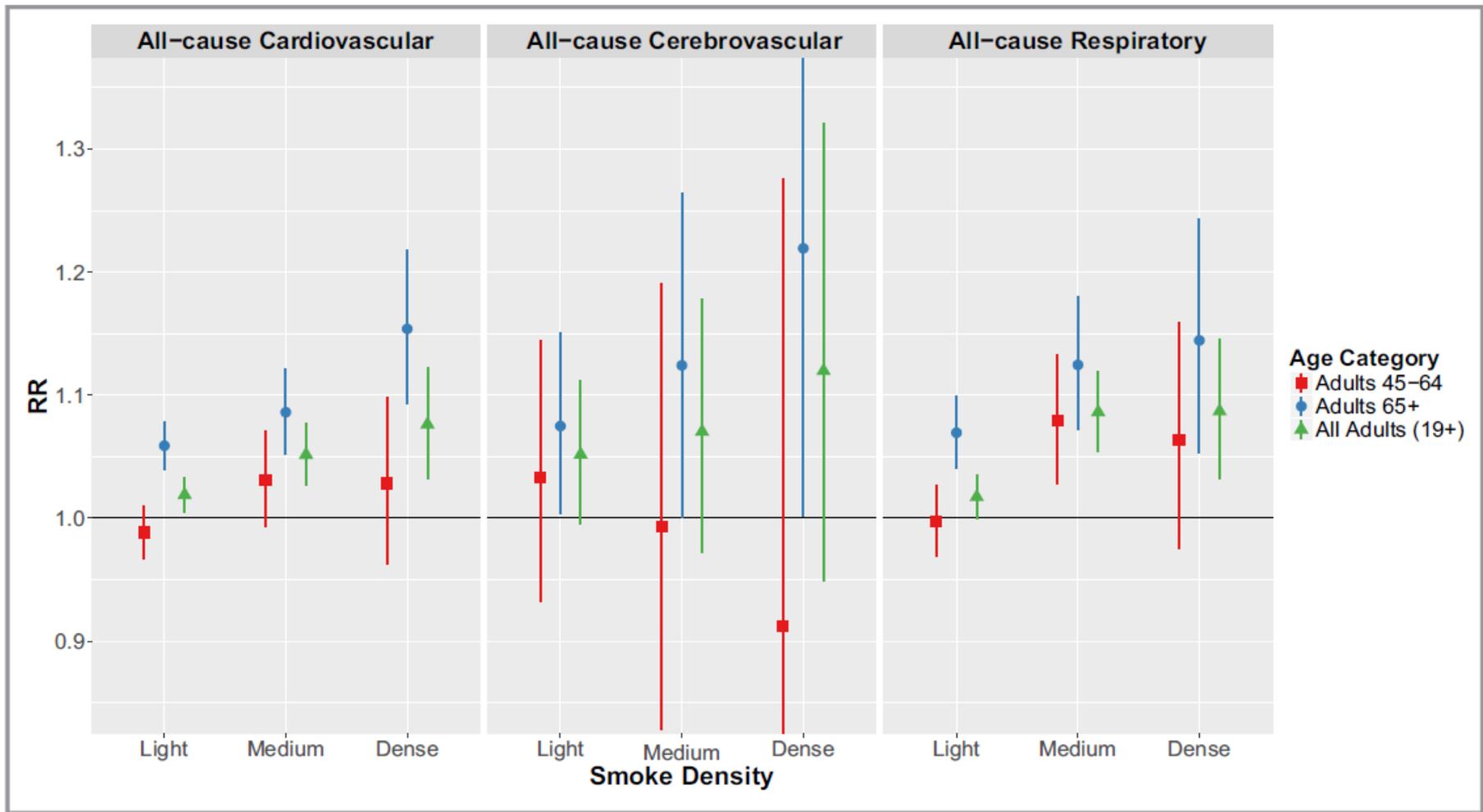
## Wildfire-PM<sub>2.5</sub> Increases Heart Attack & Stroke

- **Wildfire-PM<sub>2.5</sub> 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)

### All Cardiovascular Causes



19



Wettstein Z, Hoshiko S, Cascio WE, Rappold AG et al.  
 JAMA April 11, 2018

# Other Health Outcomes

- Adverse birth outcomes
- Mental health
- Based on the PM<sub>2.5</sub> literature
  - Metabolic outcomes
  - Cognitive decline
  - Child neurodevelopment
  - Health of pregnant mothers



# Wildland Firefighters

- Crews
  - Hand
  - Smokejumpers
  - Engine/Dozer
- Work Conditions
  - Long shifts
  - Rough terrain
  - Elevations
  - Remote locations



# 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?



## Occupational Exposure to Polycyclic Aromatic Hydrocarbon of Wildland Firefighters at Prescribed and Wildland Fires

Kathleen M. Navarro,<sup>\*,†</sup> Ricardo Cisneros,<sup>‡</sup> Elizabeth M. Noth,<sup>†</sup> John R. Balmes,<sup>†</sup>  
and S. Katharine Hammond<sup>†</sup>

- Exposures to 17 Polycyclic Aromatic Hydrocarbons (PAHs) were measured in 21 wildland firefighters suppressing two wildfires and 4 working on prescribed burns
- Naphthalene, retene, and phenanthrene were consistently the highest measured PAHs
- PAH concentrations were higher at wildland fires than at prescribed burns



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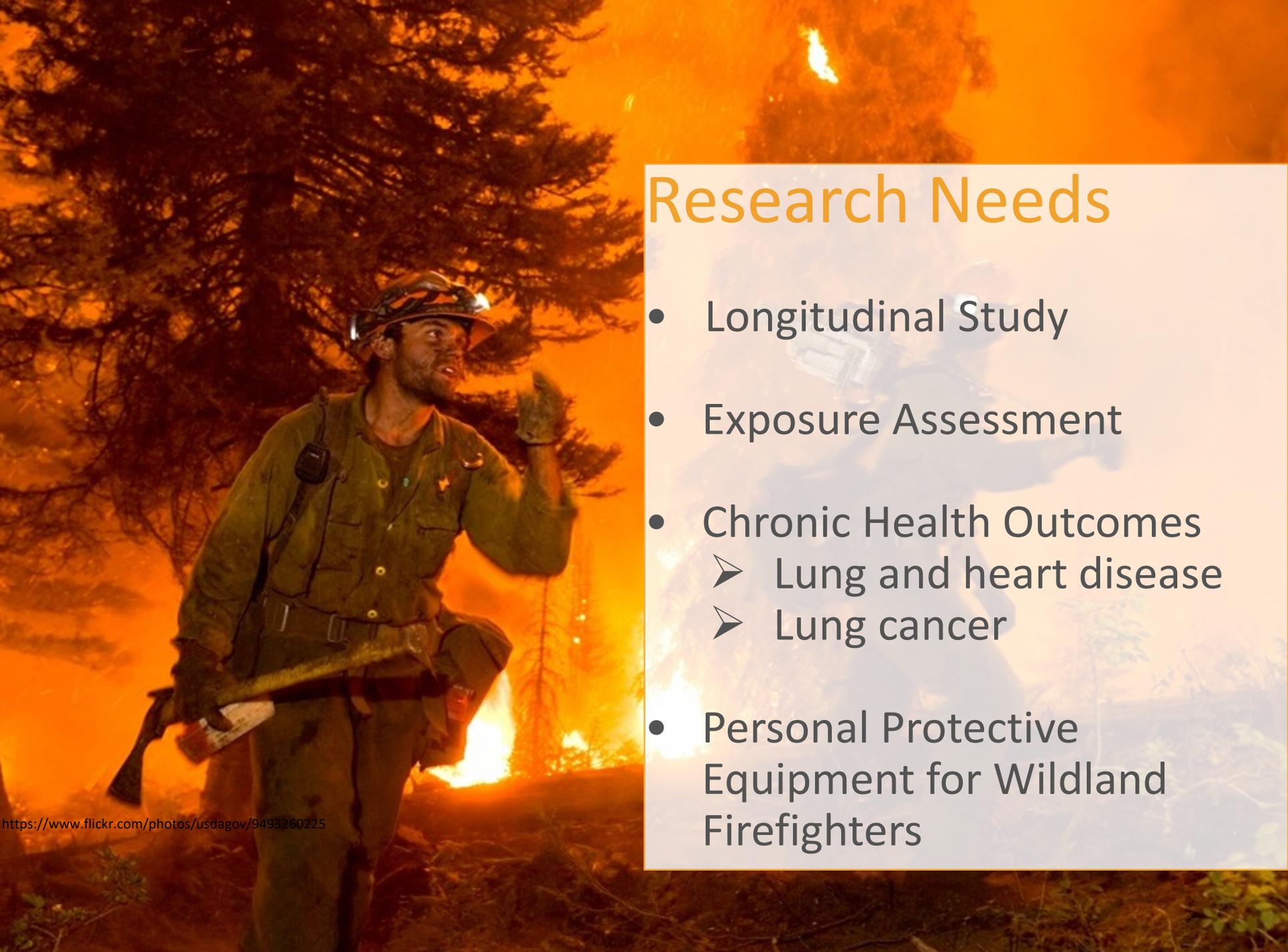
Environmental Research

journal homepage: [www.elsevier.com/locate/envres](https://www.elsevier.com/locate/envres)

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

Kathleen M. Navarro<sup>a</sup>, Michael T. Kleinman<sup>b</sup>, Chris E. Mackay<sup>c</sup>, Timothy E. Reinhardt<sup>d</sup>, John R. Balmes<sup>e</sup>, George A. Broyles<sup>f</sup>, Roger D. Ottmar<sup>g</sup>, Luke P. Naher<sup>h</sup>, Joseph W. Domitrovich<sup>i,\*</sup>

- Estimated the daily dose of wildfire smoke PM<sub>2.5</sub>
- The daily dose for firefighters working 98 days per year of PM<sub>2.5</sub> ranged from 0.30 mg to 1.49 mg
- For career durations (5–25 years), wildland firefighters had an estimated increased risk of lung cancer (8 percent to 43 percent) and cardio vascular disease (CVD) (16 percent to 30 percent) mortality

A firefighter in full gear, including a helmet and heavy jacket, stands in front of a large fire at night. The firefighter is holding a tool and looking towards the camera. The background is filled with bright orange flames and dark silhouettes of trees.

# Research Needs

- Longitudinal Study
- Exposure Assessment
- Chronic Health Outcomes
  - Lung and heart disease
  - Lung cancer
- Personal Protective Equipment for Wildland Firefighters

# 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 as well
- Long-term effects in wildland firefighters need further study

Thank you