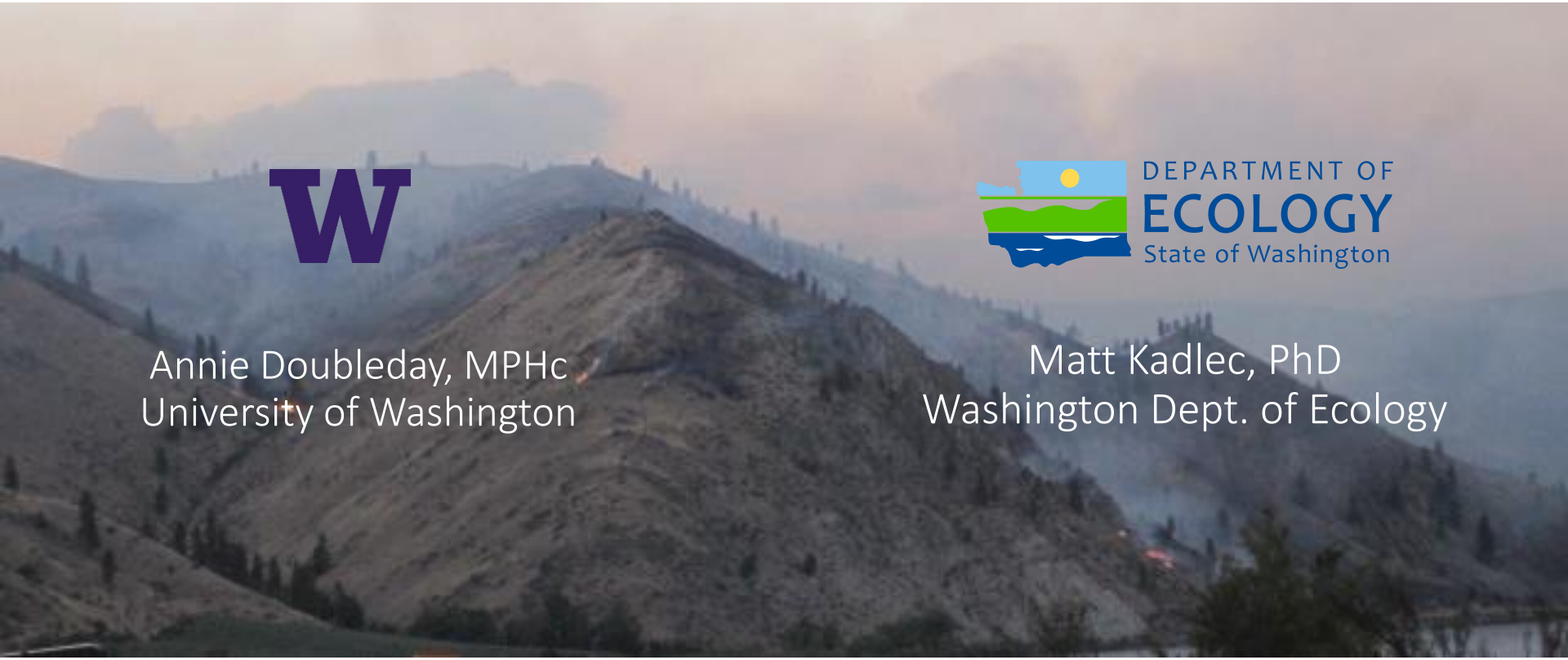
Washington Wildfire Smoke Mortality Study

EPA Smoke Management Conference

29-30 May 2019, Seattle, WA



Annie Doubleday, MPHc
University of Washington

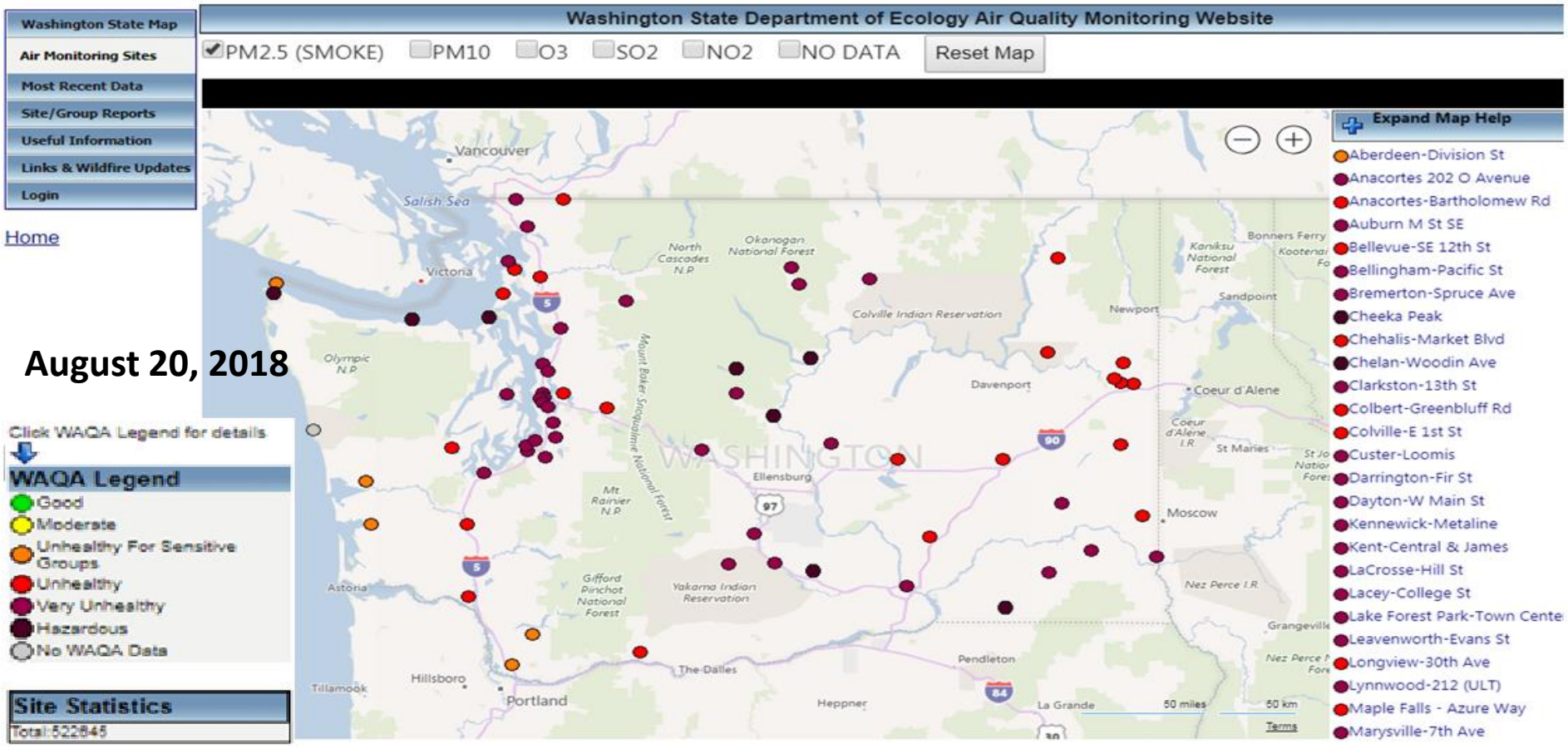
Matt Kadlec, PhD
Washington Dept. of Ecology

Study Design

1. Concentration-Response Factor Approach
• Apply mortality estimates from a previous epidemiologic study
• Incorporate Washington data for 2006-2017:
  • PM2.5 concentrations
  • Baseline mortality rate
  • Population
	EXPECTED COUNTS

2. Validate results with Washington mortality data from 2006-2017	***OBSERVED COUNTS***

Daily PM2.5 levels surge with wildfire smoke



Wildfire Smoke Day Definition

- Any day over 20.4 µg/m^3
- Any day between 9 and 20.4 µg/m^3 if:
  - Part of an event with 2 of 3 consecutive days are greater than 9 µg/m^3 and one or more days greater than 15 µg/m^3
  - For urban areas (Seattle, Tacoma, Spokane), at least 50% of the area monitors greater than 9 µg/m^3

Washington 2006-2017, June through September

	Daily average $PM_{2.5}$ ($\mu g/m^3$)	SE
Wildfire smoke	23.4	2.4
Non-wildfire smoke	5.3	0.1
Increase	18.1	2.5

Smoke Concentration-Response Factor approach

DEPARTMENT OF ECOLOGY
State of Washington

$\Delta\text{Mortality} = y_0(e^{-\beta\Delta X} - 1)\text{Pop}$

- ΔMortality > an estimate of excess mortalities attributable to $PM_{2.5}$
- y_0 > baseline mortality rate
- e > Euler's number, the natural log root
- β > concentration–response factor
- ΔX > change in $PM_{2.5}$ concentration
- Pop > size of the exposed population

DEPARTMENT OF ECOLOGY
State of Washington

Search for wildfire smoke health effect epidemiology

Select studies that reported daily average $PM_{2.5}$ concentrations together with quantified changes in mortality odds ratios

DEPARTMENT OF ECOLOGY
State of Washington

Multi-year studies of daily average wildfire $PM_{2.5}$ concentrations and natural cause mortality rates

Environmental Research 151 (2016) 351–358

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Effects of long-range transported air pollution from vegetation fires on daily mortality and hospital admissions in the Helsinki metropolitan area, Finland

Virpi Kollanus [a,*], Pekka Tiittanen [a], Jarkko V. Niemi [b,c], Timo Lanki [a,d]

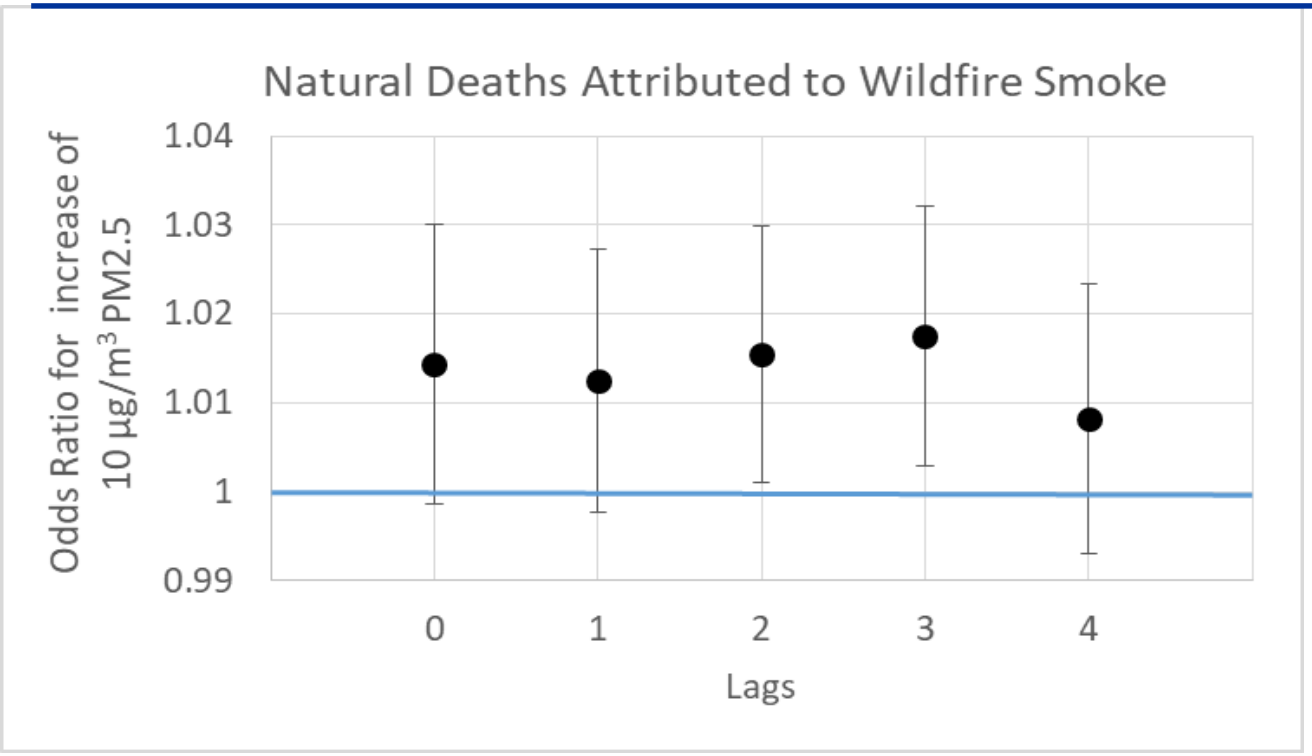
[a] Department of Health Protection, National Institute for Health and Welfare, P.O. Box 95, FI-70701 Kuopio, Finland
[b] Helsinki Region Environmental Services Authority, P.O. Box 100, FI-00066 HSY, Helsinki, Finland
[c] Department of Environmental Sciences, University of Helsinki, P.O. Box 65, FI-00014 University of Helsinki, Helsinki, Finland
[d] Unit of Public Health and Clinical Nutrition, University of Eastern Finland, P.O. Box 1627, FI-70211 Kuopio, Finland

Sarah B. Henderson and **Jiayun Yao**

The association between fine particulate matter (PM2.5) and cardio-pulmonary mortality on days with high wildfire activity

Environmental Health
Submitted

Henderson & Yao, Wildfire Smoke Study, *Submitted*



- British Columbia 2004-2015
- All natural mortalities
- All ages, male & female
- Case-crossover, logistic regression
- Lags 0-4 days
- $PM_{2.5}$ concentration model capped at
- 150 µg/m³

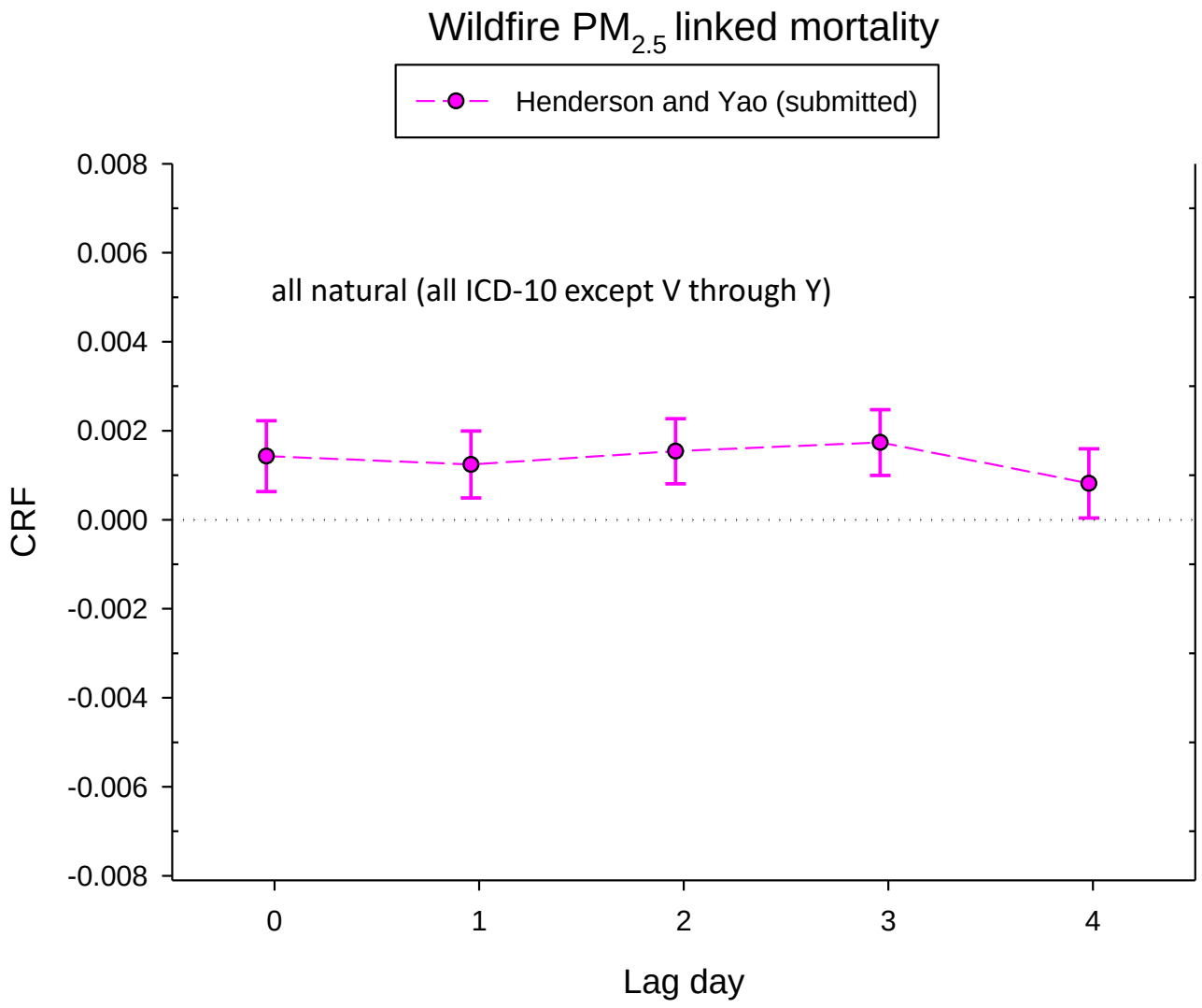
Henderson SB, Yao J. The association between fine particulate matter ($PM_{2.5}$) and cardiopulmonary mortality on days with high wildfire activity. *Environmental Health*. *Submitted.*

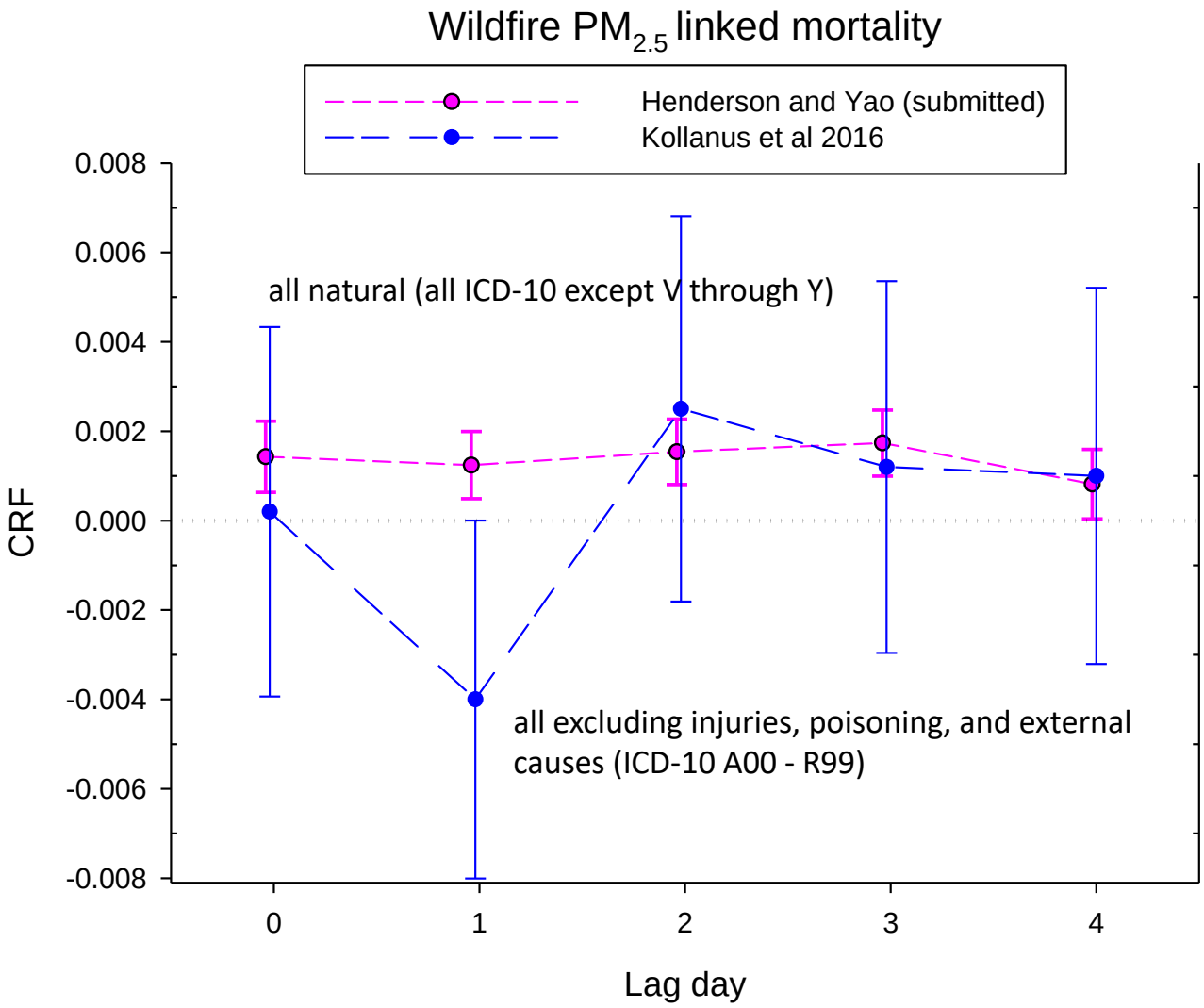
$$\textit{Concentration–Response Factor} = \beta = \frac{\ln(OR)}{\Delta PM}$$

(CRF) the estimated slope, β, of the log-linear relation between concentration and mortality)

CRFs express odds ratios or relative risks per unit $PM_{2.5}$

DEPARTMENT OF ECOLOGY
State of Washington


Wildfire PM2.5 linked mortality
Henderson and Yao (submitted)
all natural (all ICD-10 except V through Y)
CRF
0.008
0.006
0.004
0.002
0.000
-0.002
-0.004
-0.006
-0.008
0
1
2
3
4
Lag day


Wildfire PM2.5 linked mortality
Henderson and Yao (submitted)
Kollanus et al 2016
all natural (all ICD-10 except V through Y)
all excluding injuries, poisoning, and external causes (ICD-10 A00 - R99)
CRF
0.008
0.006
0.004
0.002
0.000
-0.002
-0.004
-0.006
-0.008
0
1
2
3
4
Lag day

Washington 2006-2017, June through September

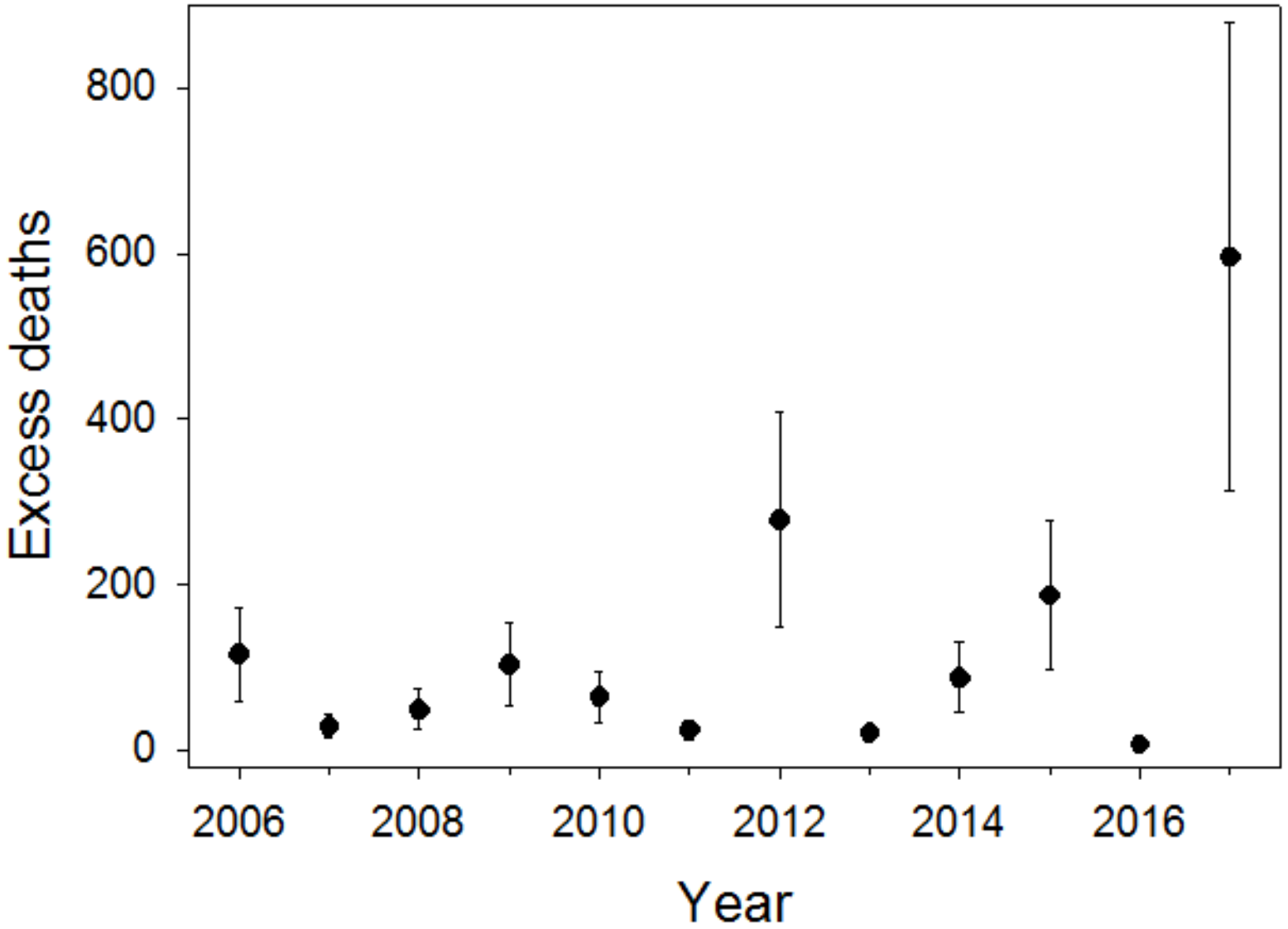
Baseline = *Non-wildfire smoke day levels from in study years*

Non-wildfire smoke day avg. mortality: 1.75 per 100,000 (SE 0.0198)

Avg. Population 2006 - 2017: 6,722,824 (SD 259,430)

DEPARTMENT OF ECOLOGY
State of Washington

CRF-based estimates of smoke-attributable deaths in Washington



Mortality Associated with Wildfire Smoke Exposure in Washington State

Annie Doubleday, MPHc
May 23, 2019

ENVIRONMENTAL & OCCUPATIONAL HEALTH SCIENCES
UNIVERSITY of WASHINGTON | SCHOOL OF PUBLIC HEALTH

BACKGROUND

Literature Background

- Evidence for association between wildfire smoke exposure and non-traumatic mortality is **mixed**
  - A few studies find an association with all non-traumatic mortality among ages 65+
  - Some find association with respiratory or cardiovascular mortality
- **No mortality studies in WA**
  - 2 hospitalization studies from 2012
    - Gan et al. 2017[1]
    - DOH 2012 report[2]

[1]Gan, R. W., Ford, B., Lassman, W., Pfister, G., Vaidyanathan, A., Fischer, E., et al. (2017). Associations with cardiopulmonary-related hospital admissions, *1*(3), 122–136. https://doi.org/10.1002/2017GH000073.

[2]Washington State Department of Health. (2012). *Surveillance Investigation of the Cardiopulmonary Health Effects of the 2012 Wildfires in North Central Washington State*.

Goal

Epidemiological analysis of wildfire smoke exposure and non-traumatic mortality in Washington, 2006-2017

METHODS

Methods

- Exposure metric
  - 24-hour average $PM_{2.5}$ and humidex data from air quality monitoring network combined with modeled $PM_{2.5}$ from the AIRPACT model
- Health outcome
  - Non-traumatic mortality in Washington State
  - June-September, 2006-2017
- Time-stratified case-crossover design
  - Cases compared to themselves to control for confounding
  - Compare exposure on day of death to exposure on referent days
  - Estimate odds ratio day of death, and on the four days prior to death

Analyses specified *a priori*

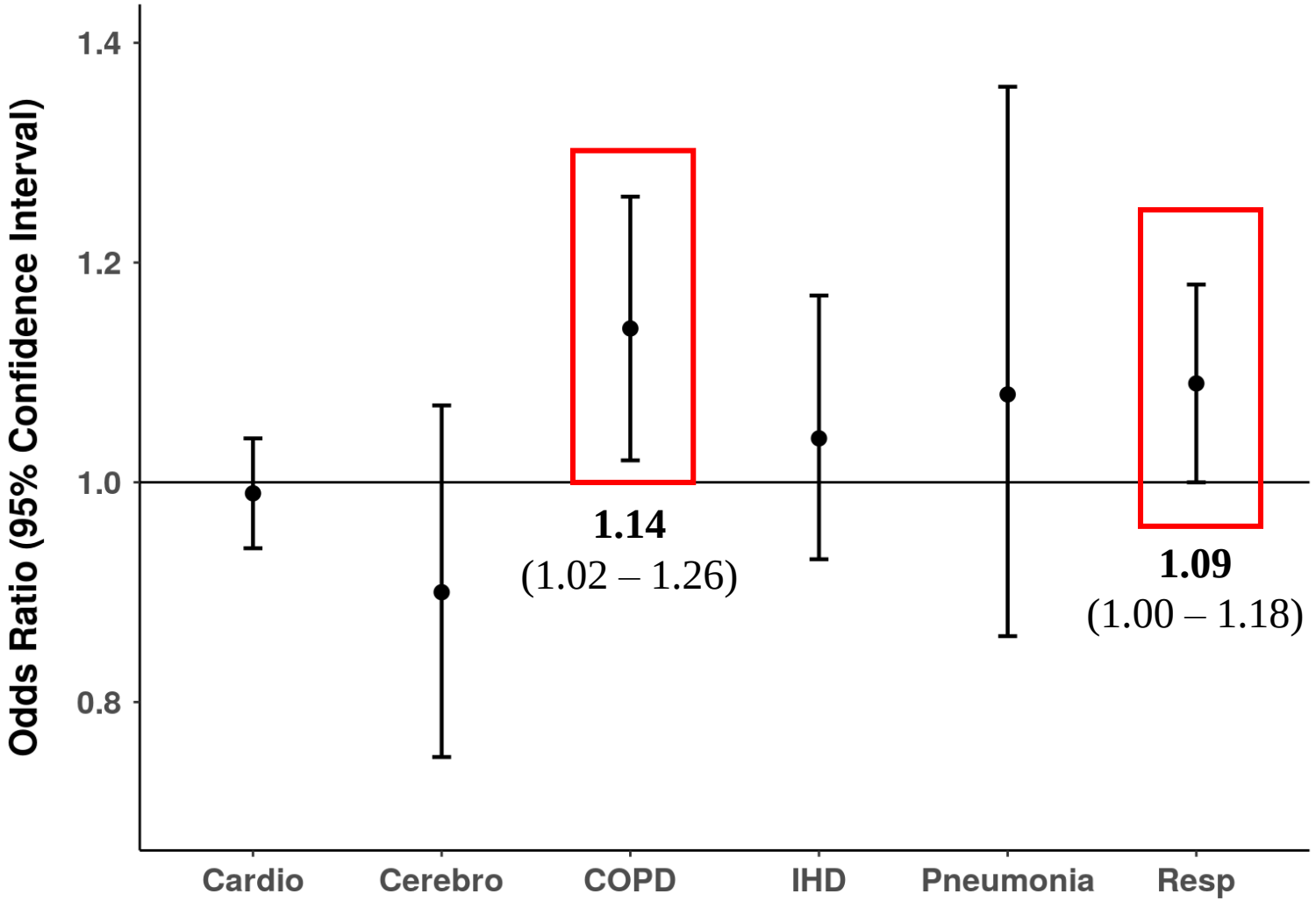
- *A priori*, we wanted to examine:
  - All same-day non-traumatic mortality
  - Causes of death: cardiovascular and respiratory
  - Age group, with emphasis on adults 65 and over
  - Effect of exposure on the four days preceding death (lag analysis)

RESULTS

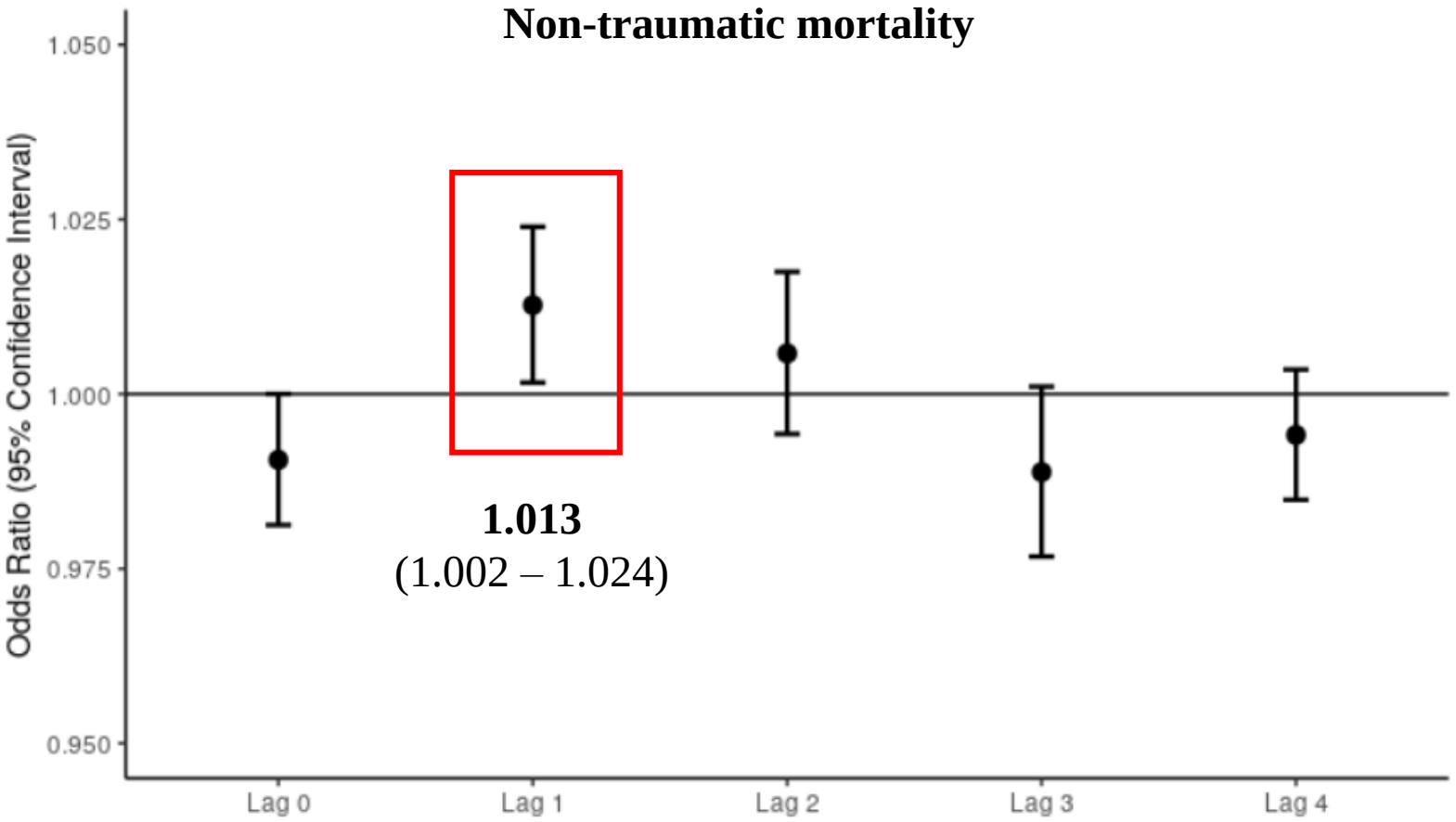
Results: Primary Analysis

Category	Adjusted OR (95% CI)	N (%)
All non-traumatic	1.01 (0.99, 1.04)	171,804 (100)
Cause of death		
Cardiovascular	0.99 (0.94, 1.04)	44,565 (25.9)
Respiratory	1.09 (1.00, 1.18)	16,286 (9.5)
Age group (years)		
65-84	1.02 (0.98, 1.06)	75,110 (43.4)
85+	1.00 (0.96, 1.05)	57,618 (33.3)

Results: Primary Analysis



Results: Lag Analysis



Results: Secondary Analysis

Category	Adjusted OR (95% CI)	N (%)
All non-traumatic	1.01 (0.99, 1.04)	171,804 (100)
Respiratory causes, by age group		
0-4	1.52 (0.58, 3.97)	119 (0.7)
5-14	-	28 (0.2)
15-44	0.91 (0.45, 1.84)	217 (1.3)
45-64	1.35 (1.09, 1.67)*	2,152 (13.2)
65-84	1.08 (0.96, 1.21)	8,489 (52.1)
85+	1.00 (0.86, 1.16)	5,281 (32.4)
COPD causes, by age group		
45-64	1.33 (1.00, 1.78)	1,281 (13.4)
65-84	1.14 (0.99, 1.31)	5,654 (59.1)
85+	1.04 (0.85, 1.28)	2,584 (27.0)

DISCUSSION

Discussion

- Overall effect estimates for primary analysis are similar to what other studies have found for mortality
- Other studies find effects for ages 65+
  - No other studies find increase in any cause of mortality for ages 45-64
    - Possible explanation: older worker effect
- Evidence for a lagged effect seen in many studies
- No other studies have examined COPD mortality
  - Evidence in literature for association between wildfire smoke exposure and an increase in COPD morbidity

Limitations

- Challenge of separating anthropogenic $PM_{2.5}$ and wildfire smoke $PM_{2.5}$
- $PM_{2.5}$ area monitors
  - Assuming area exposure equals personal exposure
- Inclusion of 2018 data would increase power and tighten confidence intervals of effect estimates

CRF approach

- Results are not age- or heat-adjusted
- $PM_{2.5}$ levels in WA exceeded upper limit used in the BC study

Methods Comparison

CRF approach

- Like other human health impact decision-support tools
- Differing exposure characterization

Epidemiological analysis

- More robust approach
- Controls for confounders and seasonality

Conclusion

- Both approaches indicate evidence for some association between wildfire smoke exposure and mortality in WA in recent years
- The effect estimates are sensitive to exposure definition
- Research needed to determine a gold standard method for wildfire smoke exposure
- Research needed to further explore subgroups, to examine less severe endpoints, and to explore long term exposure
- There is currently insufficient information to determine if there is a safe level of population exposure to wildfire smoke

Thank you!

Annie Doubleday
doubleda@uw.edu

Matt Kadlec
matt.kadlec@ecy.wa.gov

Main Study Contributors:

Matt Kadlec
Jill Schulte
Ranil Dhammapala

Annie Doubleday
Lianne Sheppard
Tania Busch Isaksen

Julie Fox

DEPARTMENT OF ECOLOGY
State of Washington

SCHOOL OF PUBLIC HEALTH
UNIVERSITY of WASHINGTON

Washington State Department of Health