What are the health impacts of smoke?
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There is consistent evidence that wildfire smoke exacerbates asthma

Environmental Research 179 (2019) 108777

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Environmental Research

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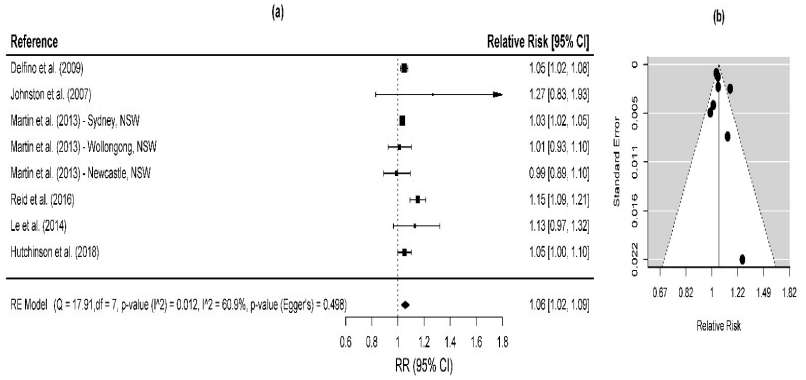
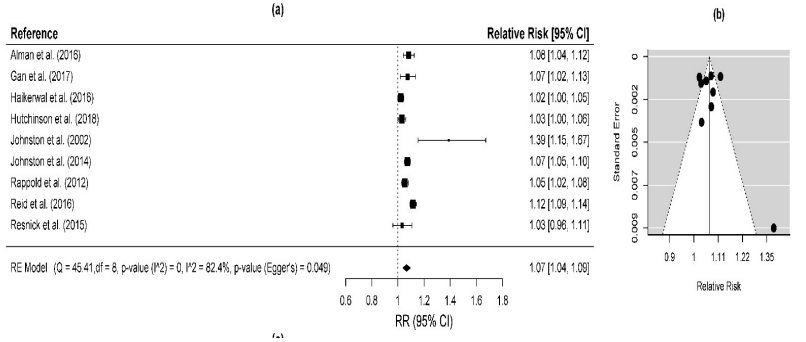
Review article

Association between fire smoke fine particulate matter and asthma-related outcomes: Systematic review and meta-analysis☆

Nicolas Borchers Arriagada[a,b], Joshua A. Horsley[c], Andrew J. Palmer[a,e], Geoffrey G. Morgan[c], Rachel Tham[d], Fay H. Johnston[a,*]





There is growing evidence that wildfire smoke exacerbates COPD and respiratory infections

Environment International 139 (2020) 105668

Contents lists available at ScienceDirect

Environment International

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

The delayed effect of wildfire season particulate matter on subsequent influenza season in a mountain west region of the USA

Erin L. Landguth[a,*], Zachary A. Holden[b], Jonathan Graham[a,c], Benjamin Stark[c], Elham Bayat Mokhtari[c], Emily Kaleczyc[d], Stacey Anderson[e], Shawn Urbanski[f], Matt Jolly[f], Erin O. Semmens[a], Dyer A. Warren[a], Alan Swanson[a], Emily Stone[c], Curtis Noonan[a]

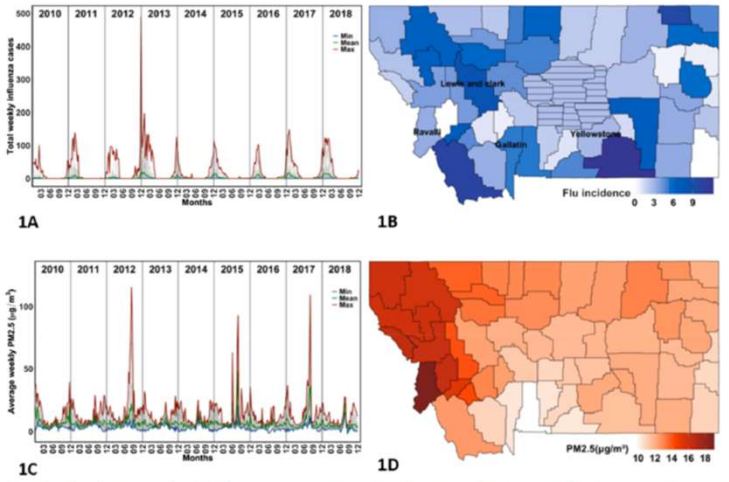
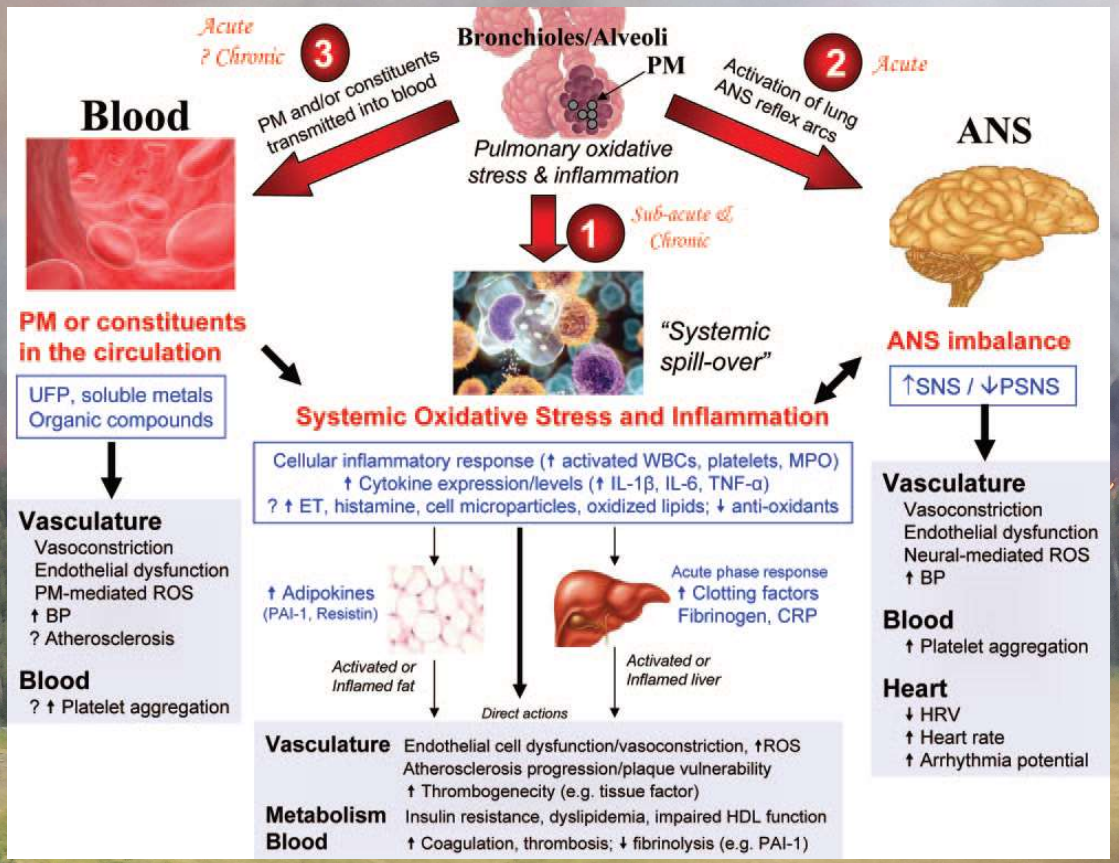


Fig. 1. (A) Total weekly influenza cases plotted for all Montana counties, 2010–2018. (B) Flu season incidence (per 1,000) for each county in Montana, 2015–2016 with the 'Central Montana Health District' (CMHD) shown with dash. (C) Average weekly $PM_{2.5}$ (ug/m^3) plotted for each county in Montana, 2010–2018. (D) Average $PM_{2.5}$ during the wildfire season (July 1 – September 30) for each county in Montana, 2015.

Wildfire smoke and cardiovascular disease

- Many studies to date have been null
- A few **recent studies** have found significant associations
- Unsure as to the cause of these differences across studies



Reid et al. 2016 *EHP*

Brook, R. D. et al. Circulation 2010;121:2331-2378

Wildfire Smoke and Mortality

- Clear evidence of wildfire smoke impacts on all-cause mortality
  - But no clear evidence for specific causes of mortality such as respiratory or cardiovascular deaths yet

Doubleday *et al. Environmental Health* (2020) 19:4
https://doi.org/10.1186/s12940-020-0559-2

Environmental Health

RESEARCH Open Access

Mortality associated with wildfire smoke exposure in Washington state, 2006–2017: a case-crossover study

Annie Doubleday[1*], Jill Schulte[2], Lianne Sheppard[1,3], Matt Kadlec[2], Ranil Dhammapala[2], Julie Fox[4] and Tania Busch Isaksen[1]

Reid et al. 2016 *EHP*

Wildfire Smoke and Diabetic Outcomes

Research

A Section 508–conformant HTML version of this article is available at https://doi.org/10.1289/EHP5792.

Sub-Daily Exposure to Fine Particulate Matter and Ambulance Dispatches during Wildfire Seasons: A Case-Crossover Study in British Columbia, Canada

Jiayun Yao,[1] Michael Brauer,[1] Julie Wei,[2] Kimberlyn M. McGrail,[1] Fay H. Johnston,[3] and Sarah B. Henderson[1,4]

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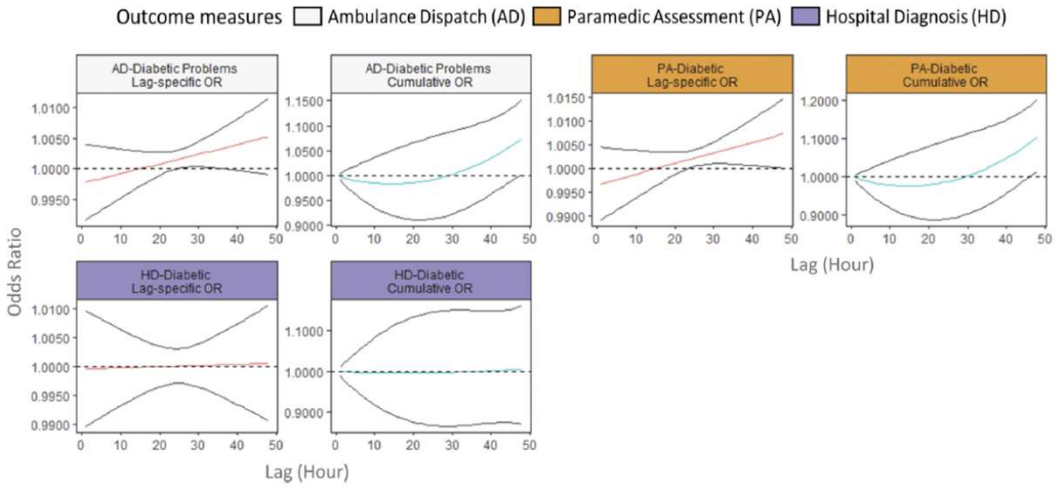


Figure 6. Lag-specific and cumulative odds ratio (OR) of diabetic outcomes associated with a 10-μg/m^3 increase in fine particulate matter ($PM_{2.5}$) in the lag period of 1–48 h in 2010–2015 wildfire seasons in British Columbia. The figure shows the lag–response curves estimated from distributed lag nonlinear model (with 95% CI), assuming a linear exposure–response relationship, adjusted for same-day and previous-day maximum apparent temperatures. Lag-specific OR refers to the OR associated with the single hour exposure, whereas cumulative OR refers to OR associated with the cumulative exposure up to the specific hour. The *y*-axes for each panel are different to clearly show the shape of the lag–response curves.

Wildfire Smoke and Deaths among Patients with Diabetes

CLINICAL EPIDEMIOLOGY www.jasn.org

Mortality in US Hemodialysis Patients Following Exposure to Wildfire Smoke

Yuzhi Xi,[1,2] Abhijit V. Kshirsagar,[3] Timothy J. Wade,[4] David B. Richardson,[2] M. Alan Brookhart,[5] Lauren Wyatt,[1] and Ana G. Rappold[4]

Due to the number of contributing authors, the affiliations are listed at the end of this article.

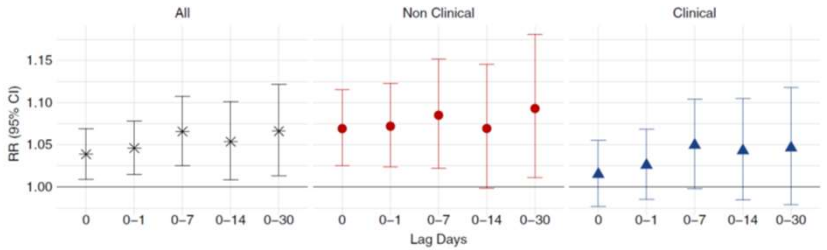


Figure 2. Association between all-cause mortality and wildfire-$PM_{2.5}$ among United States patients receiving in-center HD during 2008–2012. RRs and 95% CIs were expressed per 10-$\mu g/m^3$ increase in wildfire-$PM_{2.5}$. Numeric values are provided in the Supplemental Material.

Fires effect on birth weight

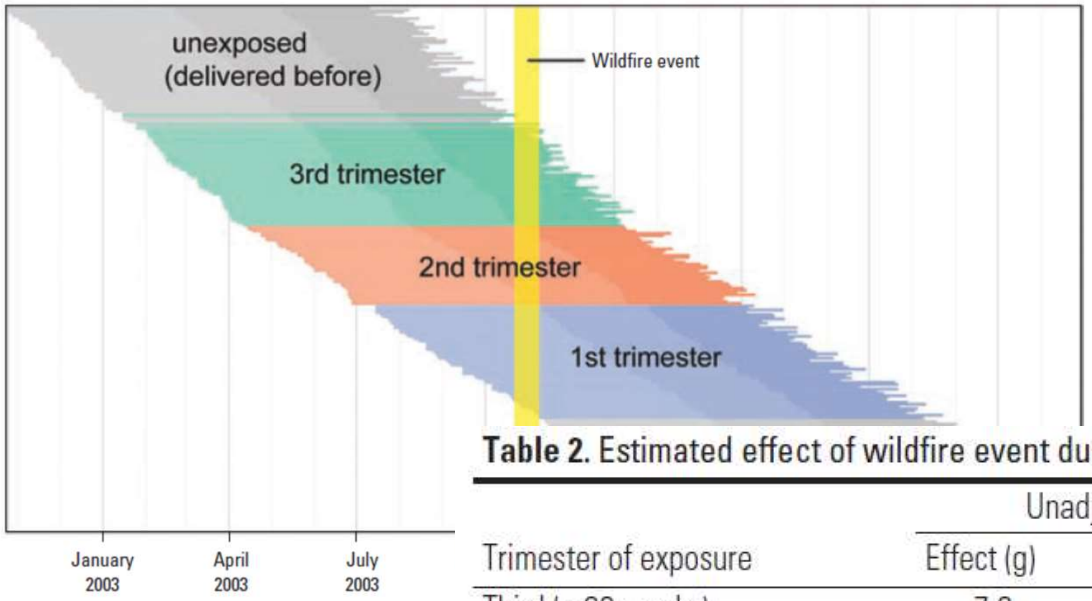


Figure 2. Schematic illustrating exposure as
lap between the wildfire event (yellow) an
clarity, gestational intervals are shown orde
from 2002–2004 is shown. Dates on the *x*-ax
seasonality.

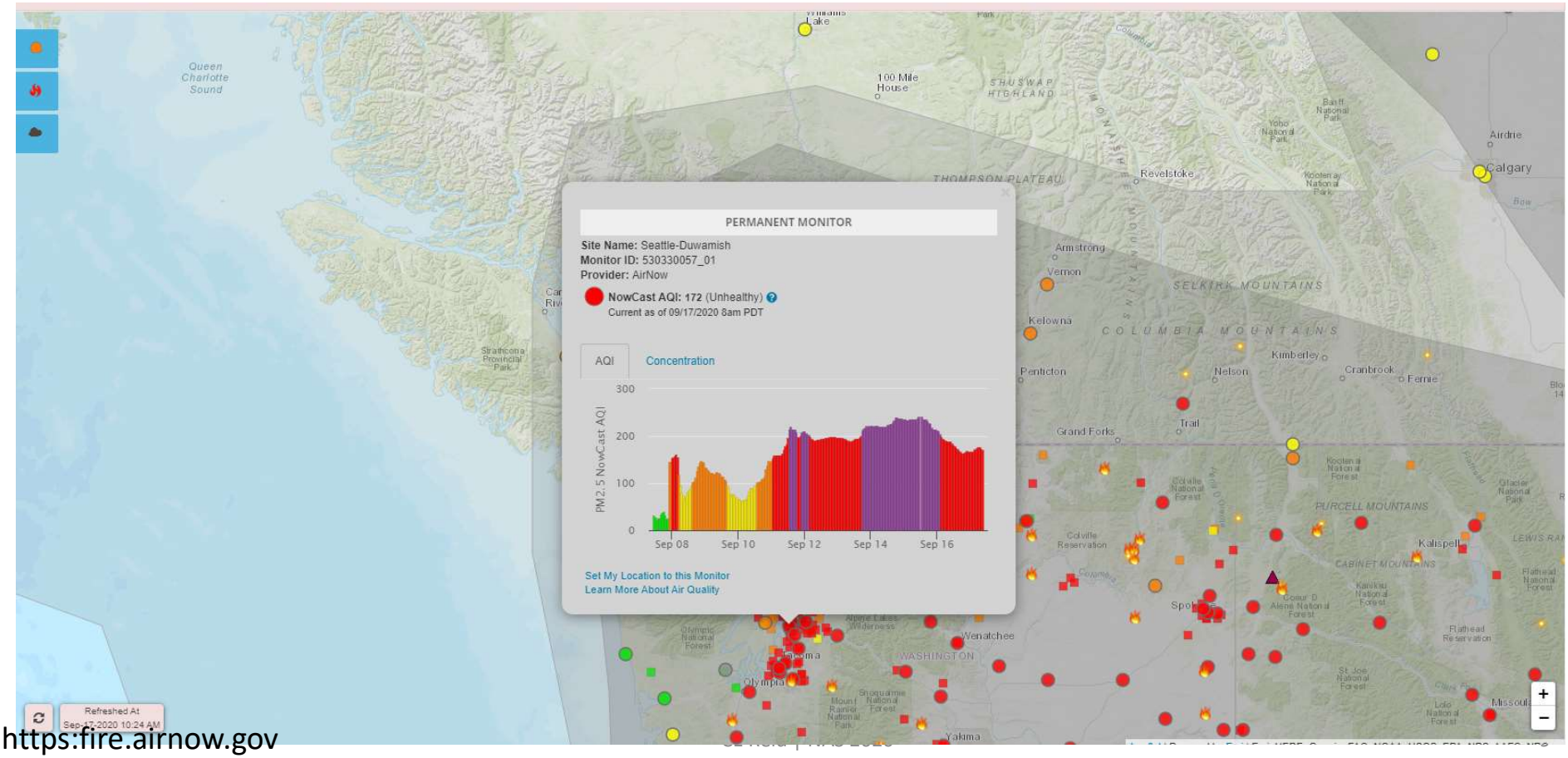
Table 2. Estimated effect of wildfire event during gestation on birth weight (g), by trimester.

	Unadjusted model		Adjusted model	
Trimester of exposure	Effect (g)	95% CI	Effect (g)	95% CI
Third (≥ 29 weeks)	–7.9	(–12.8, –3.1)	–7.0	(–11.8, –2.2)
Second (17–28 weeks)	–17.1	(–21.9, –12.3)	–9.7	(–14.5, –4.8)
First (1–16 weeks)	–3.9	(–7.8, 0.0)	–3.3	(–7.2, 0.6)
Any trimester	–8.8	(–11.5, –6.1)	–6.1	(–8.7, –3.5)

Adjusted model includes terms for fetal sex, gestational age, parity, maternal age, maternal education, maternal race/ethnicity, secular trend, and season.

Holstius et al. 2012 *EHP*

Mental Health and Wildfires



https:fire.airnow.gov

What do we know about chemical composition of PM and health impacts?

- WHO Report from 2013, EPA report from 2011, HEI report from 2015 all state that there is not enough consistent evidence of specific sources or chemical components of $PM_{2.5}$ that are more toxic/health harming (Adams et al. 2015)
- Wildfire smoke is an increasing source of $PM_{2.5,}$ particularly in the western US (O'Dell et al., 2019; McClure & Jaffe 2018)
- Similarly, we don't have consistent evidence to date that wildfire $PM_{2.5}$ affects health differently from $PM_{2.5}$ from other sources
  - Except maybe for asthma (e.g., DeFlorio-Barker et al. 2019; Kiser et al. 2020)
- No work to date on differences in health effects from $PM_{2.5}$ from different fires….

Do we know anything about the health impacts of other constituents of wildfire smoke?

Reid et al. 2019 *Environment International*

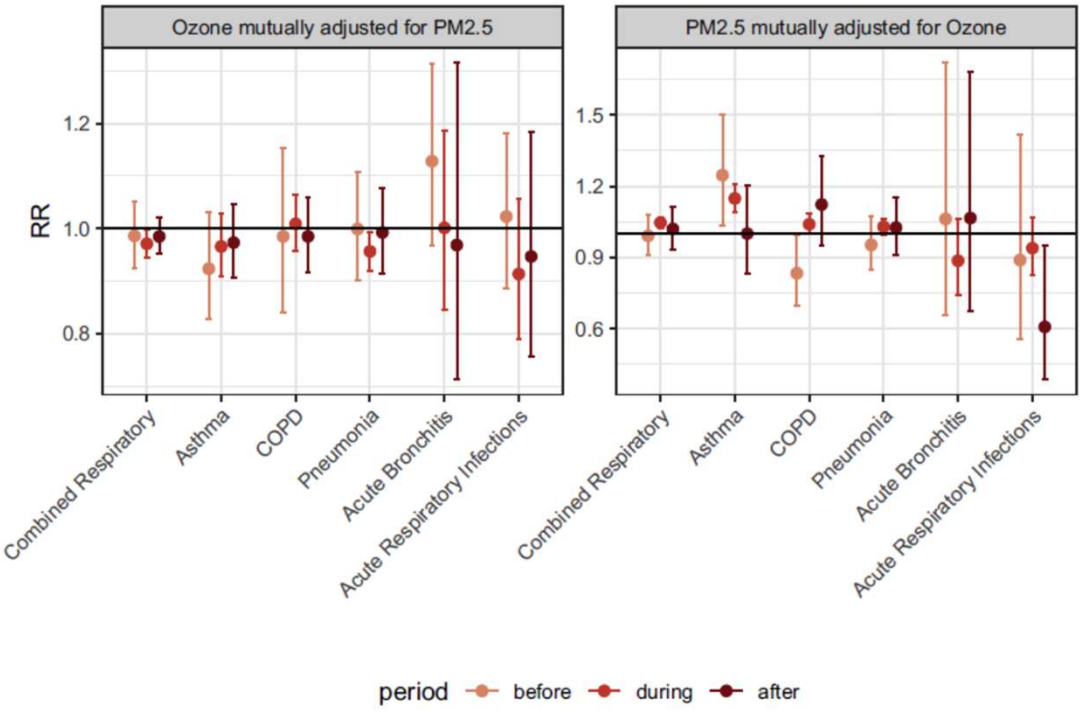


Fig. 4. Relative Risks (RRs) for hospitalizations in mutually-adjusted models for before, during, and after the wildfires.

Although $PM_{2.5}$ was more associated with respiratory health, more research is needed as ozone levels differ a lot by fire

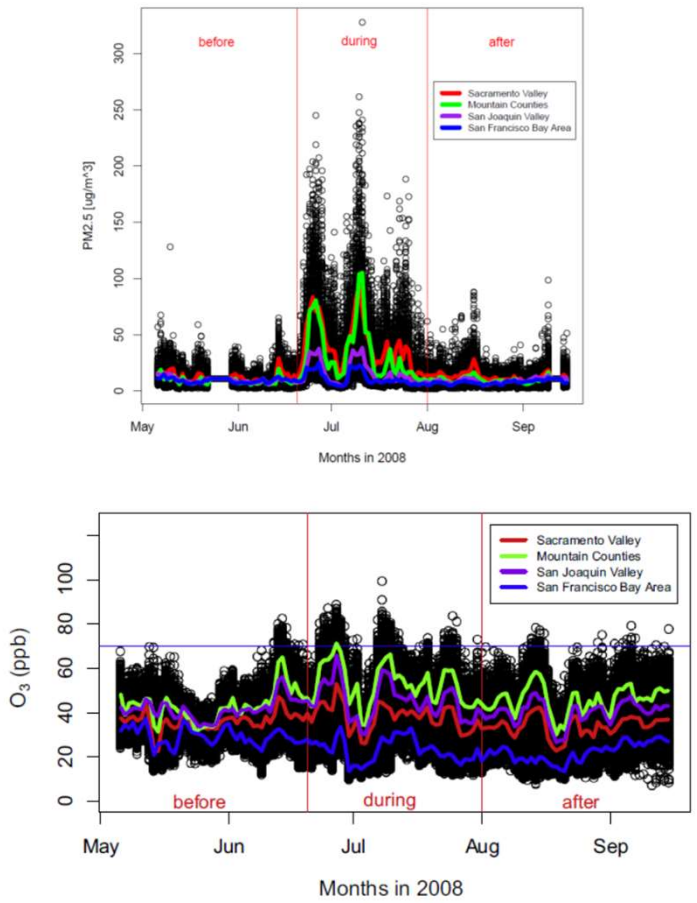


Fig. 3. Ozone levels by ZIP-code day during the study period with averages for some air basins.

Reid et al. 2019 *Env Int*

Key Messages

We know that wildfire smoke impacts respiratory health

We need more information for **other health endpoints** of concern

We need to study the **longer-term health impacts** of smoke

We need to investigate **why there are differences in findings** across health studies.

- Underlying population health status/susceptibility?
- Other components of smoke?
- Severity of outcome/subset of population?
- Study design/exposure assessment?

We need to understand **which health interventions** work best and for **which populations**

References

- Adams K, Greenbaum DS, Shaikh R, Erp AM van, Russell AG. 2015. Particulate matter components, sources, and health: Systematic approaches to testing effects. Journal of the Air & Waste Management Association 65:544–558; doi:10.1080/10962247.2014.1001884.
- Borchers Arriagada N, Horsley JA, Palmer AJ, Morgan GG, Tham R, Johnston FH. 2019. Association between fire smoke fine particulate matter and asthma-related outcomes: Systematic review and meta-analysis. Environ Res 179:108777; doi:10.1016/j.envres.2019.108777.
- Brook RD, Rajagopalan S, Pope CA 3rd, Brook JR, Bhatnagar A, Diez-Roux AV, et al. 2010. Particulate matter air pollution and cardiovascular disease: An update to the scientific statement from the American Heart Association. Circulation 121:2331–78; doi:10.1161/CIR.0b013e3181dbece1.
- DeFlorio-Barker S, Crooks J, Reyes J, Rappold AG. 2019. Cardiopulmonary Effects of Fine Particulate Matter Exposure among Older Adults, during Wildfire and Non-Wildfire Periods, in the United States 2008-2010. Environ Health Perspect 127:37006; doi:10.1289/EHP3860.
- Doubleday A, Schulte J, Sheppard L, Kadlec M, Dhammapala R, Fox J, et al. 2020. Mortality associated with wildfire smoke exposure in Washington state, 2006–2017: a case-crossover study. Environmental Health 19:4; doi:10.1186/s12940-020-0559-2.
- Holstius DM, Reid CE, Jesdale BM, Morello-Frosch R. 2012. Birth weight following pregnancy during the 2003 Southern California wildfires. Environmental health perspectives 120:1340–5; doi:10.1289/ehp.1104515.
- Kiser D, Metcalf WJ, Elhanan G, Schnieder B, Schlauch K, Joros A, et al. 2020. Particulate matter and emergency visits for asthma: a time-series study of their association in the presence and absence of wildfire smoke in Reno, Nevada, 2013–2018. Environmental Health 19:92; doi:10.1186/s12940-020-00646-2.
- Landguth EL, Holden ZA, Graham J, Stark B, Mokhtari EB, Kaleczyc E, et al. 2020. The delayed effect of wildfire season particulate matter on subsequent influenza season in a mountain west region of the USA. Environ Int 139:105668; doi:10.1016/j.envint.2020.105668.
- McClure CD, Jaffe DA. 2018. US particulate matter air quality improves except in wildfire-prone areas. Proc Natl Acad Sci U S A 115:7901–7906; doi:10.1073/pnas.1804353115.
- O'Dell K, Ford B, Fischer EV, Pierce JR. 2019. Contribution of Wildland-Fire Smoke to US PM2.5 and Its Influence on Recent Trends. Environ Sci Technol 53:1797–1804; doi:10.1021/acs.est.8b05430.
- Reid CE, Brauer M, Johnston FH, Jerrett M, Balmes JR, Elliott CT. 2016. Critical Review of Health Impacts of Wildfire Smoke Exposure. Environmental health perspectives 124:1334–43; doi:10.1289/ehp.1409277.
- Reid CE, Considine EM, Watson GL, Telesca D, Pfister GG, Jerrett M. 2019. Associations between respiratory health and ozone and fine particulate matter during a wildfire event. Environment International 129:291–298; doi:10.1016/j.envint.2019.04.033.
- Reid CE, Maestas MM. 2019. Wildfire smoke exposure under climate change: impact on respiratory health of affected communities. Current Opinion in Pulmonary Medicine 25:179; doi:10.1097/MCP.0000000000000552.
- Wettstein ZS, Hoshiko S, Fahimi J, Harrison RJ, Cascio WE, Rappold AG. 2018. Cardiovascular and Cerebrovascular Emergency Department Visits Associated With Wildfire Smoke Exposure in California in 2015. J Am Heart Assoc 7; doi:10.1161/JAHA.117.007492.
- Xi Y, Kshirsagar AV, Wade TJ, Richardson DB, Brookhart MA, Wyatt L, et al. 2020. Mortality in US Hemodialysis Patients Following Exposure to Wildfire Smoke. J Am Soc Nephrol; doi:10.1681/ASN.2019101066.
- Yao Jiayun, Brauer Michael, Wei Julie, McGrail Kimberlyn M., Johnston Fay H., Henderson Sarah B. Sub-Daily Exposure to Fine Particulate Matter and Ambulance Dispatches during Wildfire Seasons: A Case-Crossover Study in British Columbia, Canada. Environmental Health Perspectives 128:067006; doi:10.1289/EHP5792.


Thank You!!
Questions?
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