Effects of Wildfire Frequency and Intensity on Asthma Related Emergency Department Visits in California from 2008-2017

Holly Finertie
Columbia University, Mailman School of Public Health
Department of Epidemiology

Columbia University MAILMAN SCHOOL OF PUBLIC HEALTH

INTRODUCTION

The increased presence and destructiveness of wildfires have become the new normal in California. Between 1972 and 2018, the geographic area burned in California has increased by a factor of five. This is mainly due to the increasing size of wildfires,[1] with 75% of the largest recorded fires in California occurring in the last 19 years.[2] Year after year, wildfires continue to break records for destruction and death. In 2018 alone, records were set for total area burned, largest individual fire, and most destructive fire.[1]

The effects of climate change on this growing crisis cannot be overstated; however, the effects depend greatly on regional and seasonal variability. Generally, increased atmospheric aridity due to warming, delayed precipitation in winter, and wind events contribute hugely to the growing intensity and frequency of wildfires.[1,2] Further, the average wildfire season has lengthened by three months, in large part due to delayed precipitation.[3] As California grapples with this new normal, the health effects of these wildfires must be thoroughly understood.

BACKGROUND

As of 2017, the CDC estimates that 7.9% of the Americans have asthma.[4] In California, the prevalence matches the national average and affects 2.4 million individuals.[4] Of these, almost 46 per 10,000 visit the emergency department (ED) every year for an asthma related issue, which is lower than the national average of 56 per 10,000.[4–6] While there is no cure for asthma, it is critical that affected individuals avoid asthma triggers like wildfire emissions to stay safe and healthy.[6]

There is an incredible amount of information on how wildfire emissions negatively impact those who experience asthma and increase ED visits related to asthma in areas impacted. Following an infamous 1987 forest fire in California, researchers found that visits to the ED by people with asthma increased by 1.4 times.[7] Similarly, a 2012 San Diego study confirmed that increased particulate matter concentrations from a wildfire in the region resulted in a significant increase in asthma related ED visits immediately following the event.[8]

While there is sufficient evidence to conclude there are immediate spikes in asthma related ED visits following wildfire disasters, information on spatial trends between ED visits and wildfires across the years is lacking.

STUDY AIM

This study aims to analyze the relationship between asthma related ED visits and frequency and intensity of wildfires in California counties over 10 years from 2008 to 2017.

METHODS

Data:

- **Outcome:** Data on ED visits related to asthma by California county were downloaded from Tracking California. These data included crude rates per 10,000 across all ages, genders, and races from 2008 – 2017. Once downloaded, crude rates were averaged across 10 years by county. Alpine county had no data.
- **Explanatory Variables**: Data on California wildfires since 1953 were downloaded from California Department of Forestry and Fire Protection's Fire and Resource Assessment Program. Variables of interest included wildfire frequency and acres burned, an indicator for wildfire intensity. Data were filtered by years from 2008 – 2017.

Analyses:
Data on wildfires from 2008 – 2017 were imported into QGIS 3.4 as a polygon shape file, where each polygon represented a unique wildfire occurrence. This file was spatially joined to the asthma polygon shape file by county. Data on wildfires across California counties from 2008 – 2017 were aggregated by count and total acres burned.

Visualization of the data were completed first (Figure 1). Graduated visualization showed the average rate of crude ED visits related to asthma per 10,000 from 2008 – 2017 by California county. The polygon shape file showing frequency and intensity of wildfires from 2008-2017 was layered on top.

Next, spatial clustering was completed using GeoDa 1.14 for all variables using a first order Queen spatial weight. High-high and low-low clusters were identified per county, if present.

- **Frequency of wildfires:** The Moran's I after 999 permutations for frequency of wildfires by county was 0.32 with p-value 0.001, indicating significant spatial autocorrelation (Figure 2).
- **Intensity of wildfires:** The Moran's I after 999 permutations for frequency of wildfires by county was 0.26 with p-value 0.005, indicating significant spatial autocorrelation (Figure 3).
- **ED Visits:** The Moran's I after 999 permutations for the average rate of asthma related ED visits per 10,000 by county was -0.04 with p-value 0.111. We conclude that there is no significant spatial autocorrelation for crude ED visit rates related to asthma.

To test the association between asthma related ED visits and wildfire explanatory variables, OLS multivariable regression was run in GeoDa 1.14. The OLS model spatial diagnostics showed no evidence of spatial effects using both the LM-Lag (p-value = 0.65615) and LM-Error (p-value = 0.66020).

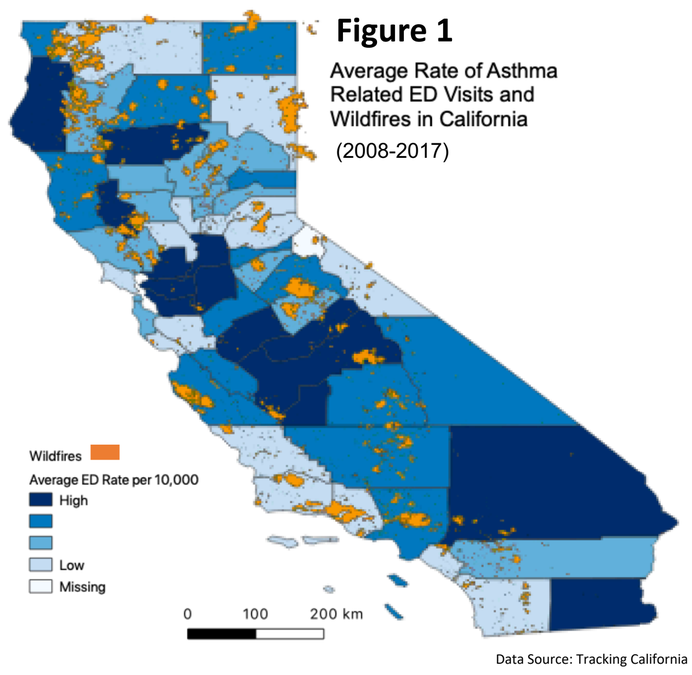

Figure 1
Average Rate of Asthma Related ED Visits and Wildfires in California (2008-2017)

Data Source: Tracking California

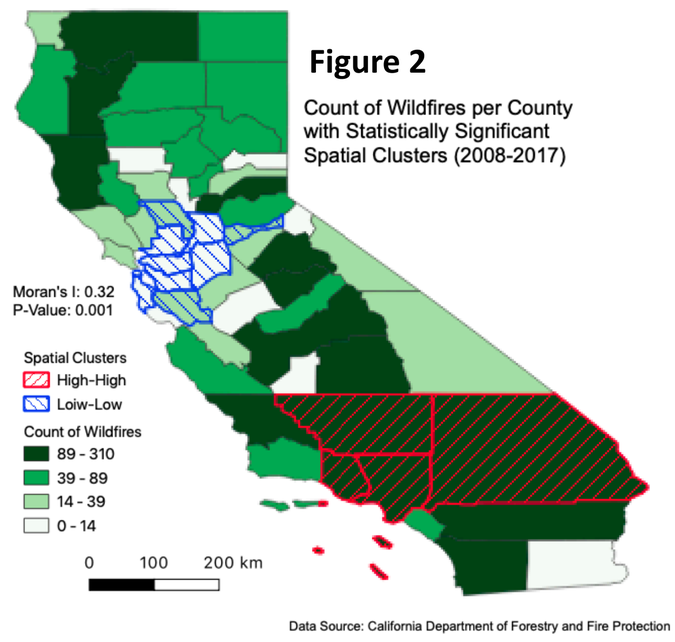

Figure 2
Count of Wildfires per County with Statistically Significant Spatial Clusters (2008-2017)

Data Source: California Department of Forestry and Fire Protection

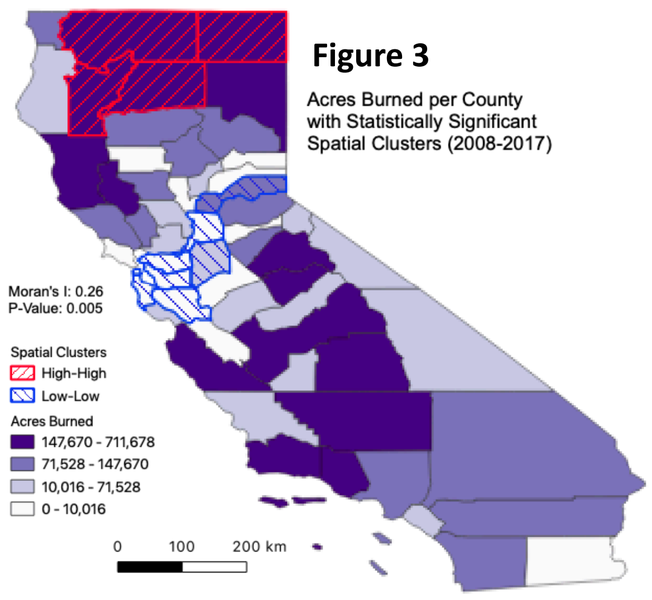

Figure 3
Acres Burned per County with Statistically Significant Spatial Clusters (2008-2017)

Data Source: California Department of Forestry and Fire Protection

RESULTS/DISCUSSION

There was no significant relationship between frequency of wildfires (p-value = 0.583) or intensity of wildfires (p-value = 0.814) and rate of asthma related ED admissions per 10,000 in California counties from 2008 - 2017. Overall, this model did a poor job of explaining the variance in asthma related ED visits (R-square = 0.015). While previous studies found significant associations between wildfires and asthma related ED visits immediately following occurrences, this study found no general trends across time or space.

There are limitations to this study. First, county level data were used and California counties represent extremely large and diverse geographic areas. Second, no other covariates were introduced into the model that could explain asthma related ED visits like SES, race, and access to healthcare or insurance. Future studies should expand their models and use census tract data if available.

REFERENCES

1. Williams AP, Abatzoglou JT, Gershunov A, et al. Observed Impacts of Anthropogenic Climate Change on Wildfire in California. *Earth's Futur*. 2019;7(8):892-910. doi:10.1029/2019ef001210
2. Climate change is making California's fires bigger. https://www.nationalgeographic.com/environment/2018/11/climate-change-california-wildfire/. Accessed November 9, 2019.
3. Will wildfires keep spreading with climate change? | Environmental Defense Fund. https://www.edf.org/climate/will-wildfires-keep-spreading-climate-change. Accessed November 9, 2019.
4. Most Recent National Asthma Data | CDC. https://www.cdc.gov/asthma/most_recent_national_asthma_data.htm. Accessed November 9, 2019.
5. Asthma Data Query - TrackingCalifornia.org. https://trackingcalifornia.org/asthma/query. Accessed November 9, 2019.
6. Asthma. https://www.cdph.ca.gov/Programs/CCDPHP/DEODC/EHIB/CPE/Pages/Asthma.aspx. Accessed November 9, 2019.
7. Duclos P, Sanderson LM, Lipsett M. The 1987 forest fire disaster in california: Assessment of emergency room visits. *Arch Environ Health*. 1990;45(1):53-58. doi:10.1080/00039896.1990.9935925
8. Viswanathan S, Eria L, Diunugala N, Johnson J, Mc Clean C. An Analysis of Effects of San Diego Wildfire on Ambient Air Quality. *J Air Waste Manag Assoc*. 2006;56(1):56-67. doi:10.1080/10473289.2006.10464439