

# The Association of Acute Smoke Exposure with Elevated ED Visits for Anxiety Disorders in the Western US



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# Introduction

- Climate change and increasing wildland-urban interface leads to longer fire seasons, larger fires, and more population exposure
- Wildfire smoke  $\text{PM}_{2.5}$ 's composition is different from ambient particles, which may result in different health impacts
- Estimating wildfire smoke  $\text{PM}_{2.5}$  contribution with high spatial and temporal resolution is challenging

## Overall Study Objectives

- Build a daily wildfire smoke  $\text{PM}_{2.5}$  model in Contiguous US at 1 km resolution.
- Investigate the associations between acute and chronic smoke  $\text{PM}_{2.5}$  exposure and various adverse health outcomes

# Smoke PM<sub>2.5</sub> Modeling Strategy (Danlu Zhang et al.)

## Smoke impact grid cells

$$\text{Total PM}_{2.5} = \text{background PM}_{2.5} + \text{smoke PM}_{2.5}$$

## No smoke grid cells

$$\text{Total PM}_{2.5} = \text{background PM}_{2.5}$$

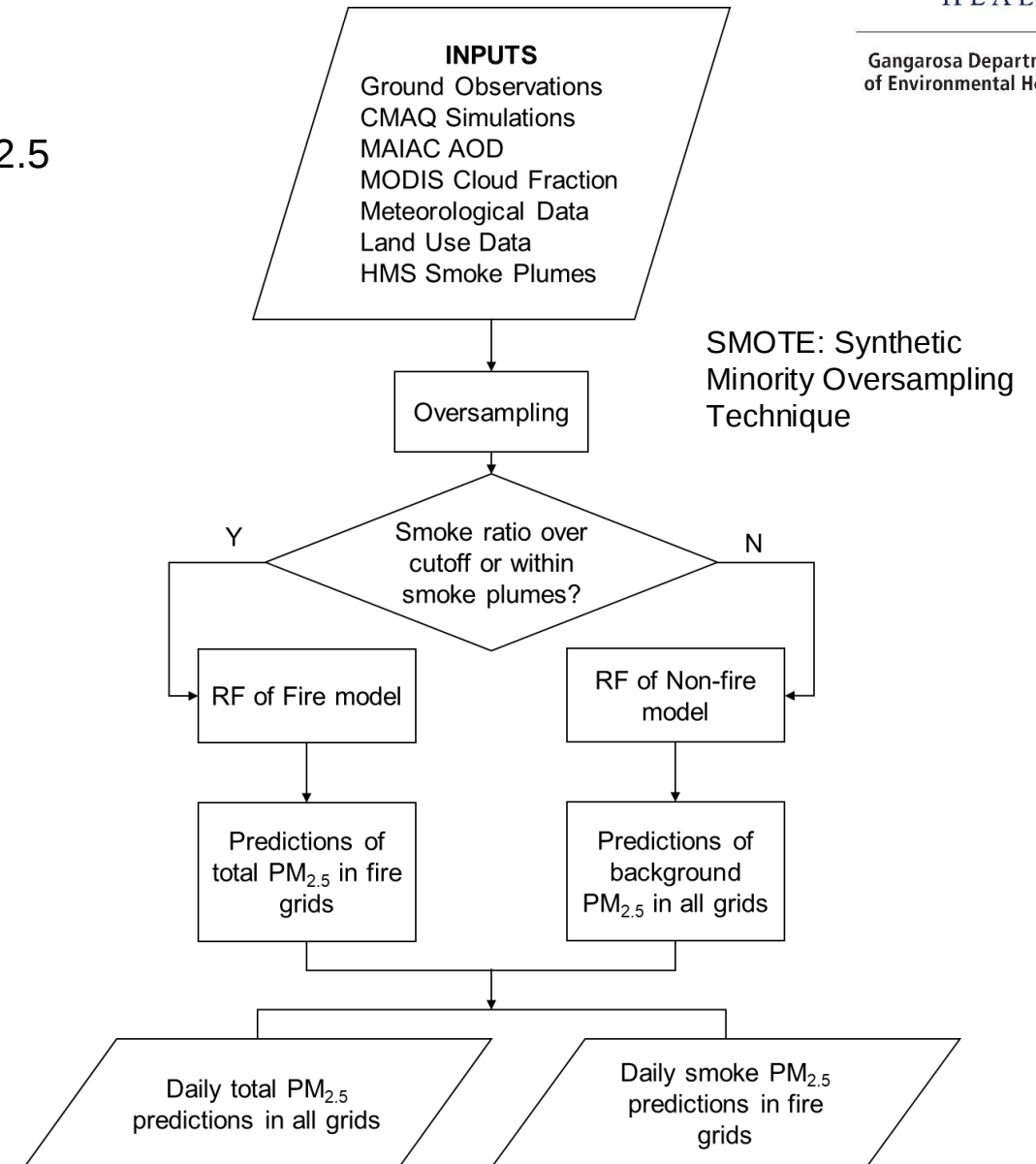
## Fire Model

$$\text{PM}_{2.5} \sim \text{AOD} + \text{Meteorological Data} + \text{Land Cover Data} + \text{Road Length} + \text{Population} + \text{HMS Data} + \text{Cloud Fraction} + \text{Elevation} + \text{CMAQ Total PM}_{2.5}$$

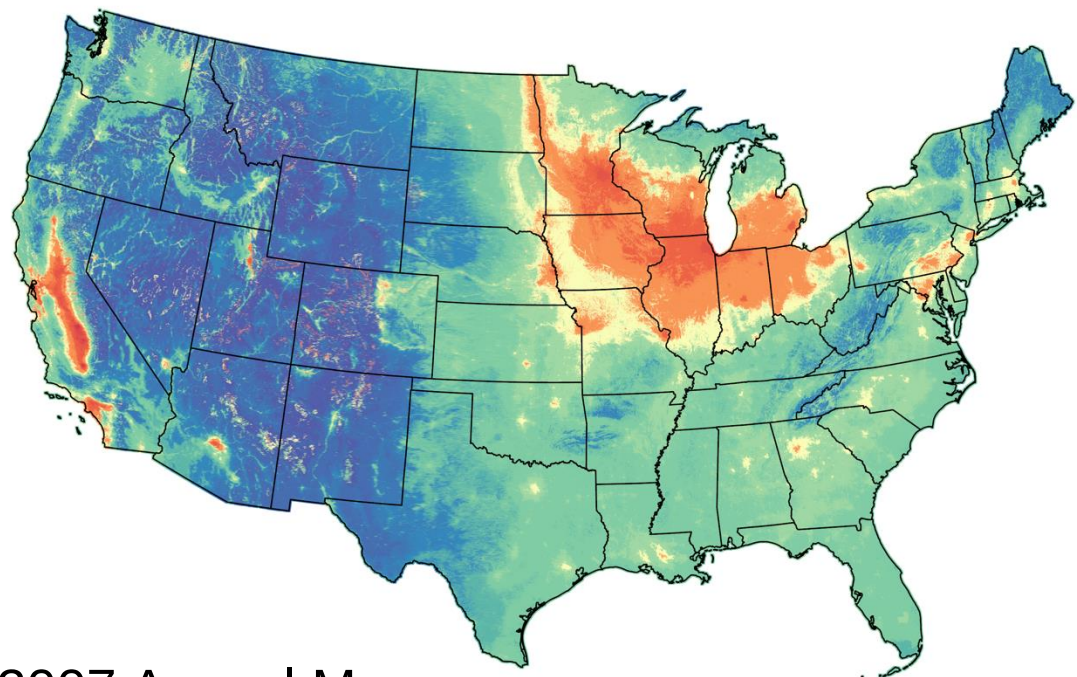
## Non-fire Model

$$\text{PM}_{2.5} \sim \text{AOD} + \text{Meteorological Data} + \text{Land Cover Data} + \text{Road Length} + \text{Population} + \text{Cloud Fraction} + \text{Elevation} + \text{CMAQ Background PM}_{2.5}$$

Random, Spatial and Temporal 20-fold CV



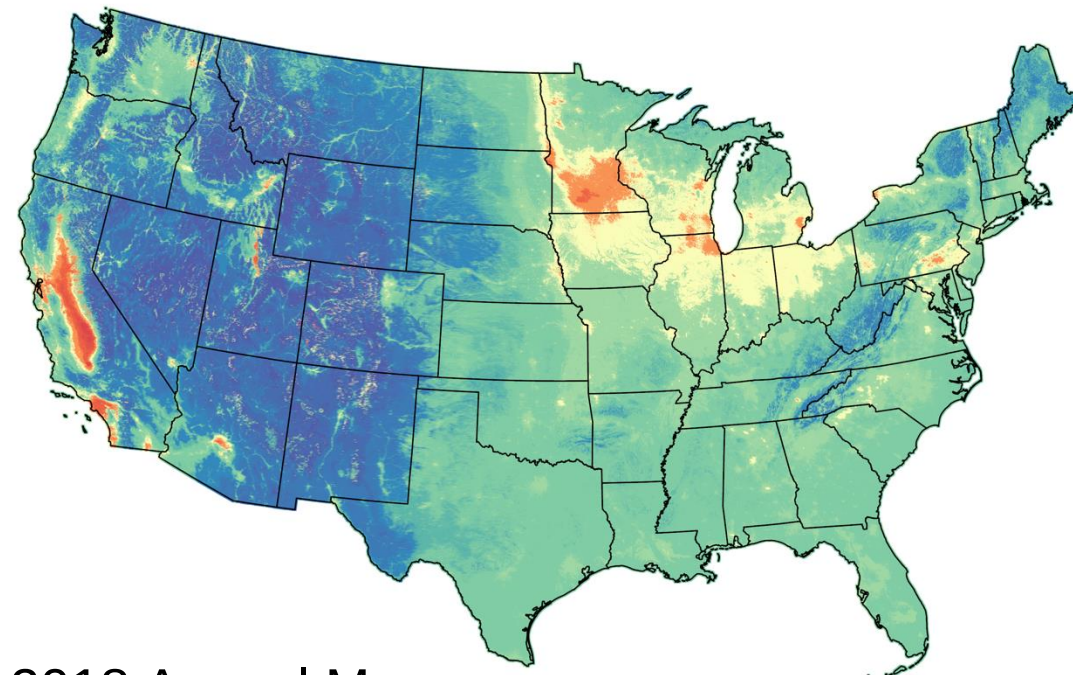
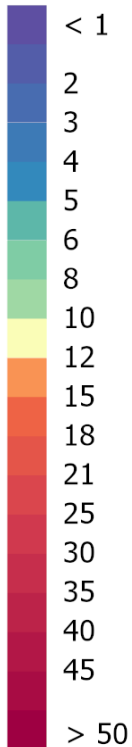
# Total PM<sub>2.5</sub> Prediction Results



2007 Annual Mean

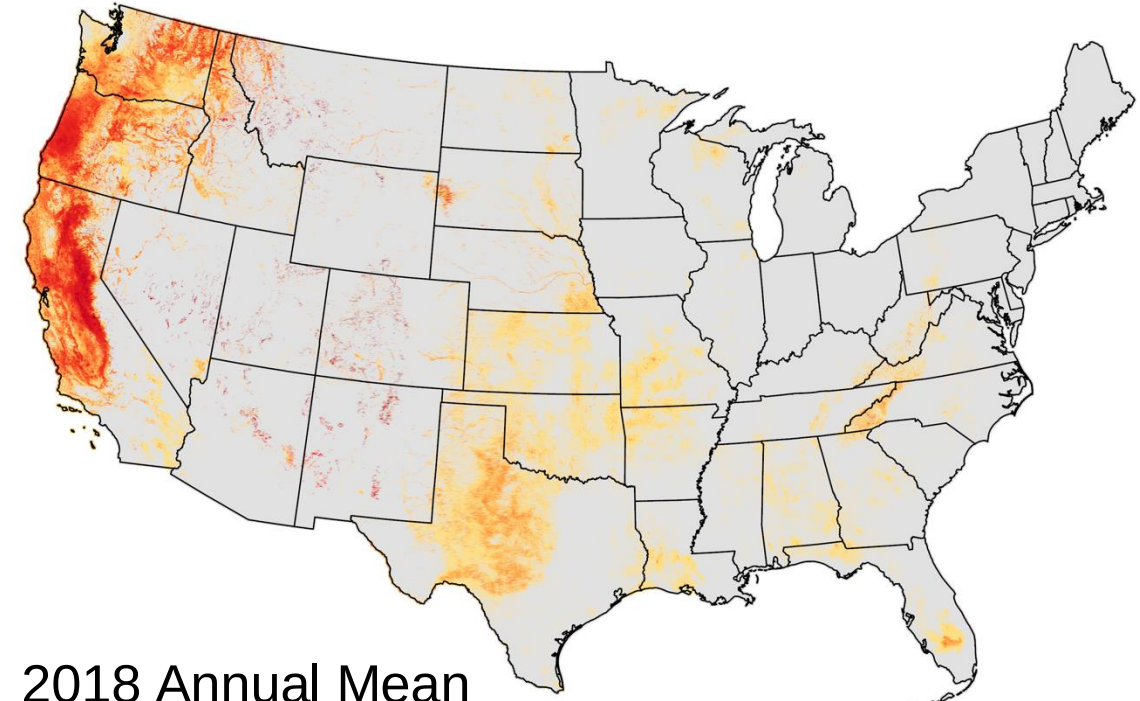
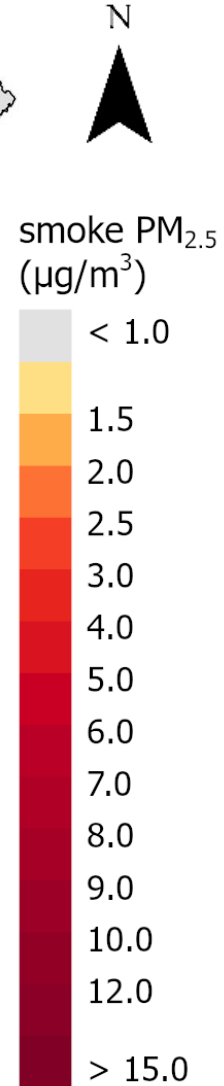
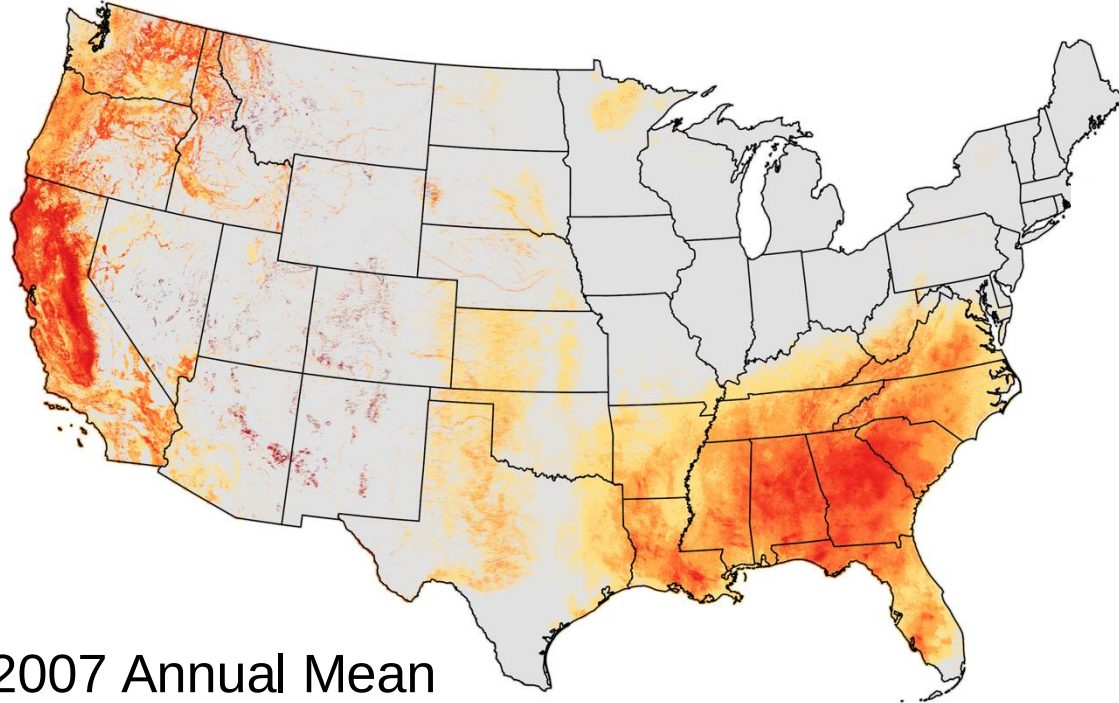


total PM<sub>2.5</sub>  
( $\mu\text{g}/\text{m}^3$ )



2018 Annual Mean

# Smoke PM<sub>2.5</sub> Prediction Results

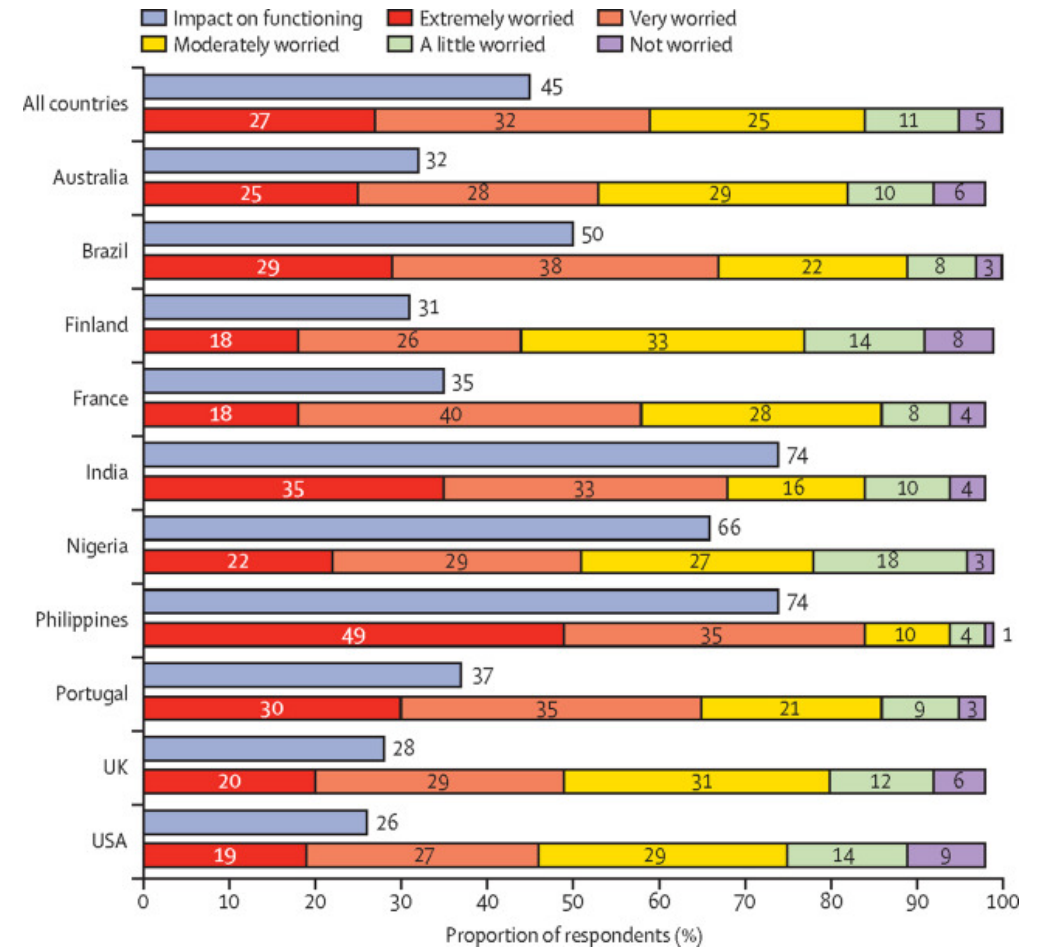


# Climate anxiety / Eco-anxiety (Qingyang Zhu et al.)

While we are taking actions to mitigate climate change, the awareness of the negative impact of climate change is also causing stress and anxiety.

A recent study showed that, nearly half of the population in the selected countries are extremely worried, or very worried about climate change.

However, it is still unclear that if the natural disasters, such as wildfires, are directly contributing to climate anxiety.



Source: Hickman et al., The Lancet Planetary Health, 2021

# Study questions

- 1) Are wildfires associated with ED visits for anxiety disorders in the Western US?
- 2) If yes, is this association established through exposure to **wildfire smoke PM<sub>2.5</sub>**?
- 3) Are there **any other pathways** that underlie this association?

# ED visits for anxiety disorders

- Individual records of ED visits from 2007-2018 were obtained from five WUS states (**Arizona, California, Nevada, Utah, and Oregon**). A total of **1,897,865** ED visits, and ~80% of the cases were from California
  - We only included patients whose **primary reason** for the ED visit was anxiety disorders. Anxiety disorders are defined as:
  - ICD-9: 300, 308, 309.0, 309.1, 309.24, 309.28, 309.29, 309.3, 309.4, 309.8, 309.9, or
  - ICD-10: F40-F48
- \* A transition from ICD-9 codes to ICD-10 codes happened on Oct 1, 2015.**

# Methods - a case-crossover design

If an ED visit occurred on day  $x$  (weekday  $y$ ). All the other weekdays  $y$  in the same month will be used as self-control. We used a conditional logistic regression model :

$$\text{Logit}(P_{il}) = \alpha_{il} + \beta^T X_{il}$$

X included: national holidays (factor); mean temperature (NS, 6); relative humidity (NS, 6); day of year(NS, 4); **ZIP code 48-h smoke PM<sub>2.5</sub>**, other wildfire-related exposures including, **smoke events, major smoke events, active fire points, and cumulative FRP.**

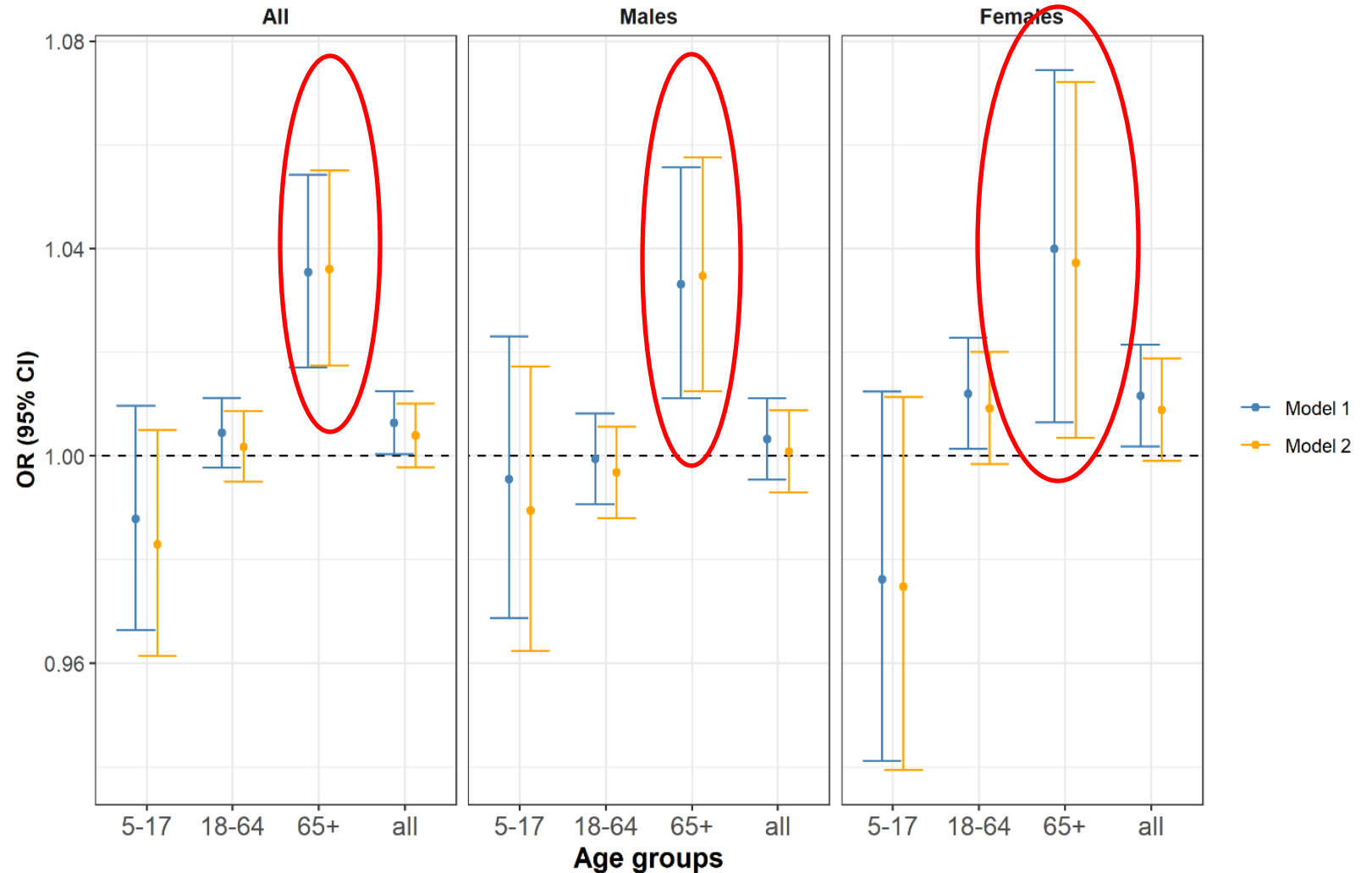
# Results

| Exposures                            | Smoke-only             |         | Adjusted for background PM2.5 |         |
|--------------------------------------|------------------------|---------|-------------------------------|---------|
|                                      | OR (95% CI)            | P-value | OR (95% CI)                   | P-value |
| Smoke PM <sub>2.5</sub> <sup>1</sup> | 1.006<br>(1.000,1.012) | 0.029*  | 1.003<br>(0.998,1.010)        | 0.169   |
| Smoke events                         | 1.005<br>(0.998,1.013) | 0.183   | 1.005<br>(0.997,1.012)        | 0.230   |
| Major smoke events                   | 1.063<br>(1.015,1.113) | 0.009*  | 1.056<br>(1.009,1.106)        | 0.019*  |
| Fire points                          | 1.002<br>(0.999,1.005) | 0.066   | 1.002<br>(0.999,1.005)        | 0.068   |
| Cumulative FRP <sup>2</sup>          | 1.000<br>(0.999,1.001) | 0.200   | 1.000<br>(0.999,1.001)        | 0.205   |

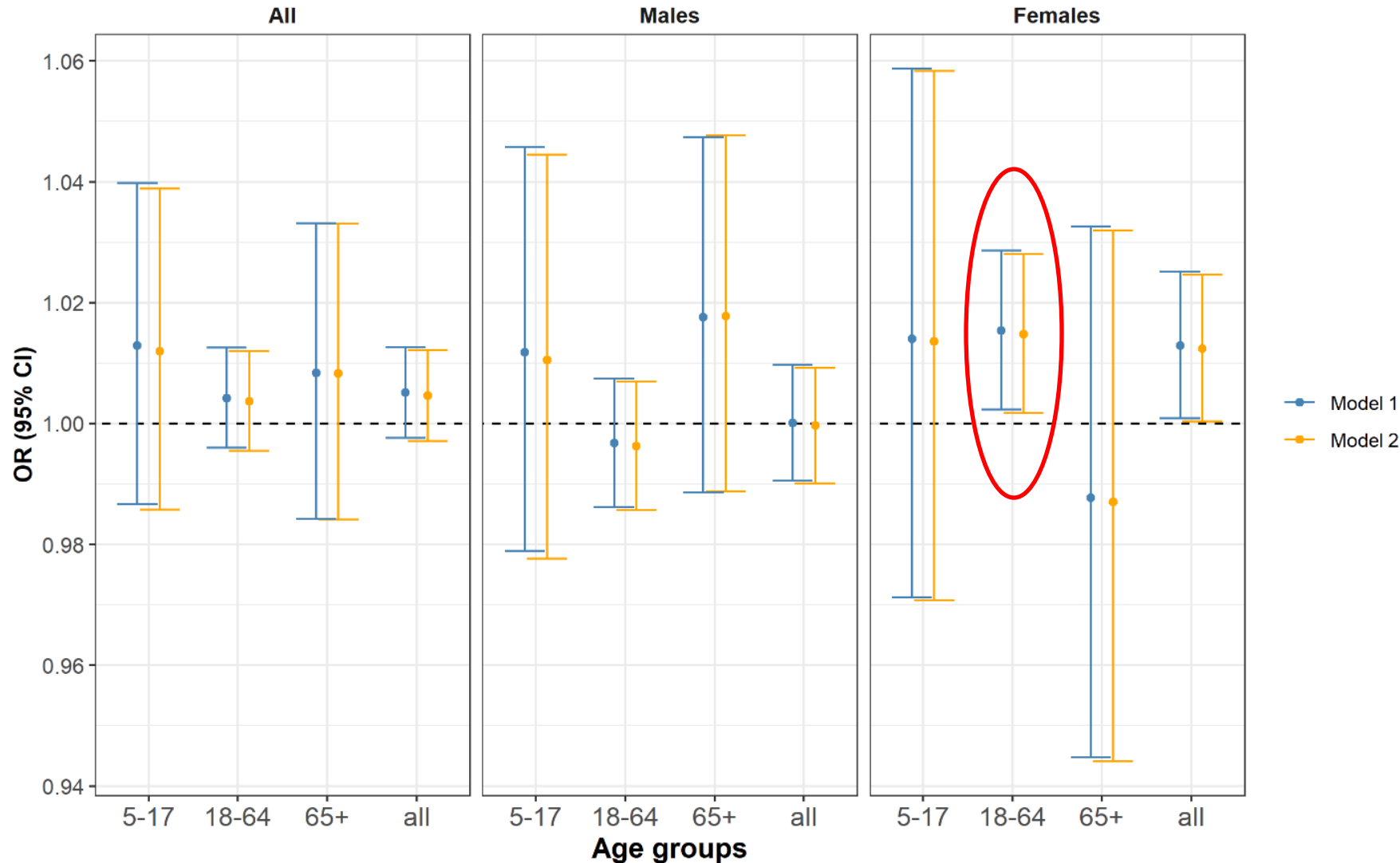
\*:  $p < 0.05$ . 1: The OR was for a 10  $\mu\text{g}/\text{m}^3$  increase in 48-h smoke PM<sub>2.5</sub>. 2: The OR was for an IQR increase in the cumulative FRP.

# Age- and sex-stratified analysis

The age- and sex-stratified analysis for **smoke PM<sub>2.5</sub>** showed that **females and the elderly population** are more vulnerable than other population groups.



# Age and sex-stratified analysis for smoke events



Additionally, females are also more vulnerable to **smoke events**.

# Major conclusions

- Wildfire-related exposures are associated with an increased risk of ED visits for anxiety disorders.
- Two potential pathways are identified:
  - Physiological impact of **inhaling fire smoke**, and
  - Psychological impact **of being in the vicinity of a wildfire event**.

**Females and the elderly population** are more susceptible to the anxiety disorders associated with wildfires.