Beth Israel Lahey Health

Pulmonary Health Effects and Clinical Implications of Wildfire Smoke

Webinar for the Society of Toxicology
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Disclosures

- No relevant financial relationships with a commercial interest

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Objectives of this Talk

- Describe the reasons for recent increases in wildland fire activity in the U.S.
- Identify respiratory effects of wildfire exposure
- Discuss clinical interventions for high risk patients

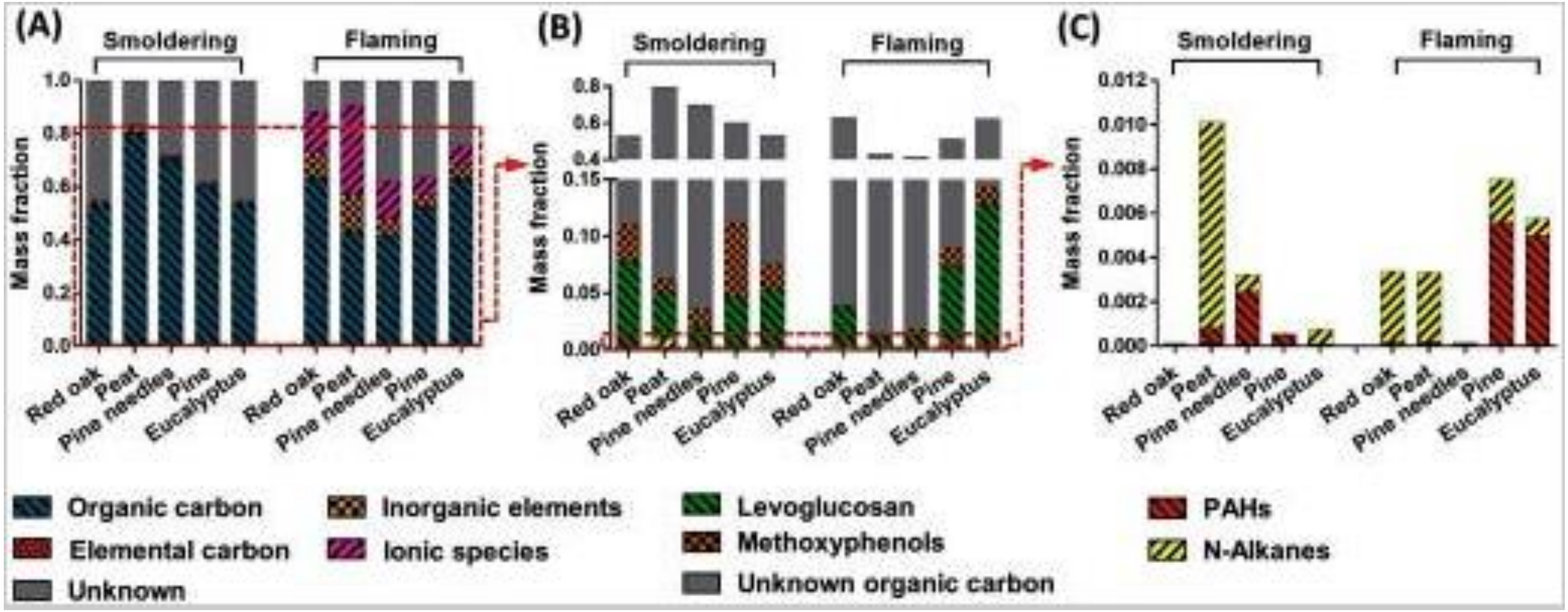
2 Types of Wildland Fire

Wildfire

Prescribed Fire

Photos from Kathleen Navarro

More Heavy Metals and PAHs in Flaming Smoke



Kim et al. *Environ Health Perspect.* 2019.

Key Drivers of Wildland Fire Activity

More Acres Burned

- Drier conditions (climate change explains ~55% increase in aridity 1979-2015 in Western U.S.[1])
- Many more prescribed fires (300% ↑in acres/yr in past 10 years)[2]

More Loss of Life & Property

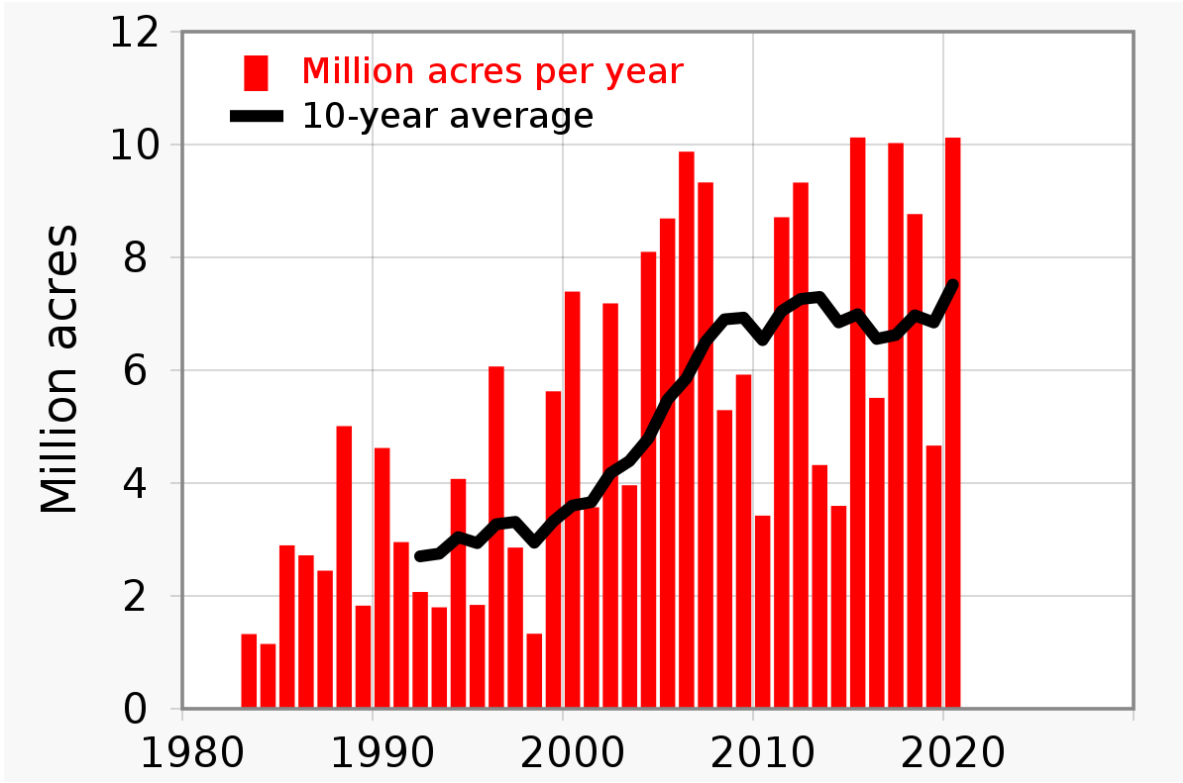
- Years of fire suppression (biomass accumulation)
- Wildland-urban interface

1. Abatzoglou and Williams. *Proc Natl Acad Sci USA*. 2016
2. Data from John Hall, Director, Joint Fire Science Program

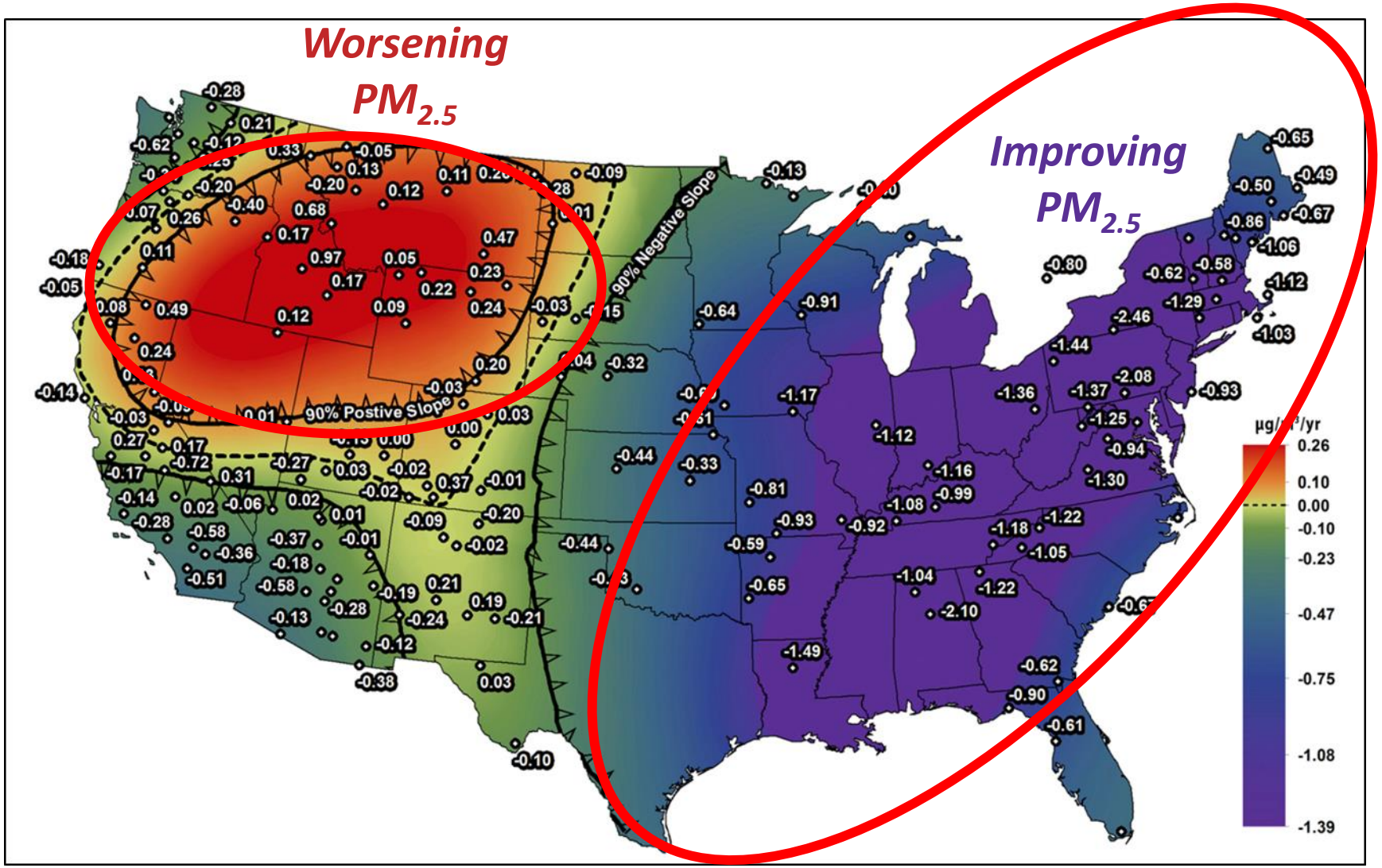
Hot, dry conditions increase risk of large destructive wildfires

Australian Bush Fires 2020

Camp Fire, California 2018



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



McClure and Jaffe. *Proc Natl Acad Sci.* 2018

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

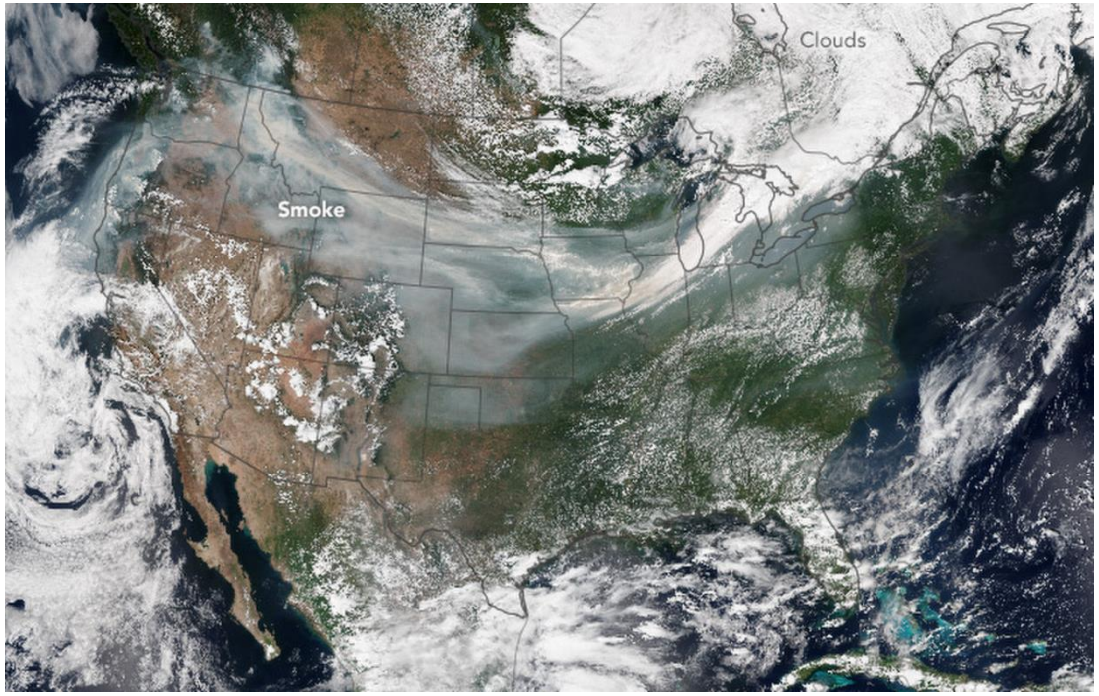


Image Source: October 12 2017 NASA Satellite images
EPA Federal Emissions Inventory 2014

Smoke from wildfires in #NovaScotia has travelled into New England. Air quality will go from good to moderate across Central & Southern Mass, with hazy skies anticipated this evening.

12:36 PM · May 30, 2023

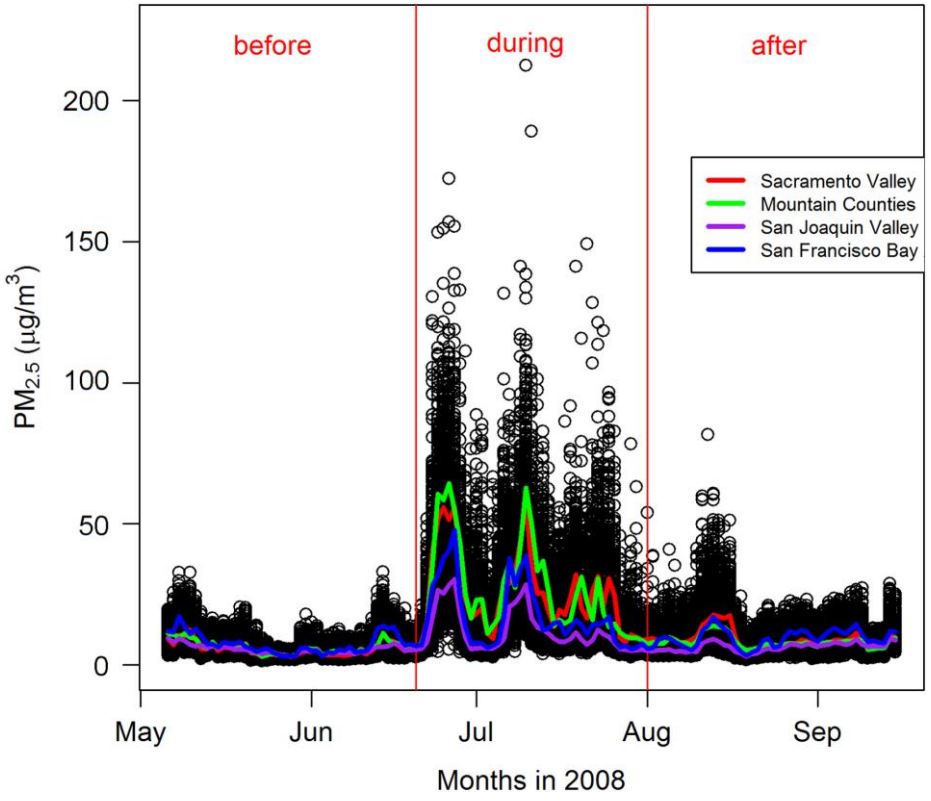
May 30, 2023

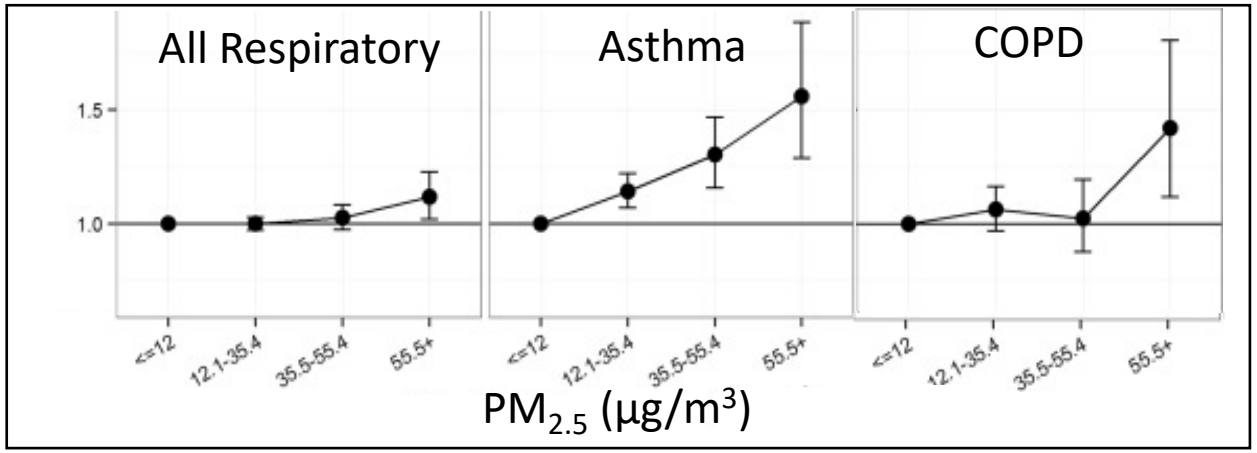
Wildfires are “Natural” Experiments

- **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

Wildfires increase respiratory admissions

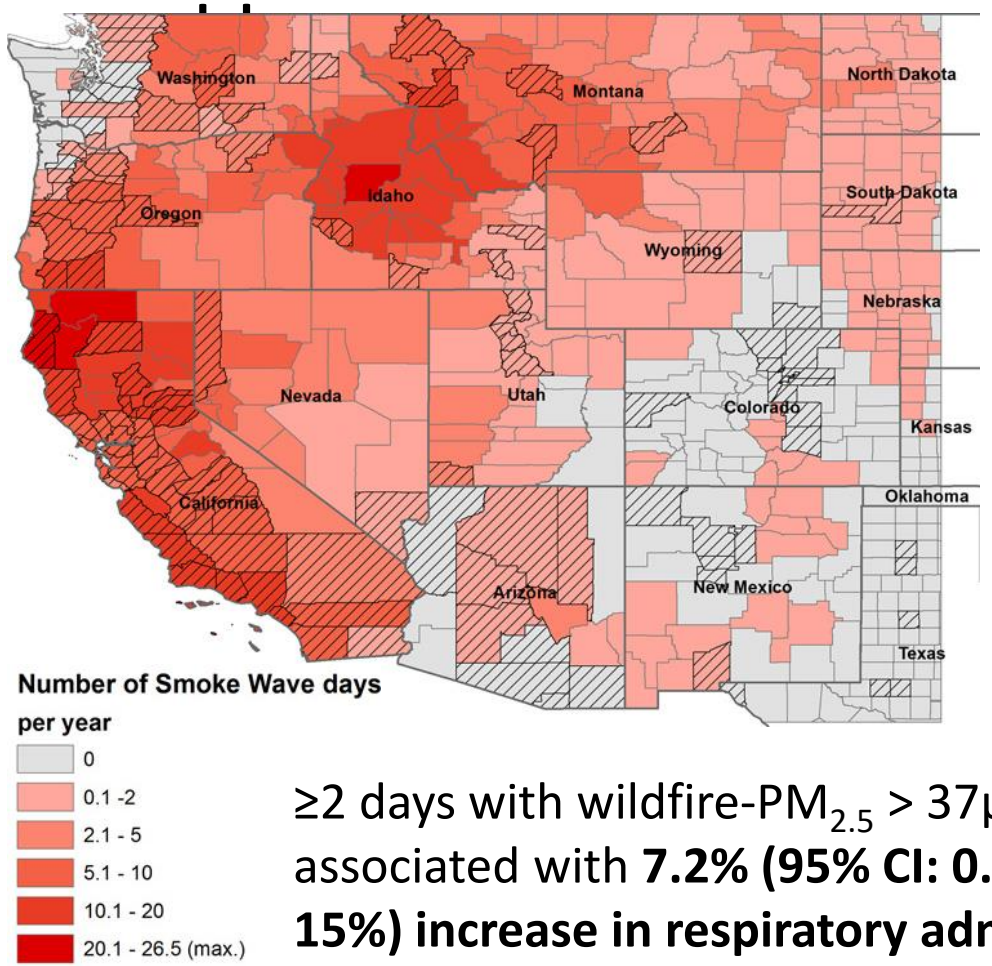




Reid, Balmes et al. *Environ Res.* 2016.

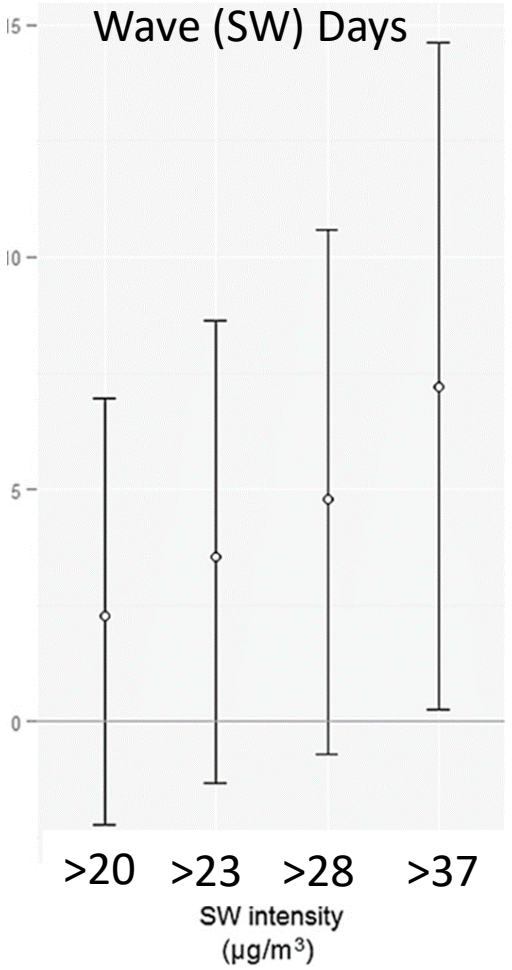
Wildfire-Specific $PM_{2.5}$ and Respiratory Hospitalization of Medicare Patients

wildfire-specific $PM_{2.5}$ was estimated using a global chemical transport



≥2 days with wildfire-$PM_{2.5}$ > 37µg/m^3 associated with **7.2% (95% CI: 0.25%, 15%) increase in respiratory admissions**

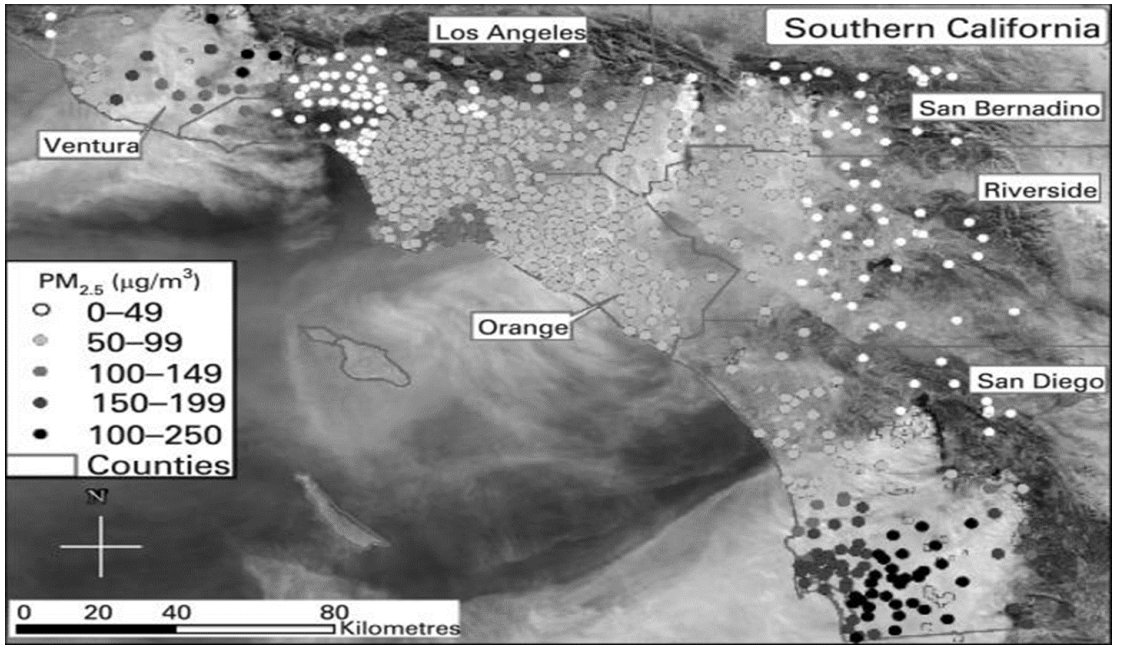
% Increase in Respiratory Admissions on Smoke Wave (SW) Days



Liu et al. *Epidemiology*. 2017

Many Studies Find Increases in Asthma Admissions & Treatment During Wildfires

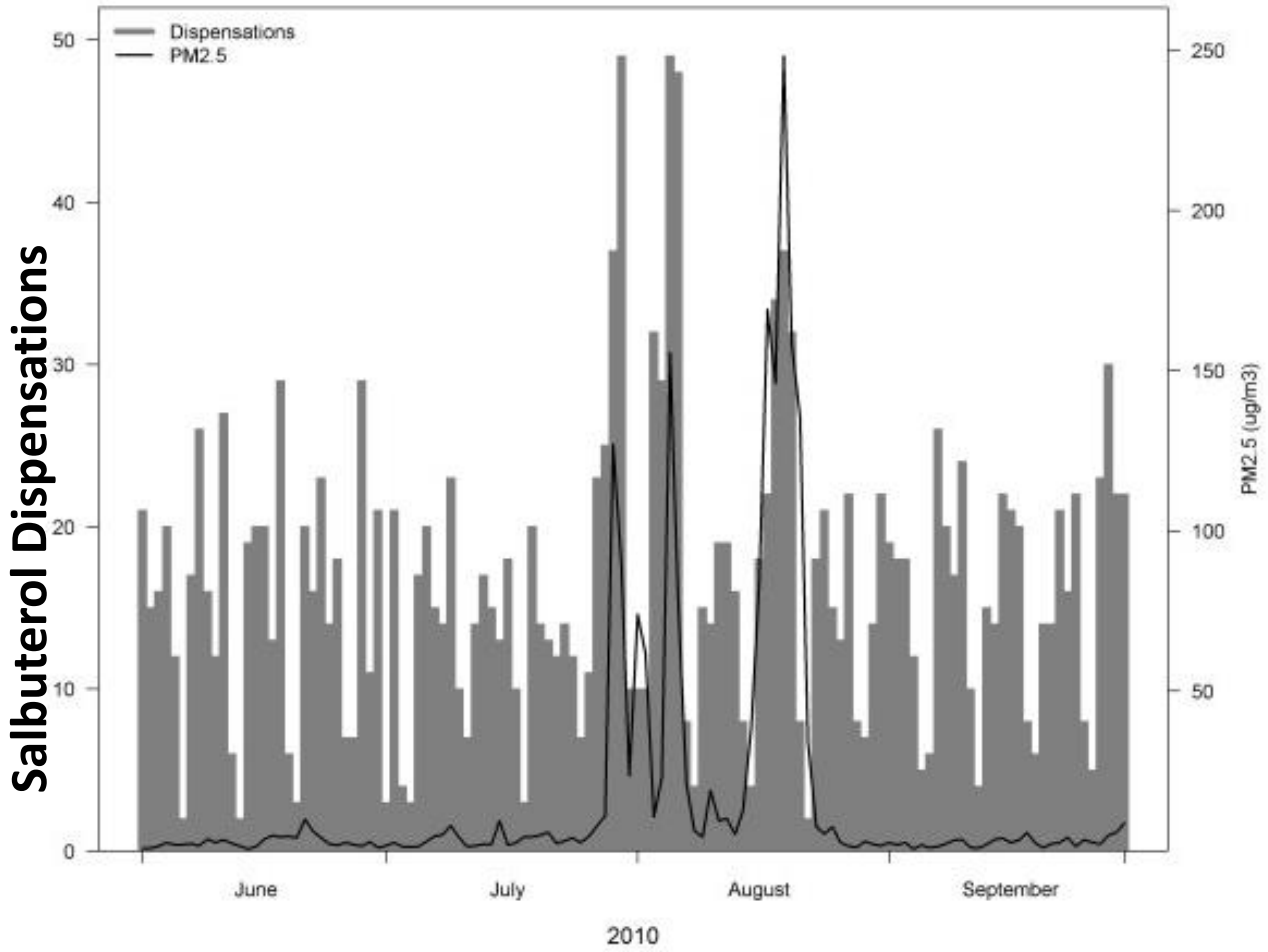
- 34% increase in asthma admissions during heavy smoke
- COPD, acute bronchitis, pneumonia also higher



- Wildfire PM may be <u>more toxic for asthmatics</u> than PM from other sources: 6.7% vs 1.3% increase in Medicare asthma hospitalization per 10 µg/m^3 of wildfire vs non-wildfire PM^2

1. Delfino et al. *Occup Environ Med*. 2009
2. DeFlorio-Barker et al. *EHP*. 2019.

Wildfire-PM and Rescue Inhaler Dispensation



6% higher RR (95% CI: 4 – 7%) of inhaler dispensation per 10 µg/m^3 higher wildfire PM

Elliott et al. *Environ Health*. 2013

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, wheeze)
  - Medication use for above symptoms
  - Greater symptom increases among asthmatics
  - 63% increase in asthma attacks

- Among <u>non-asthmatic</u> children, airway size (MMEF:FVC) associated with greater susceptibility to respiratory symptoms[2]

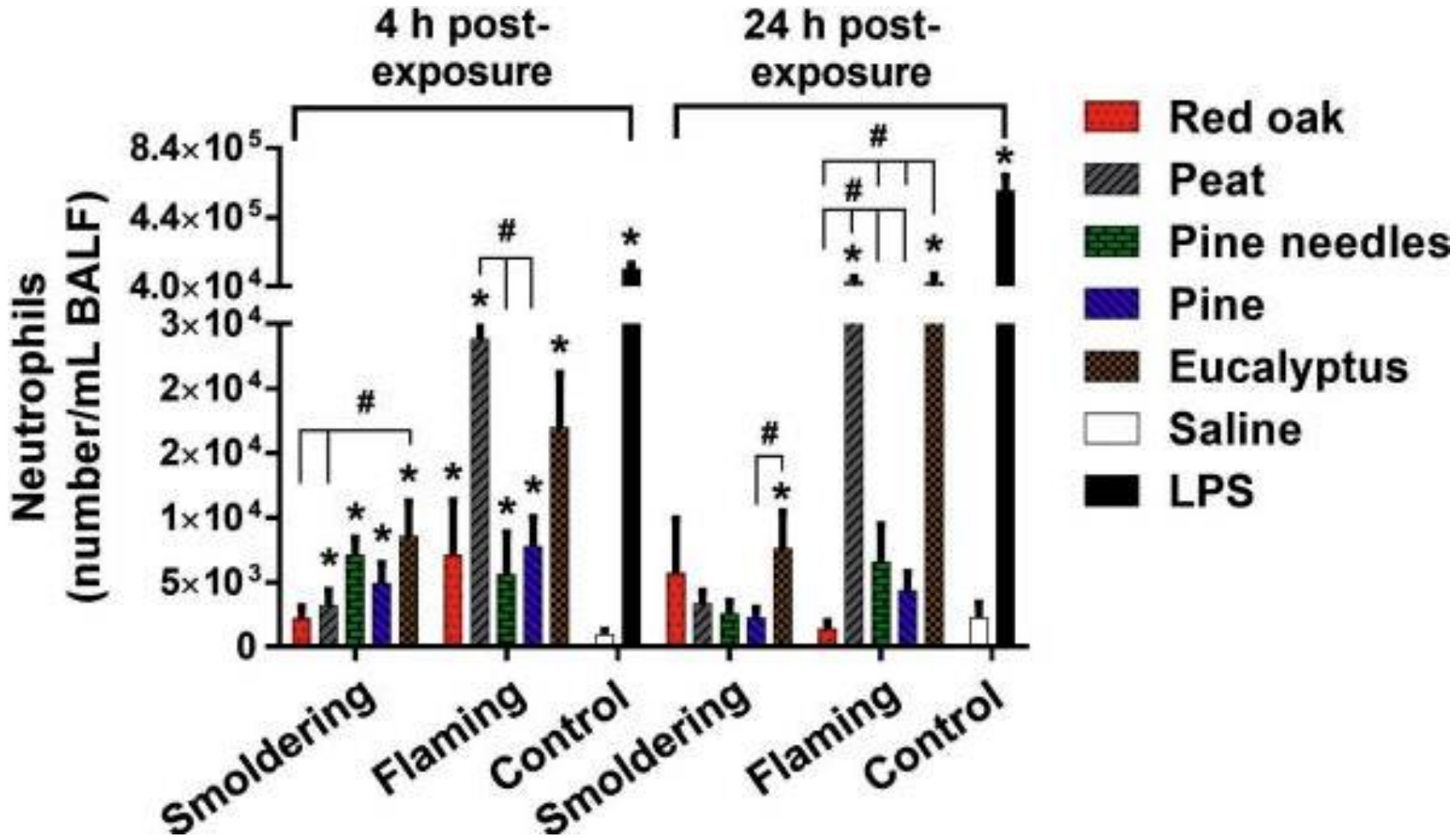
1. Kunzli et al. *AJRCCM*. 2006.
2. Mirabelli et al. *Epidemiology*. 2009.

Wildland Firefighters are the Most Exposed

- Volunteer and professional (e.g. USFS firefighters)
- No approved respirator!
- Few studies of health effects due to research challenges

Photo by Kathleen Navarro.

Flaming > Smoldering Smoke Causes Acute Neutrophilic Inflammation in the Lung



Kim et al. *Environ Health Perspect.* 2019.

AMERICAN THORACIC SOCIETY DOCUMENTS

Respiratory Impacts of Wildland Fire Smoke: Future Challenges and Policy Opportunities

An Official American Thoracic Society Workshop Report

Mary B. Rice, Sarah B. Henderson, Allison A. Lambert, Kevin R. Cromar, John A. Hall, Wayne E. Cascio, Paul G. Smith, Brenda J. Marsh, Sarah Coefield, John R. Balmes, Ali Kamal, M. Ian Gilmour, Chris Carlsten, Kathleen M. Navarro, Gwen W. Collman, Ana Rappold, Mark D. Miller, Susan L. Stone, and Daniel L. Costa; on behalf of the American Thoracic Society Environmental Health Policy Committee and the American Thoracic Society Assembly on Environmental, Occupational, and Population Health

Major research needs:

- What is the toxicity of smoke from different fuel sources and burn types?
- Is PM2.5 the best index to use to measure health effects of wildland fires?
- What are respiratory health consequences of repeated, long-term wildfire smoke exposure?

Rice et al. AnnalsATS. 2021.

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Systems for Providing Protection from Inhalation Hazards Should Extend to the Public and Broader Groups of Workers, Says New Report

News Release | February 10, 2022

Frameworks for

PROTECTING WORKERS AND THE PUBLIC

from Inhalation Hazards

Jonathan Samet, Autumn Downey, and Olivia C. Yost, *Editors*

Committee on Respiratory Protection for the Public and Workers Without Respiratory Protection Programs at Their Workplaces

Board on Health Sciences Policy

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A Consensus Study Report of

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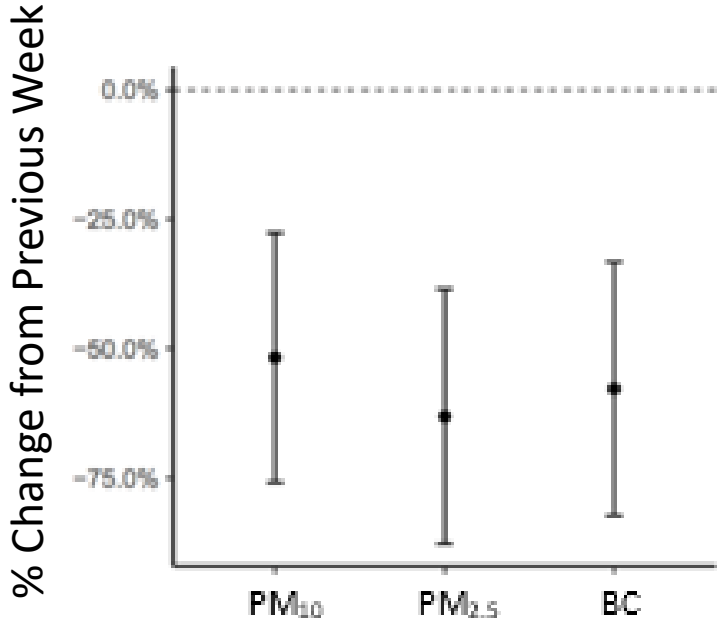
Personal Air Quality Interventions

Tier in Hierarchy of Controls	Exposure Control Action	Estimated Exposure Reduction	Considerations
1. Elimination	Relocation	100%	Stress of relocation may be harmful, especially for vulnerable populations Exposure to air pollution and other unsafe conditions while in transit May not have feasible places to go
2. Engineering	Reduce indoor infiltration by closing doors and windows Filter air with portable air filters, central air filters, or air conditioners in recirculation mode	20–80%	Effectiveness varies greatly with ventilation and filtration rates. Portable HEPA filters generally more effective, if properly sized and used Central forced-air filtration is generally less effective due to lower-efficiency filters and shorter run times. Upfront costs, but may provide year-round benefit by reducing indoor PM from other sources
3. Administrative	Stay indoors Avoid heavy or prolonged physical activity	~50% on average, but varies widely Lowers inhaled dose of pollutants	Without added filtration, the building envelope limits infiltration to a widely variable extent depending on tightness Especially important for outdoor activity Pulmonary ventilation rates may increase 10- to 20-fold during heavy exertion If temporary, little risk of harmful reduction in beneficial physical activity
4. Personal protective equipment	Wear a NIOSH-approved N95 or P100 filtering facepiece respirator	90% or greater, depending on quality of fit. Near 0% if poorly fitted	Should be used only when outdoor activity cannot be avoided Performance depends on fit Fit testing and medical clearance are not generally available Physiological stress due to increased work of breathing, heat, discomfort Populations vulnerable to wildfire PM may also be more vulnerable to adverse effects of wearing a respirator

Laumbach RJ. *Ann Am Thorac Soc*. 2019

Household HEPA Air Cleaners

- Reduce indoor $PM_{2.5}$ by 20-80%[1] (but modest if any effect on gaseous pollutants)
- Appear to reduce asthma morbidity[2]
- Appear to reduce adult respiratory symptoms during wildfire events[3]



1. U.S. EPA. Residential Air Cleaners: A Technical Summary. 2018.
2. Van Boven et al. Air Purification for Allergic Asthma: a Meta-Analysis. *Int Arch Allergy Immunol.* 2020
3. Mott et al. J West Med. 2002

Respirators (e.g. N95)

- Reduce exposure to PM but not gas pollutants, which also have health effects
- May mitigate short-term physiological effects of PM (evidence limited to healthy adults)
- None approved for children (NIOSH certifies N95s)
- Safety of prolonged use not evaluated in adults with severe heart or lung disease

Source: FEMA

Shi et al. *Environ Health Perspect.* 2017

Conclusions

- 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, respiratory infection and respiratory admissions
- Air purification and respirator use reduces PM exposure / inhalation
- There is a need for clinical effectiveness research to warn and protect high risk patients

Thank you

- Meghan Rebuli
- David Rosse

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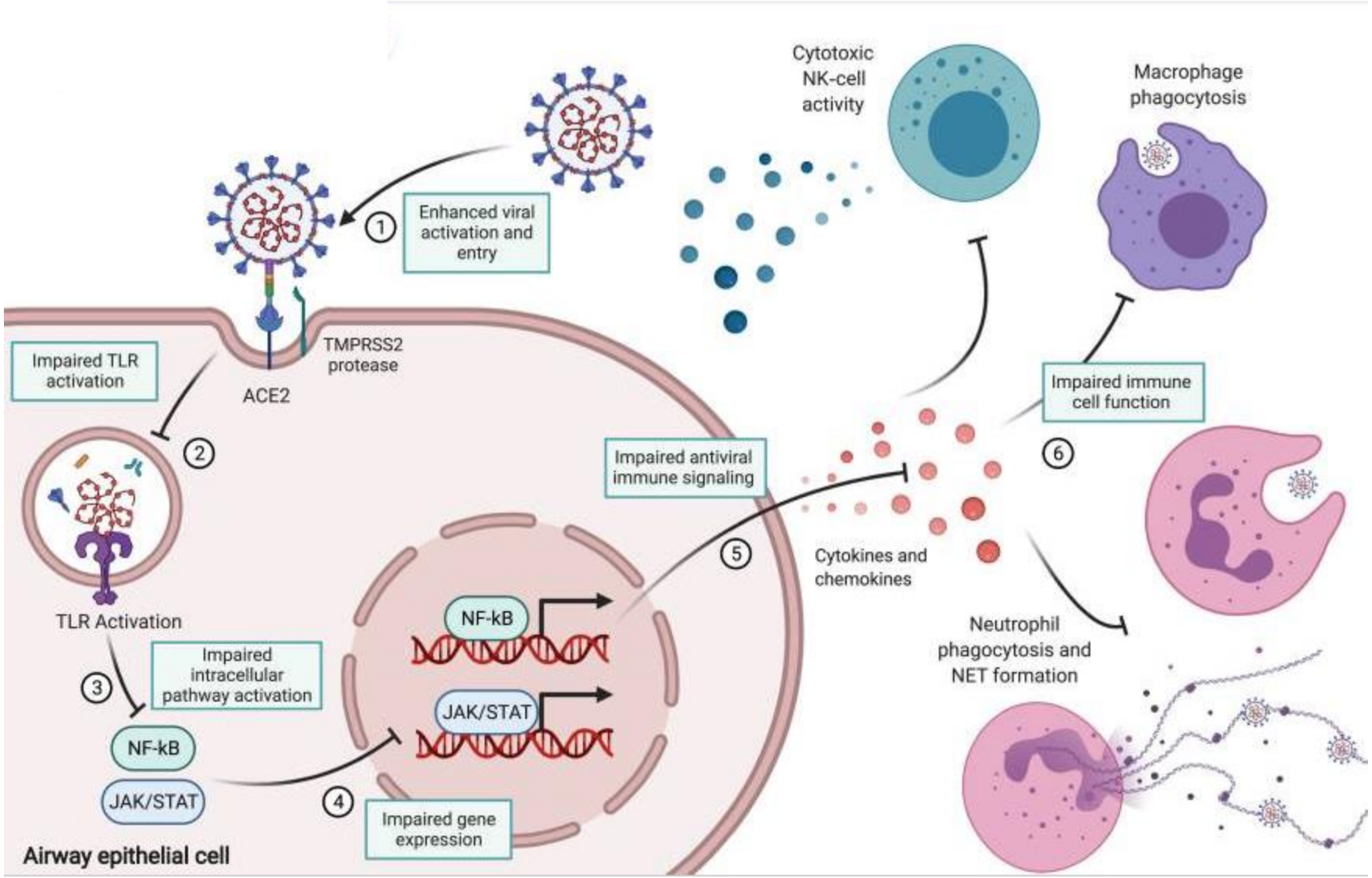
***Support*, by Lorenzo Quinn. Venice, Italy.**

How Smoke May Interact with Viral Life Cycle



Rebuli et al. JACI. 2021.