



Health Effects of Wildfires

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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.

<https://wjla.com/news/nation-world/death-toll-wildfires-northern-southern-california>

15 FIRES 8 COUNTIES

MENDOCINO

NAPA

SONOMA

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

101

Patients Evacuated From Santa Rosa's Kaiser Hospital

Patients being evacuated from Santa Rosa hospital



While thousands of residents were under evacuation orders, hospitals threatened by fires were also having to evacuate patients.



TUBBS FIRE - SONOMA COUNTY

4:17 PM

BREAKING NEWS

Close to Catastrophe

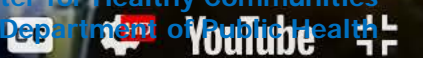
Santa Rosa

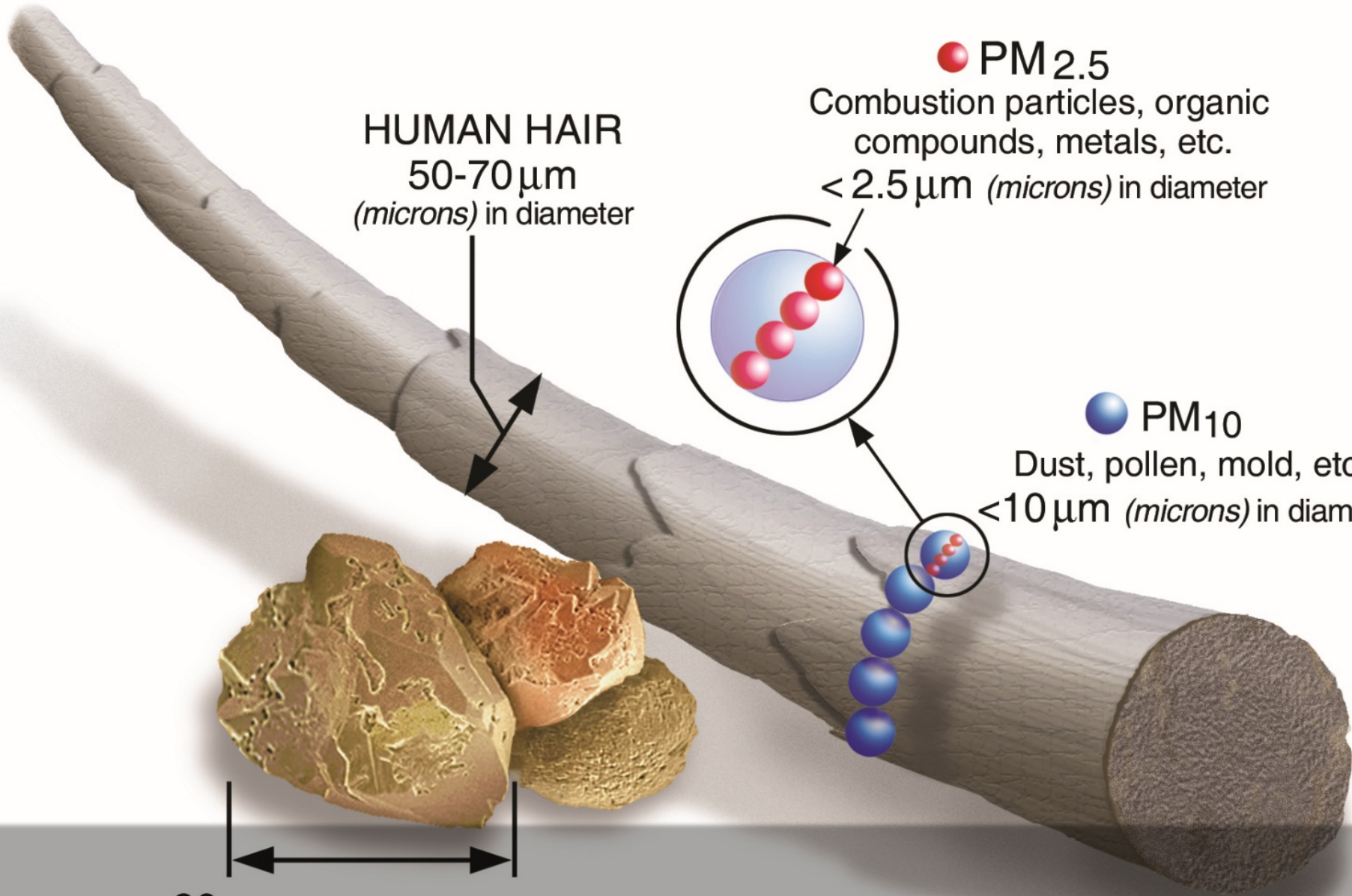


KPIX

Environmental Health Investigations Branch
Center for Healthy Communities
California Department of Public Health

0:27 / 1:46





HUMAN HAIR
50-70 μm
(microns) in diameter

90 μm (microns) in diameter
FINE BEACH SAND

PM_{2.5}
Combustion particles, organic
compounds, metals, etc.
< 2.5 μm (microns) in diameter

PM₁₀
Dust, pollen, mold, etc.
< 10 μm (microns) in diameter

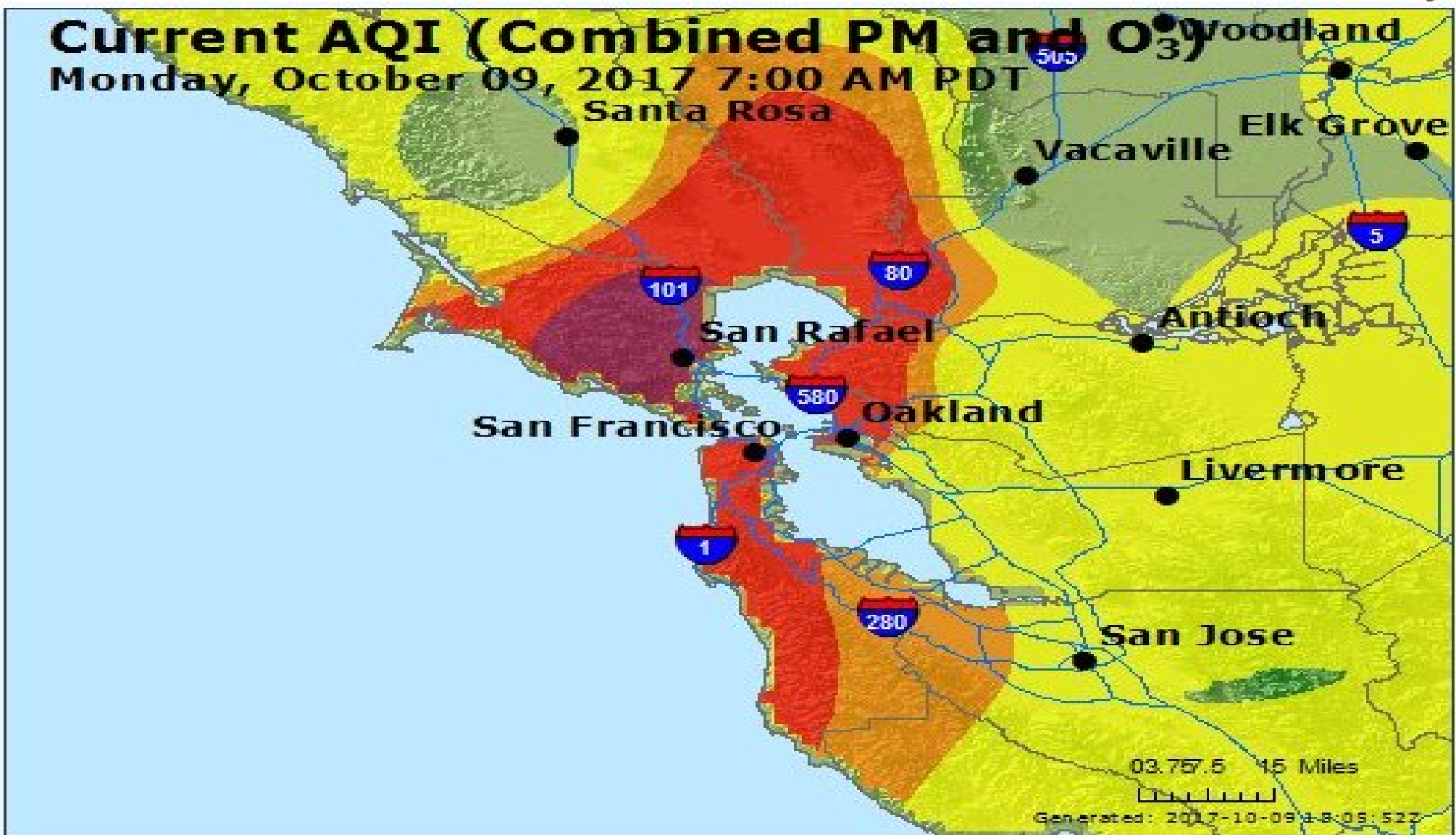
Particulate matter

PM₁₀ : 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

Current AQI (Combined PM and O₃)

Monday, October 09, 2017 7:00 AM PDT



Current AQI (Combined PM and O₃)

Monday, October 09, 2017 9:00 AM PDT



Current AQI (Combined PM and O₃)

Monday, October 09, 2017 11:00 AM PDT



Current AQI (Combined PM and O₃)

Monday, October 09, 2017 1:00 PM PDT

Santa Rosa



Current AQI (Combined PM and O₃)

Monday, October 09, 2017 3:00 PM PDT

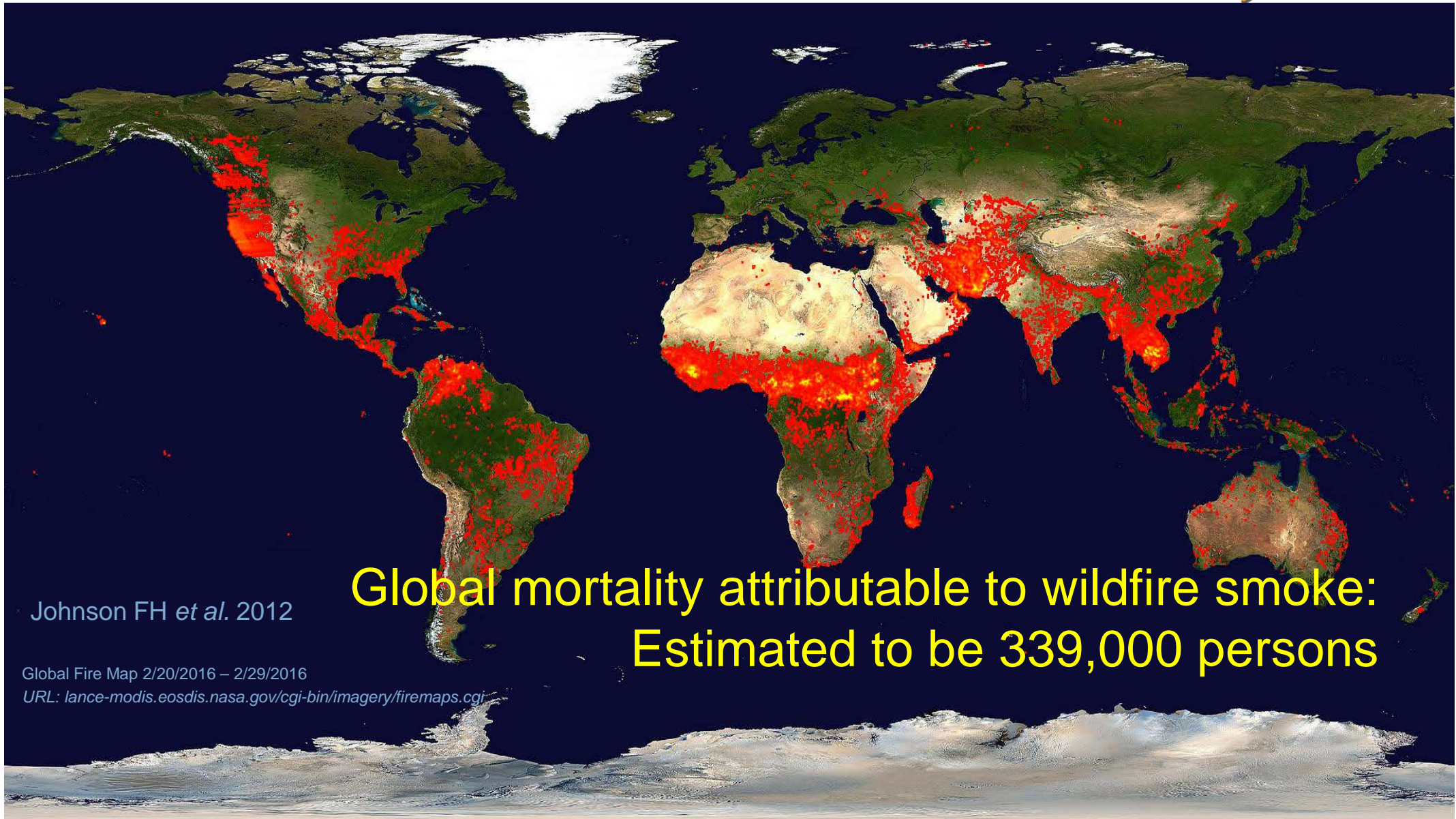




Air-quality impacts extend hundreds of miles => distant urban areas

- 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



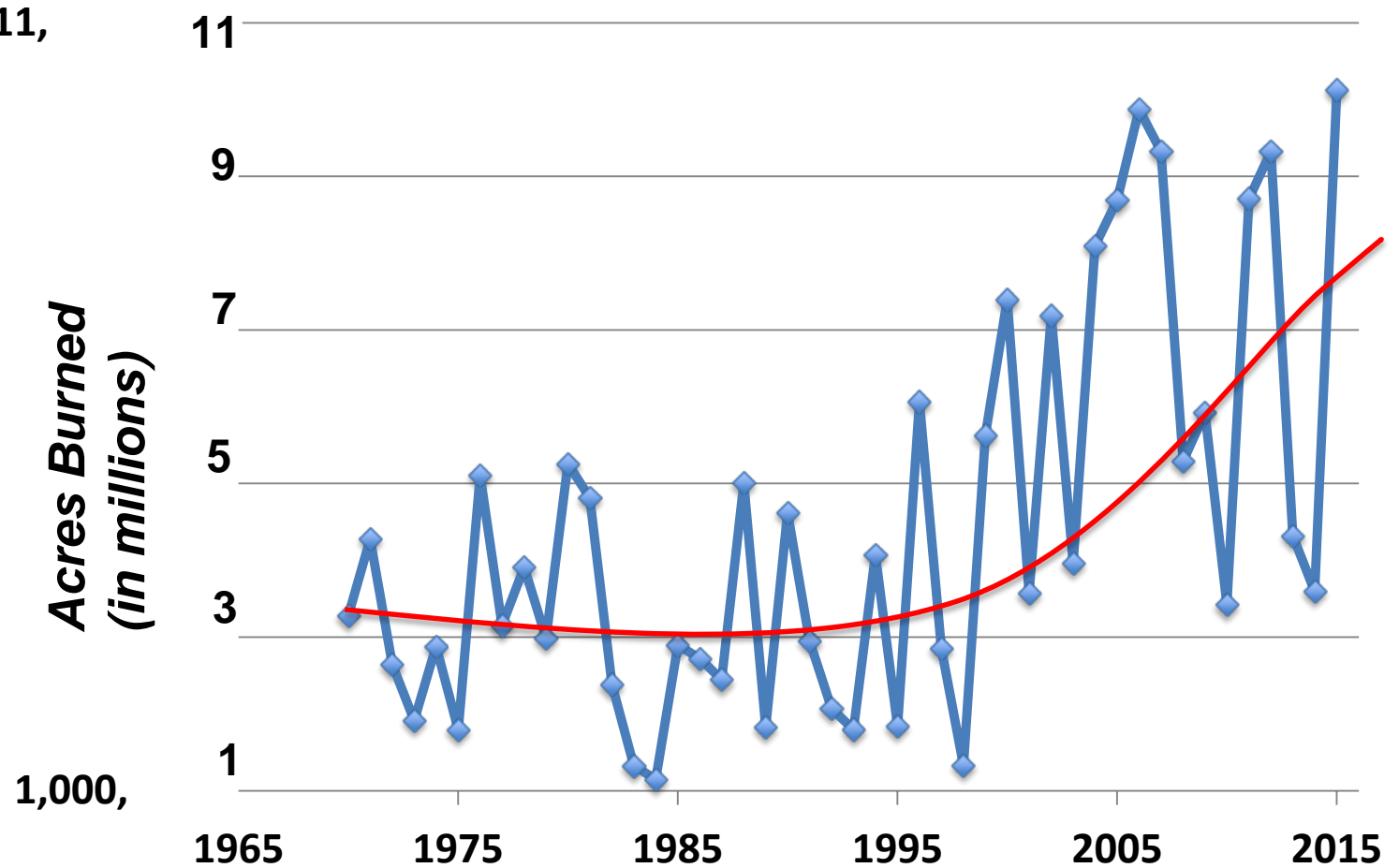
**Global mortality attributable to wildfire smoke:
Estimated to be 339,000 persons**

Johnson FH *et al.* 2012

Global Fire Map 2/20/2016 – 2/29/2016
URL: lance-modis.eosdis.nasa.gov/cgi-bin/imagery/firemaps.cgi

Increasing Wildfire Risk in the U.S.

Acres Burned in the U.S. Annually



Drought -- 129 Million Dead Trees >



Increasing Wildfire Risk to Human Populations: Wildland– Urban Interface (“WUI”)

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



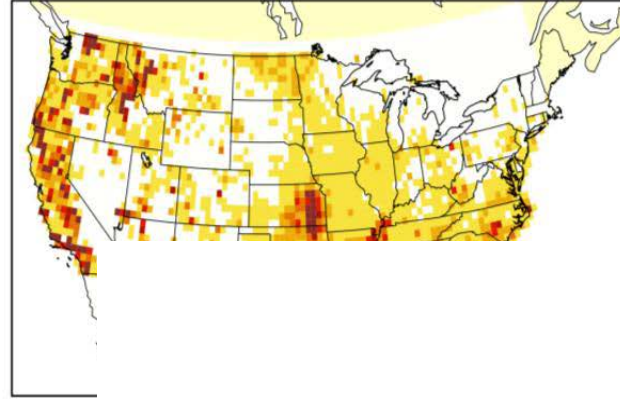
headwaterseconomics.org/wildfire/homes-risk/northern-california-homes-and-cost-of-wildfires

Fires from Agricultural and Prescribed (controlled) Burns

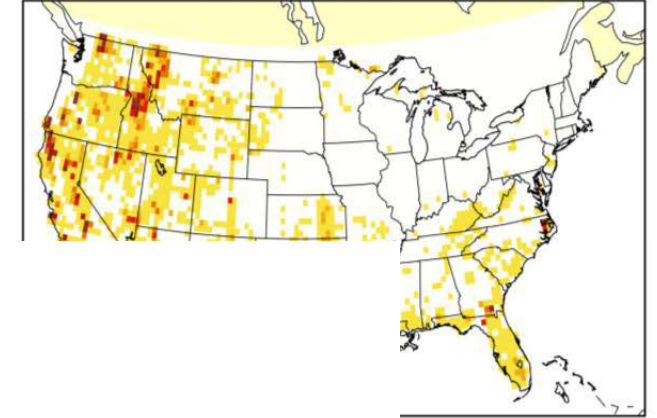
Agricultural fires and
prescribed burns
account for 70% of total
number of fires in U.S.

CO₂ emissions
increasing

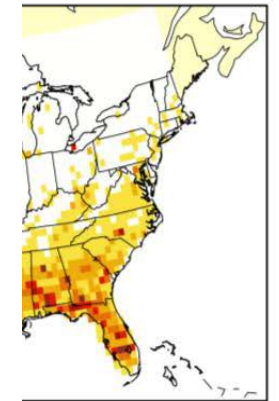
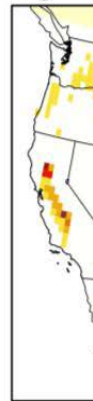
All fires



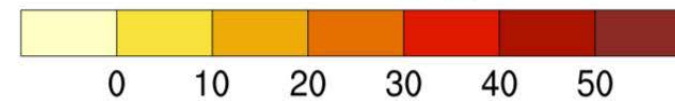
Wildland fires




Agric



Active fires (#/yr)





Wildfire smoke is a complex mixture of gases and particles

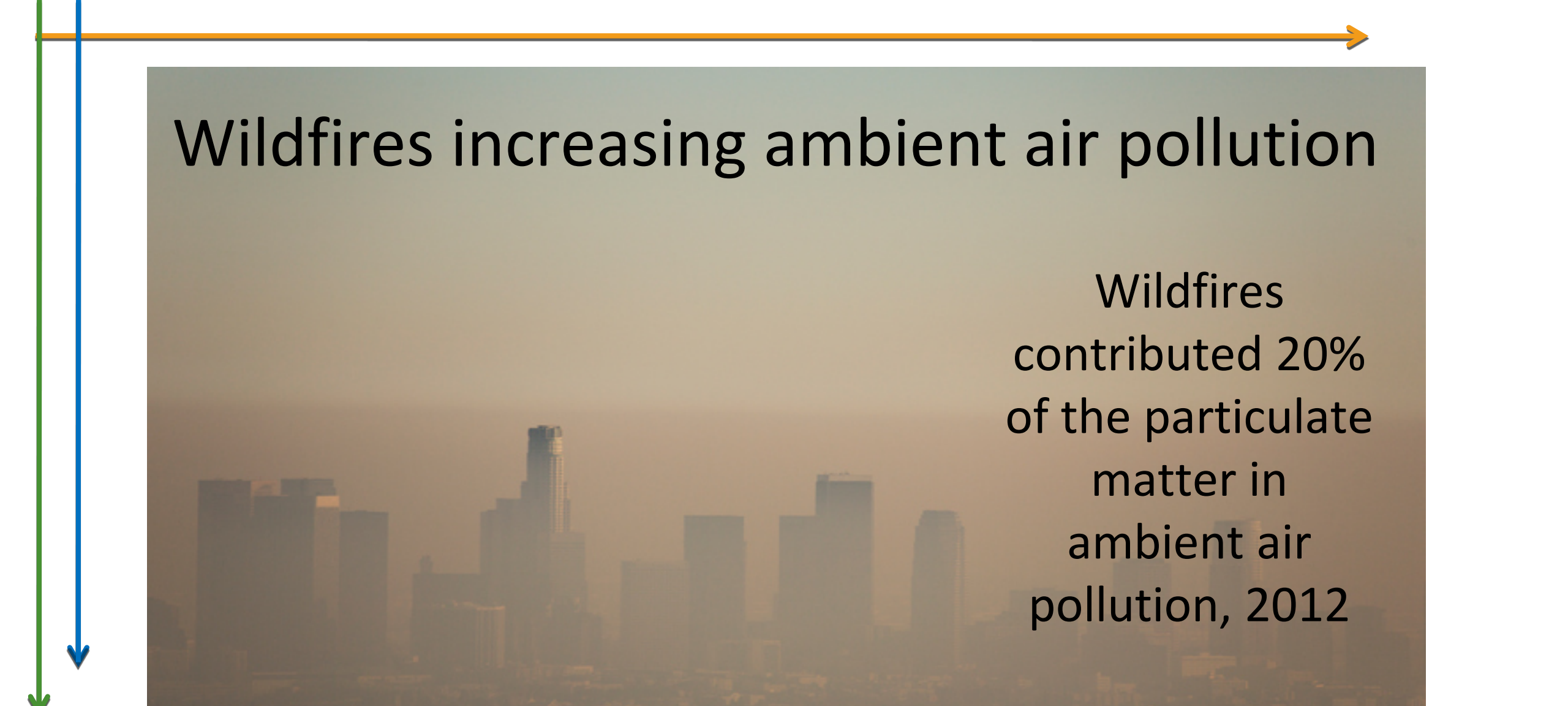
Depends on fuel & combustion conditions

Gases

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

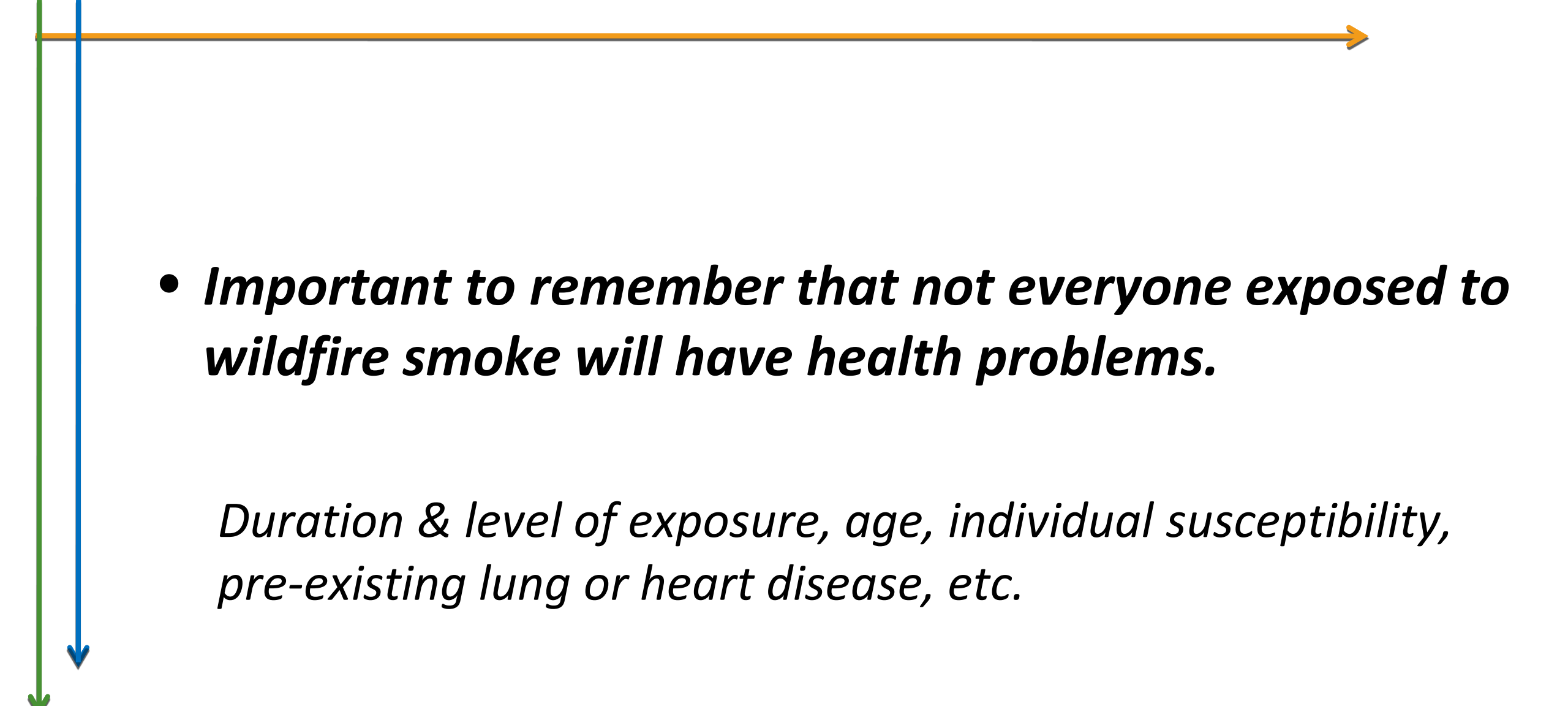
Particles

- 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

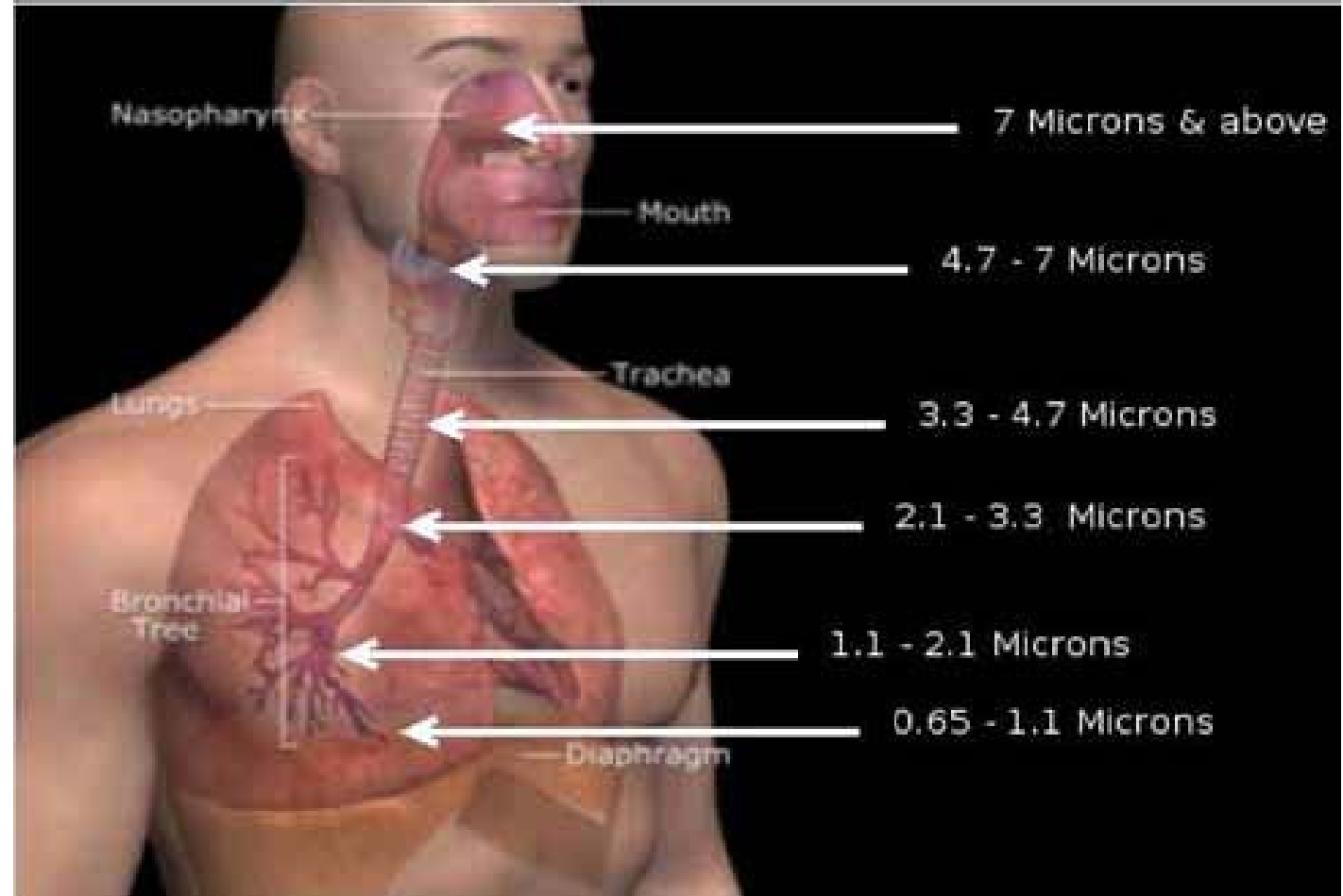
Wildfires
contributed 20%
of the particulate
matter in
ambient air
pollution, 2012

- 
- ***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



Wegesser TC et al, California wildfires of 2008: coarse and fine particulate matter toxicity. Environ Health Perspect. 2009;117:893-7

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?*

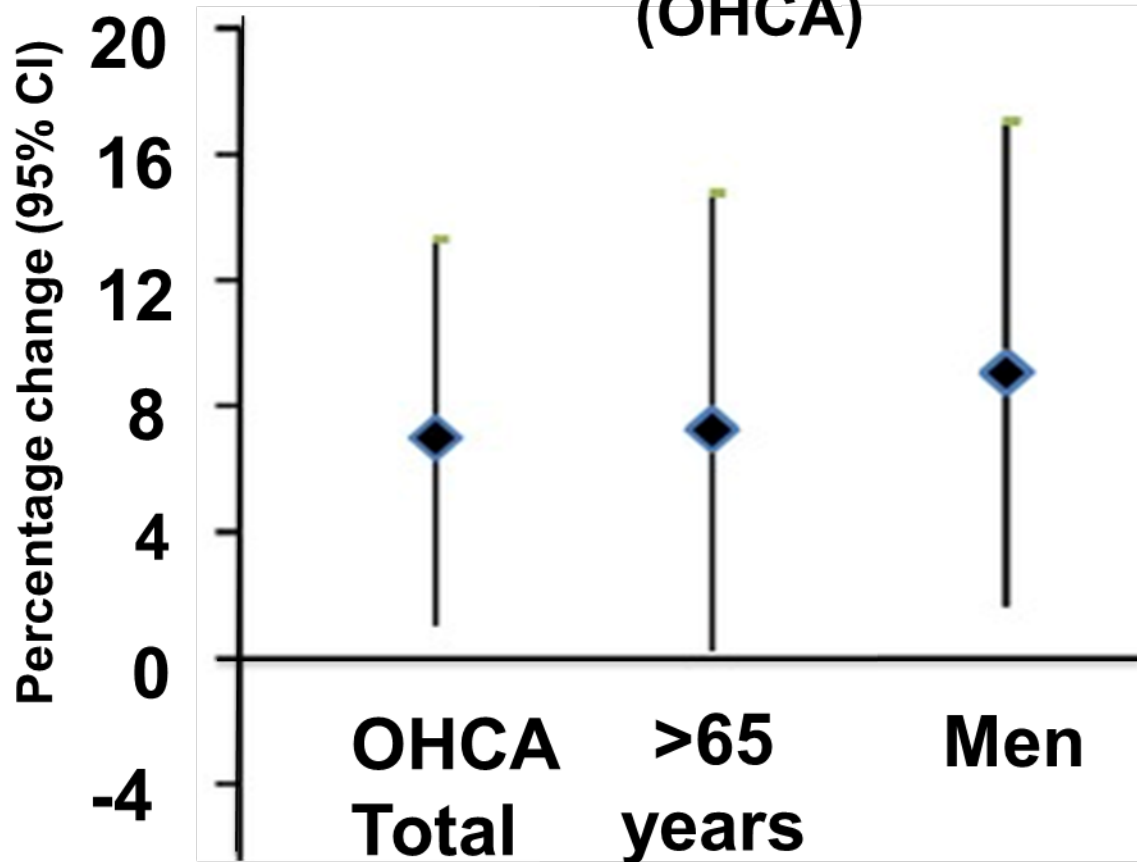
- *relatively few studies look at separate endpoints within cardiovascular*



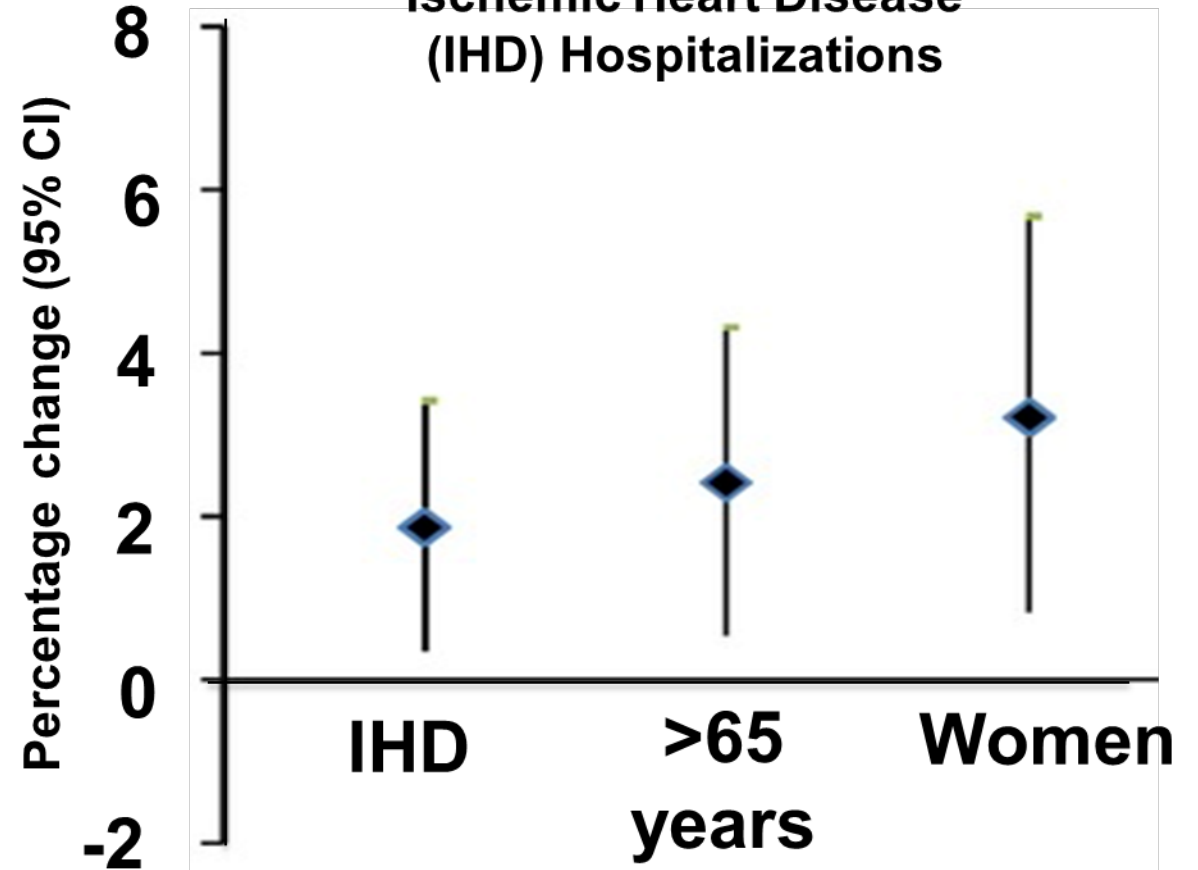
Cardiovascular effects

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

Out-of-Hospital Cardiac Arrest (OHCA)



Ischemic Heart Disease (IHD) Hospitalizations



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

Susceptible category	N	Percent (95% CI)
None	7135	73.0 (71.4, 74.6)
Respiratory only	642	6.4 (5.5, 7.2)
Cardiovascular only	319	2.6 (2.3, 2.9)
>65 years only	1713	10.9 (10.1, 11.8)
Respiratory and cardiovascular	136	1.0 (0.7, 1.3)
Respiratory and >65 years	220	1.6 (1.3, 1.8)
Cardiovascular and >65 years	608	3.8 (3.3, 4.3)
All three groups	125	0.7 (0.5, 0.9)



Wildfire Susceptible Populations NHANES 2007-2010

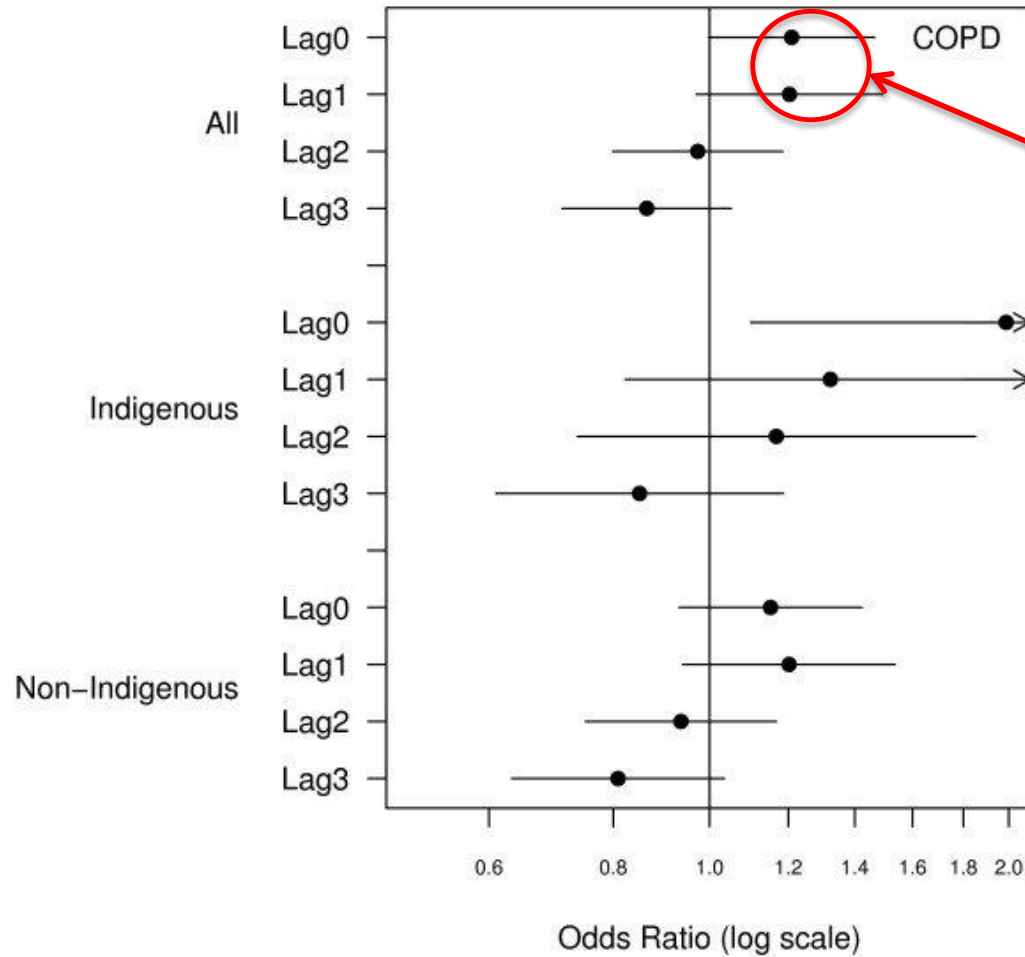
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>65 years only		11.8)
Respiratory and cardiovascular		2)
Respiratory and >65 years		1.8)
Cardiovascular and >65 years	608	(3.3, 4.3)
All three groups	125	0.7 (0.5, 0.9)

*27% fall into
at least one
susceptible
group*

Vulnerable Populations: Indigenous vs. Non-indigenous

COPD Hospital admissions Australia

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



General
population:
~20%
increase in
COPD

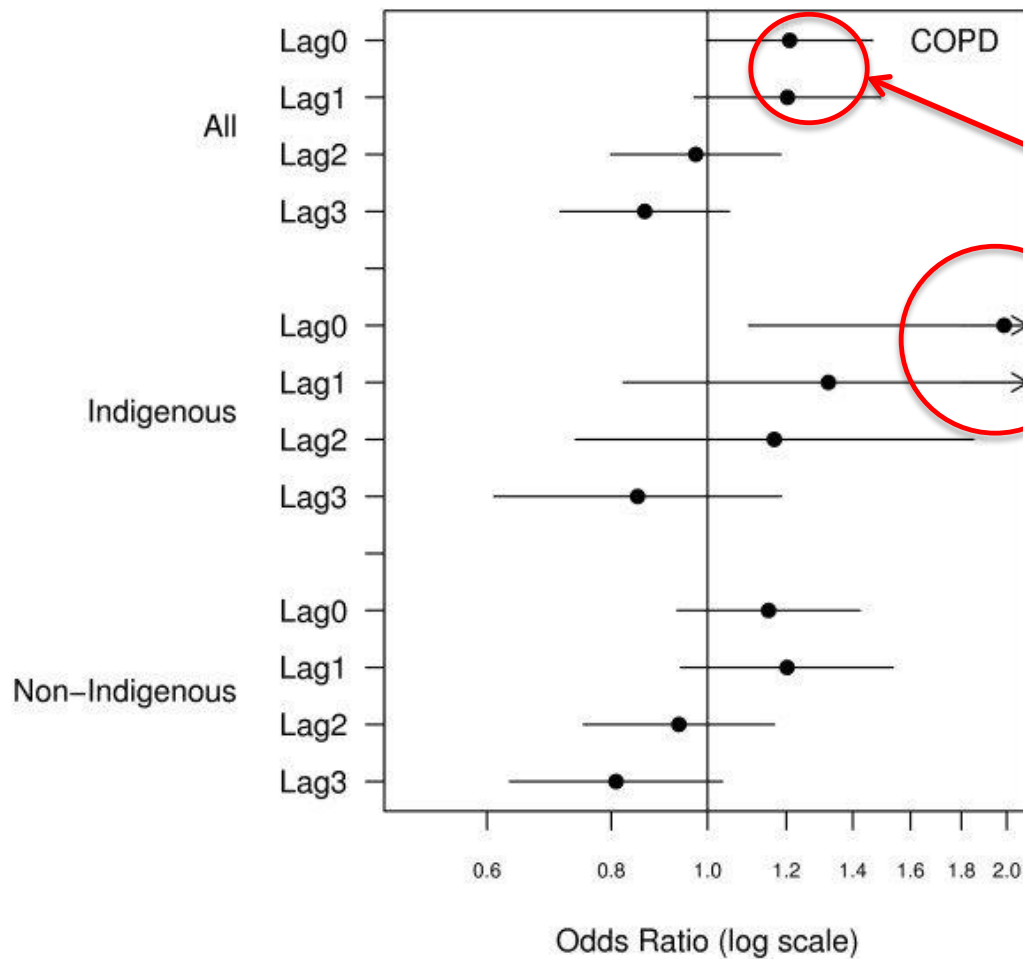
[Johnston FH](#), [Baillie RS](#), [Pilotto LS](#), [Hanigan IC](#).

Ambient biomass smoke and cardio-respiratory hospital admissions in Darwin, Australia. [BMC Public Health](#). 2007 Sep 13;7:240.

Vulnerable Populations: Indigenous vs. Non-indigenous

COPD Hospital admissions Australia

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



General population:
~20%
increase in
COPD

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

[Johnston FH](#), [Baillie RS](#), [Pilotto LS](#), [Hanigan IC](#).

Ambient biomass smoke and cardio-respiratory hospital admissions in Darwin, Australia. [BMC Public Health](#). 2007 Sep 13;7:240.

San Diego 2007 Wildfire Research Study:

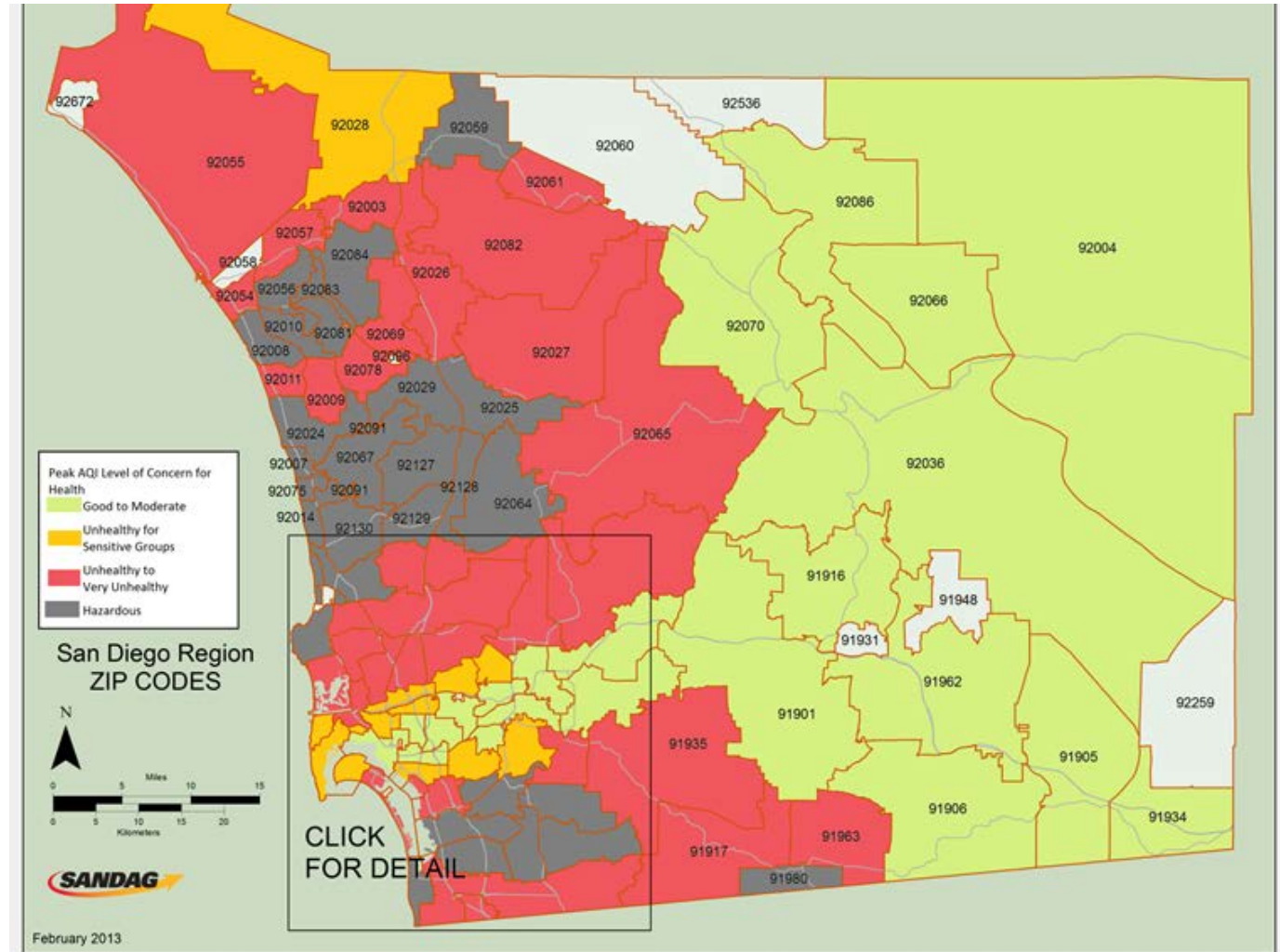
Collaboration with San Diego County, Michigan Tech Research Institute

California

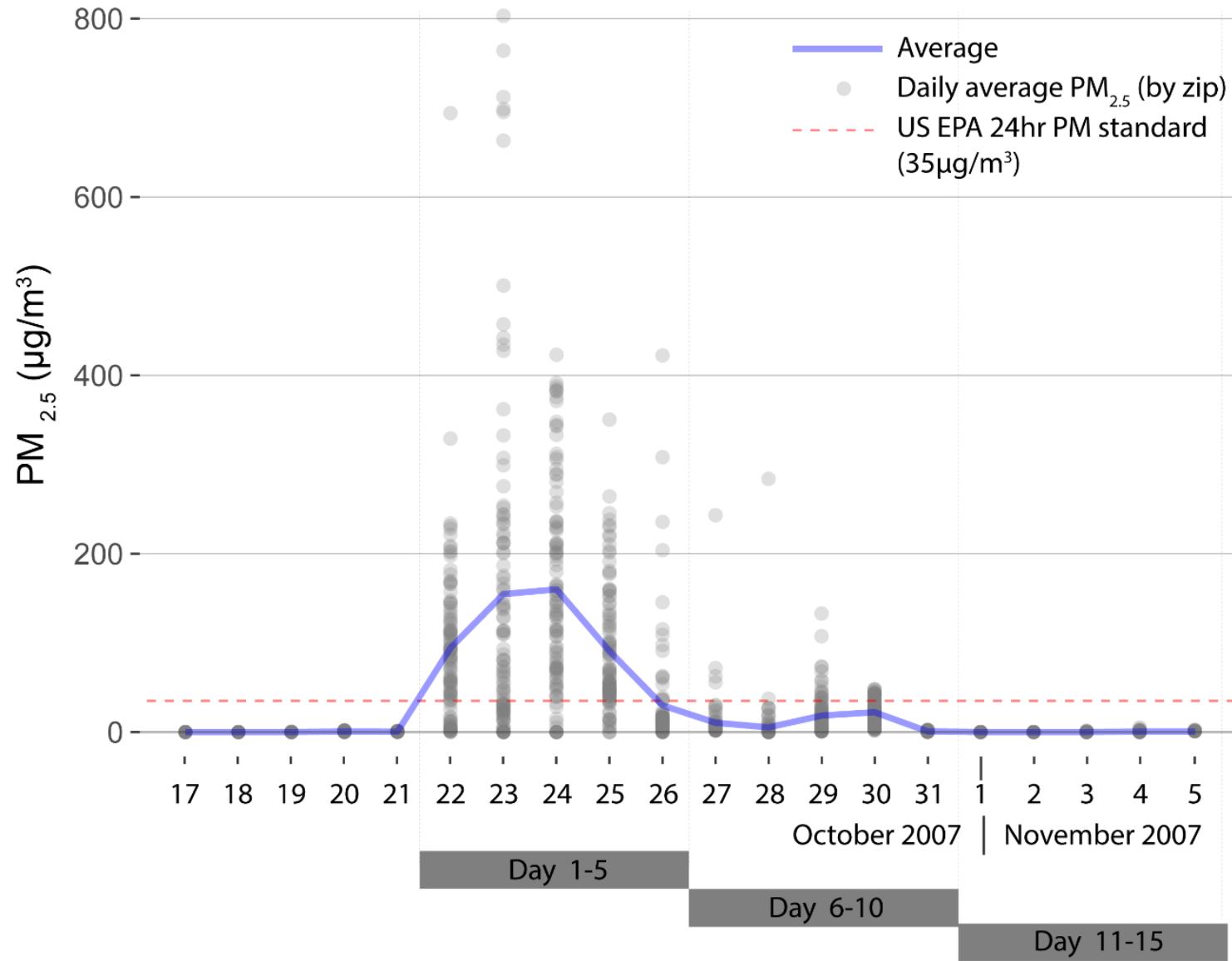
- 9,000 separate wildfires
- >1,000,000 acres burned

San Diego

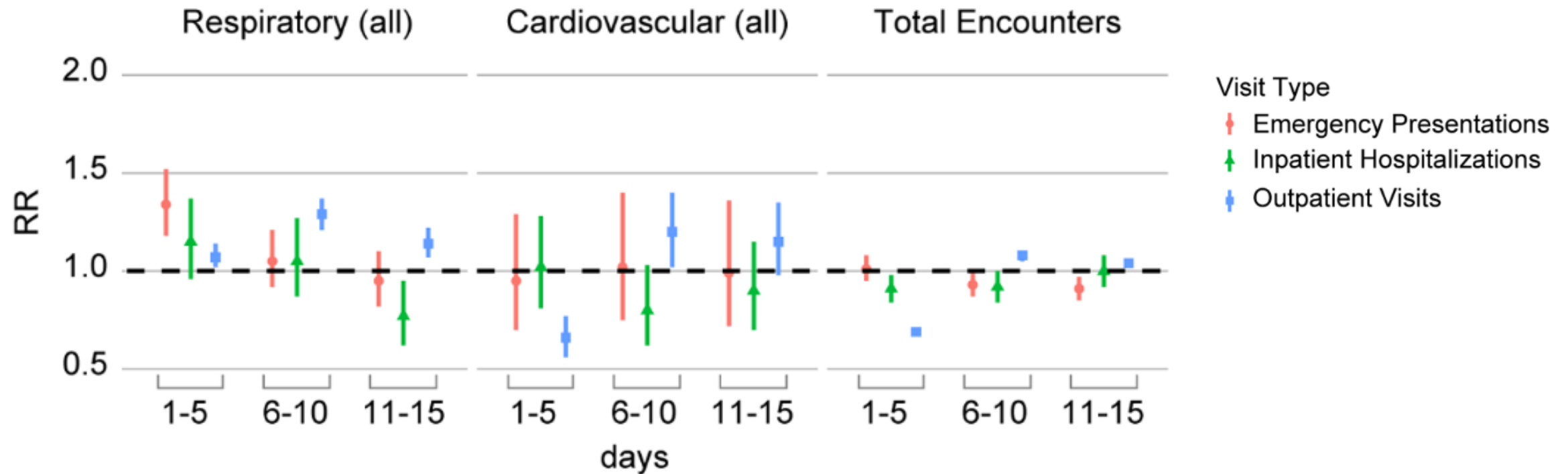
- Medi-Cal population
- San Diego firestorm
 - 500,000 evacuated
 - Multiple school & road closings



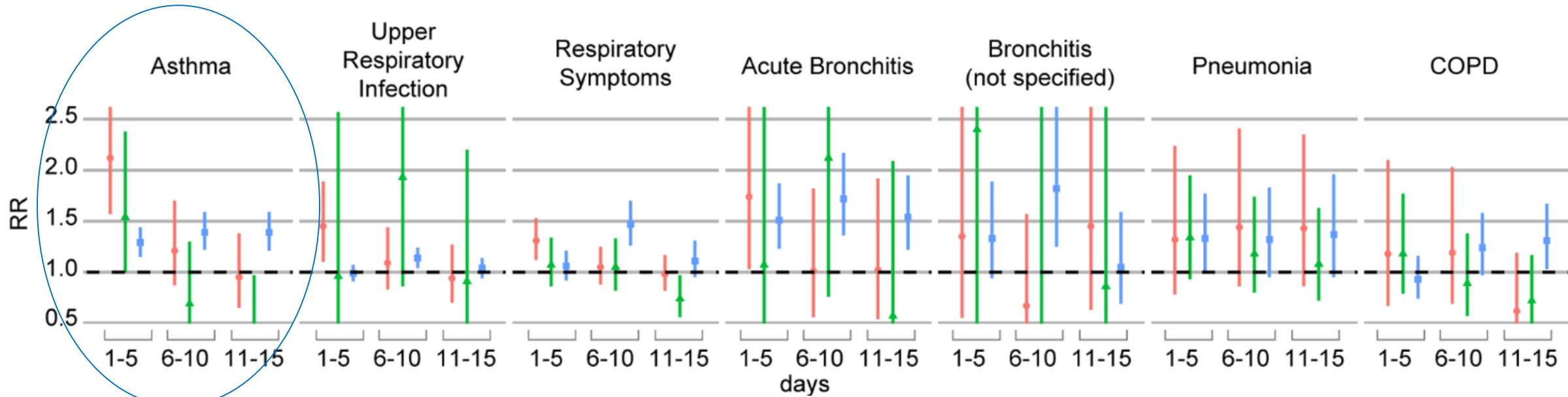
Daily PM_{2.5}



Respiratory and cardiovascular visits San Diego County during 2007 fire period



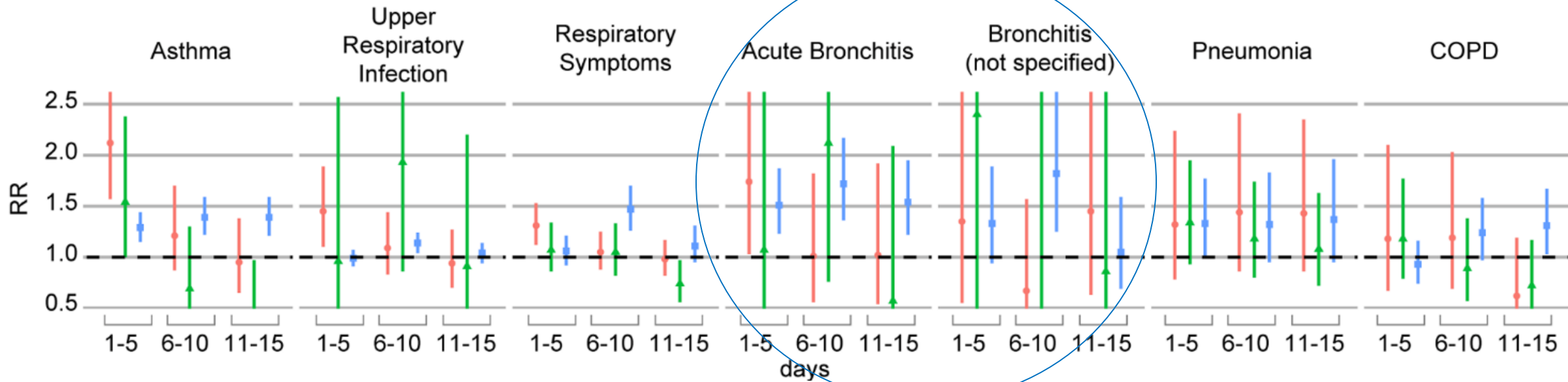
Respiratory visits



Visit Type

- Emergency Presentations
- Inpatient Hospitalizations
- Outpatient Visits

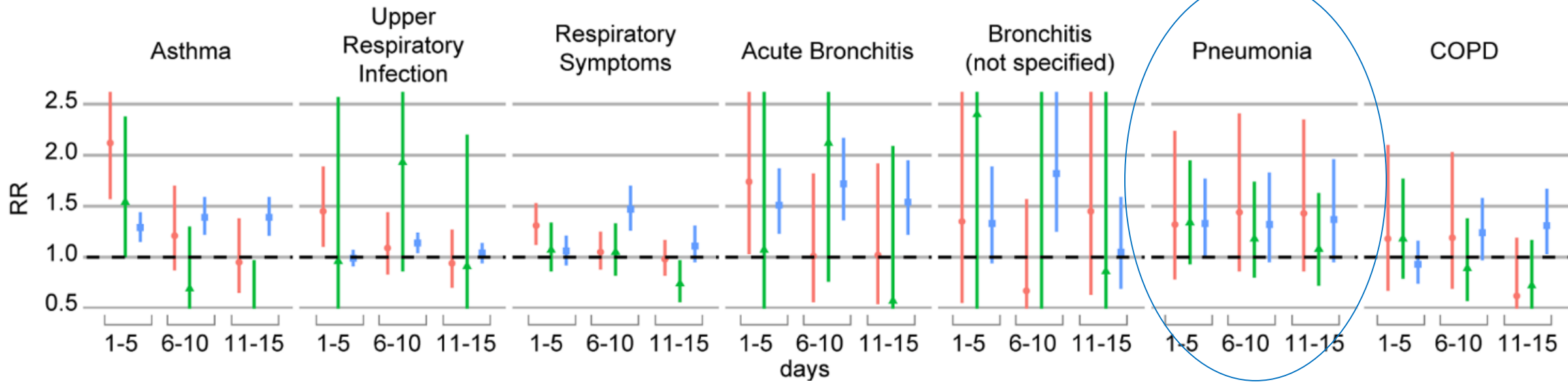
Respiratory visits



Visit Type

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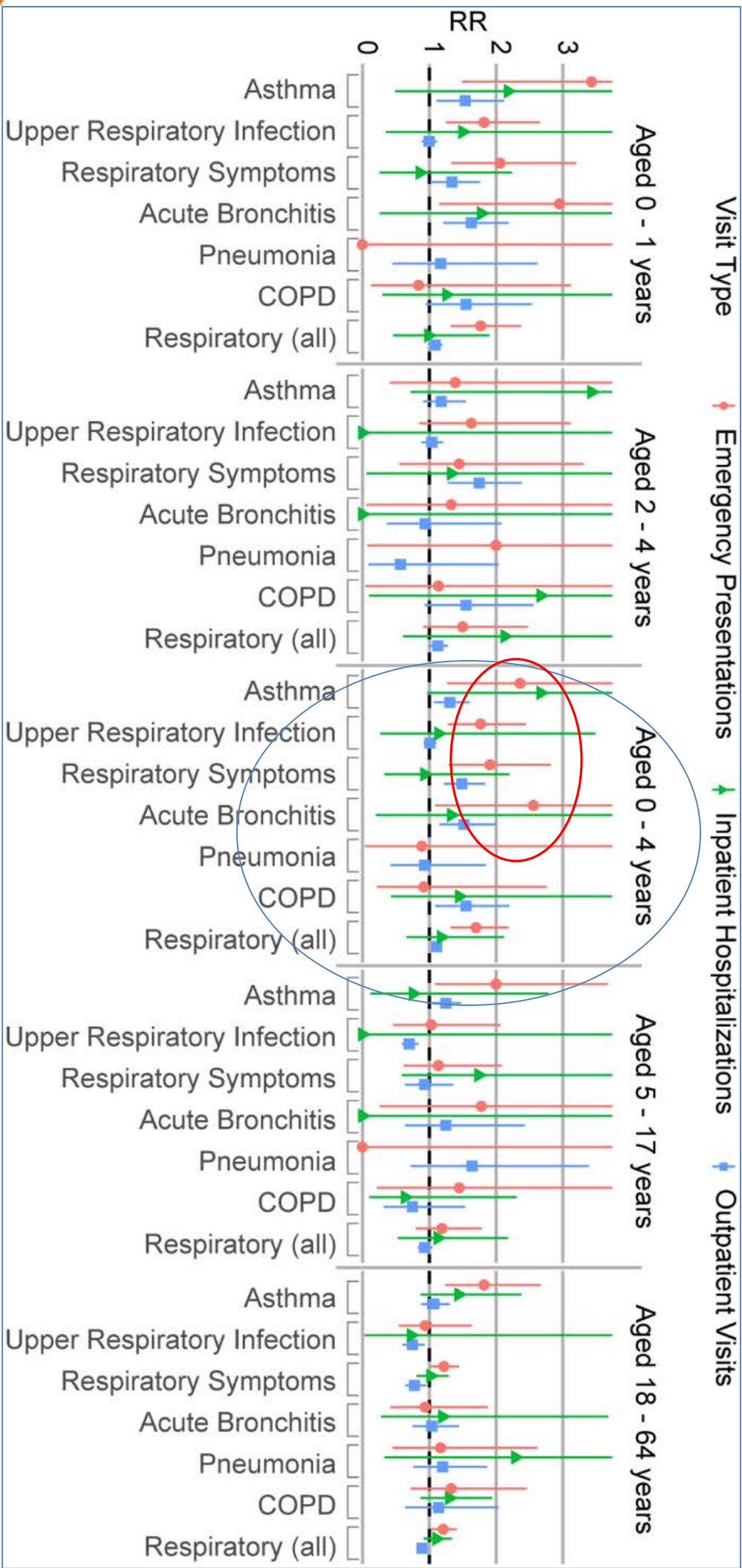
Respiratory visits



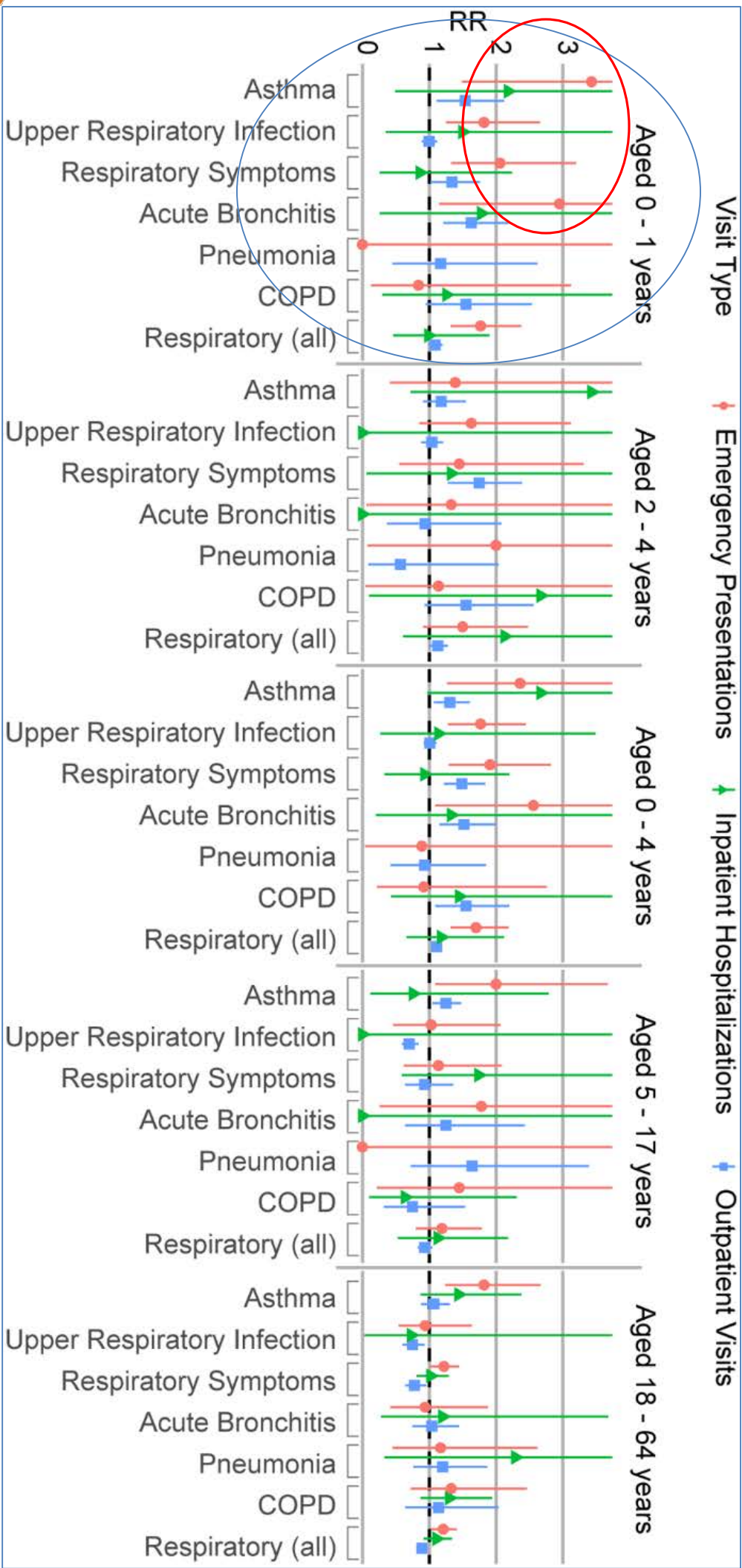
Visit Type

- ♦ Emergency Presentations
- ♦ Inpatient Hospitalizations
- ♦ Outpatient Visits

Respiratory visits, by age group



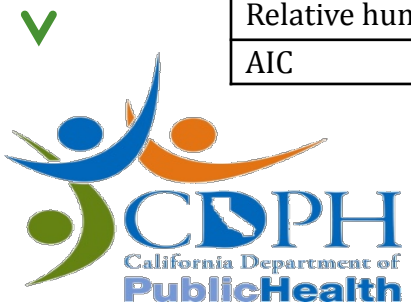
Respiratory visits, by age group



Air Quality Index (AQI)

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

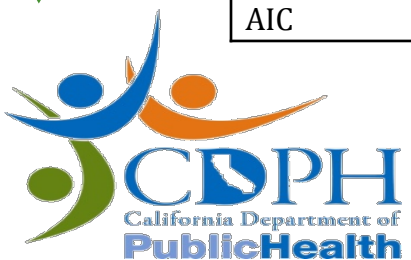
AQI categories PM _{2.5} (µg/ m ³)	OR (95% CI) Same day	OR (95% CI) 1-day lag	OR (95% CI) 2-day lag
Good (0 -12)			
Moderate (12.1 - 35.4)			
Unhealthy for Sensitive Groups (35.5 - 55.4)			
Unhealthy (55.5 - 150.4)			
Very unhealthy (150.5 - 250.4)			
Hazardous (≥ 250.5)			
Temperature			
Relative humidity			
AIC			



Air Quality Index (AQI)

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

AQI categories PM _{2.5} (µg/ m ³)	OR (95% CI) Same day	OR (95% CI) 1-day lag	OR (95% CI) 2-day lag
Good (0 -12)	Reference	Reference	Reference
Moderate (12.1 - 35.4)	1.20 (0.91-1.59)	1.11 (0.84-1.47)	0.80 (0.59-1.08)
Unhealthy for Sensitive Groups (35.5 - 55.4)	1.43 (0.96-2.13)	1.73 (1.18-2.53)*	1.51 (1.00-2.28)*
Unhealthy (55.5 - 150.4)	1.27 (0.97-1.67)	1.79 (1.30-2.23)*	1.50 (1.13-1.98)*
Very unhealthy (150.5 - 250.4)	1.68 (1.00-2.83)	1.58 (0.93-2.68)	1.87 (1.07-3.27)*
Hazardous (≥ 250.5)	2.41 (1.39-4.18)*	1.28 (0.70-2.36)	1.74 (1.00-3.03)*
Temperature	1.00 (0.99-1.01)	1.00 (0.99-1.01)	1.00 (0.99-1.00)
Relative humidity	1.01 (1.00-1.01)*	1.01 (1.00-1.01)*	1.01 (1.00-1.01)*
AIC	5233.2	5228.9	5231.8



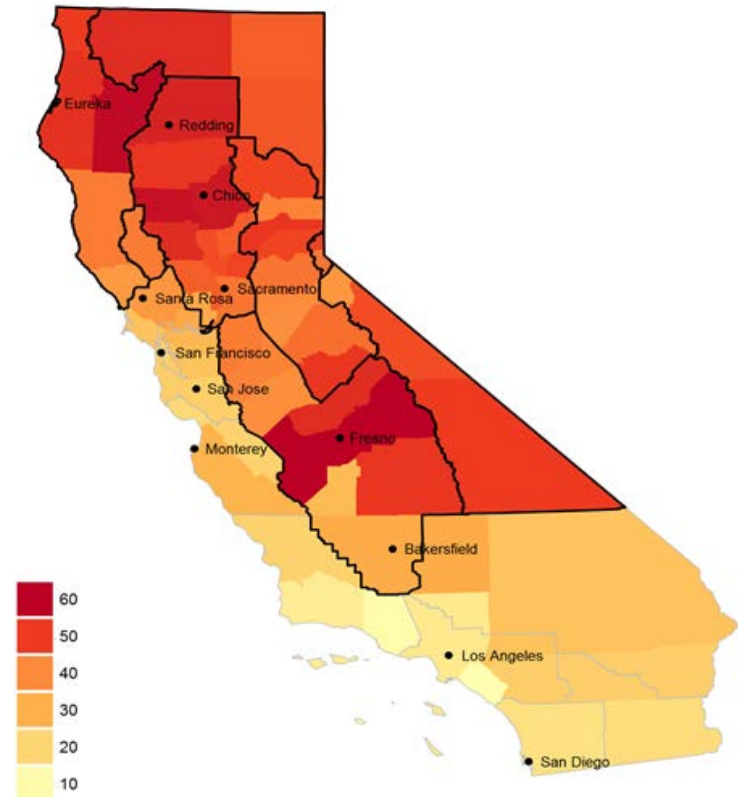
CARDIOVASCULAR EFFECTS & WILDFIRE SMOKE

2015 WILDFIRES

CDPH Collaborative Research

Number of Smoky Days per County:

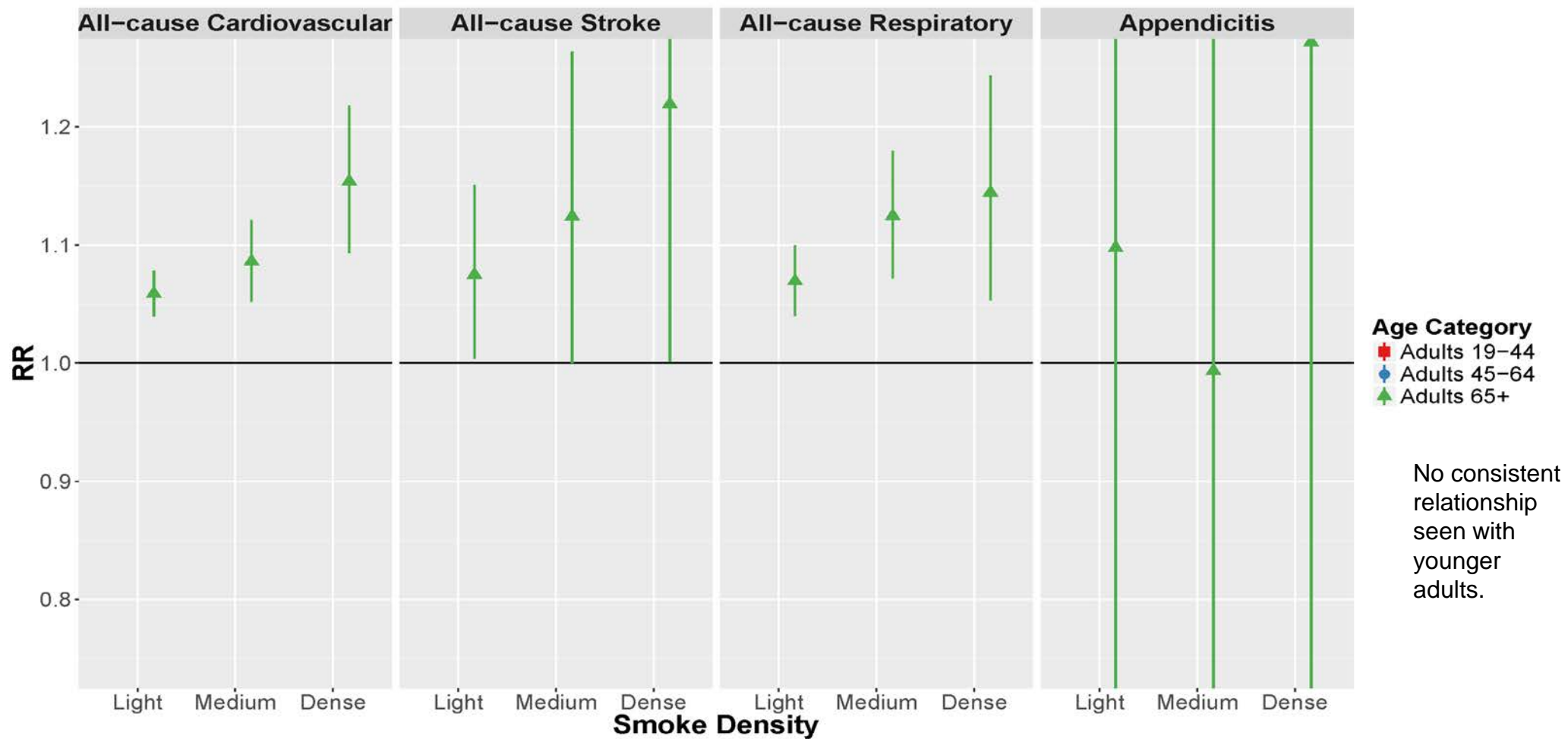
May 1 through September 30, 2015



[Wettstein ZS](#)¹, [Hoshiko S](#)², [Fahimi J](#)³, [Harrison RJ](#)^{4,5}, [Cascio WE](#)⁶, [Rappold AG](#)⁷. *J Am Heart Assoc. Cardiovascular and Cerebrovascular Emergency Department Visits Associated With Wildfire Smoke Exposure in California in 2015.* 2018 Apr 11;7(8).

Cardiovascular and other ER visits

↑ Risks from light, medium and dense smoke -- Adults 65+





Smoke Sense

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



USEPA – AirNow

<https://www.airnow.gov/>



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

Resources

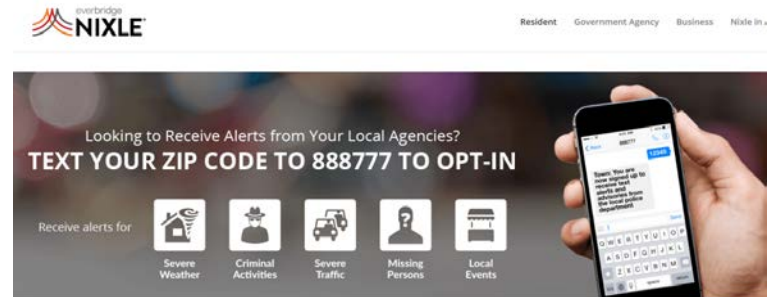


Smoke Sense

Download
 SmokeSense
 EPA Citizen
 Science Project
 Mobile App

Supported in part by
 the American Lung
 Association

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



Resources

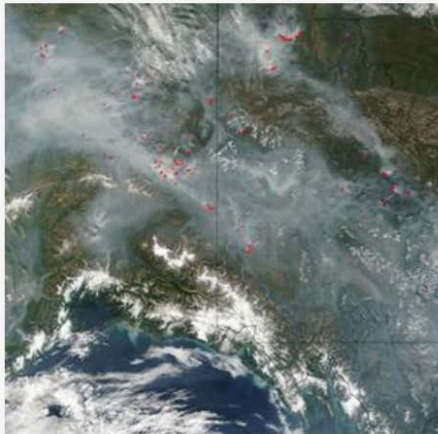
USEPA – AirNow Fires and Your Health

USEPA – CME Education

CONTACT US



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,

Public

- Wildfire: What You Need to Know for Public Officials, Firefighters, and the Community
- How Smoke Can Affect Your Health
- Particle Pollution and Your Health
- Other Air Quality Publications

Exit AirNow

- Before, During, and After a Wildfire: Information for the Public

they can cause health problems such as burning eyes, runny nose,

<https://airnow.gov/index.php/air-quality-and-health/fires-and-your-health>

Particle Pollution and Your Patients' Health

Evidence-based Training for Healthcare Professionals

describes the biological mechanisms responsible for the cardiovascular and respiratory health effects associated with particle pollution exposure.

provides educational tools to help patients understand how particle pollution exposure can affect their health and how they can use the Air Quality Index to protect their health.



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

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

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University of California San Francisco
California Department of Public Health



Robert Harrison, MD, MPH (left in photo)
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