RESEARCH NOTE

Pilot study of publicly available data to evaluate the relationship between forest fires and emergency department visits due to asthma in the state of California [version 1; peer review: 1 approved with reservations]

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Abstract

The focus of this study was to determine the relationship between asthma-related emergency department (ED) visits and fires in the state of California. Publicly available data of ED visits due to asthma, as well as occurrence of forest fires in California from 2005 to 2015 were obtained, where the California counties were grouped by region: North, Coastal, Motherload, Central, and South. There were no statistical differences with regards to acres of forest burned, but statistically significant differences were found (although small) with regards to ED visits due to asthma attacks by region (Motherload higher than South region). When evaluating the relationship of ED visits due to asthma and acres of forest burned, forest fires barely explained the variability of emergency department visits ($r^2 = 0.05$, $p < 0.01$). With aims to establish a connection between natural disasters and respiratory distress, we faced obstacles in data limitations and confounding variables. This paper serves as a pilot study supporting the need for further exploration of environmental, health, and socio-demographic variables that interplay when evaluating relationships of natural disasters and incidence of chronic diseases, such as asthma.

Keywords

asthma, forest fires, California, acres burned

Peer review discontinued

At the request of the author(s), this article is no longer under peer review. [What does this mean?](#)

Approval Status

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Any reports and responses or comments on the article can be found at the end of the article.

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Introduction

Forest fires are devastating events causing widespread damage and contributing enormous environmental pollution^{1,2}. According to the [National Interagency Fire Center](#), in 2017 there were 9,988 fires within the state of California. While the immediate effects of forest fires are well known, the lingering implications are less apparent. As some of the main by-products of forest fires are CO₂ and PM_{2.5}^{3,4}, questions remain with regards to how forest fires contribute to the incidence of respiratory diseases.

Asthma is a chronic respiratory illness characterized by the constriction of the bronchi, leading to difficult breathing and sometimes irreversible respiratory tissue remodeling⁵. According to the [US Center of Disease and Control and Prevention](#), there is an asthma prevalence of 7.7% among the population in California. Because asthma symptoms can be exacerbated by airborne pollutants, such as CO₂ and PM_{2.5}^{6,7}, we hypothesized that an increase in acres of forest burned would be linked to increased emergency department (ED) visits due to asthma.

Methods

Dataset

Data was retrieved from the [California Environmental Health Tracking Program](#). The inclusion criteria to extract the data included ED visits due to asthma, all ages, all races/ethnicities, and all genders.

Reported forest fires were collected from the [Historical Wildfire Activity Statistics section](#) (HWAS) of the California Department of Forestry and Fire Protection. Only fires greater than 300 acres were included in the final dataset; as per [National's Park Services terminology](#), fires above 300 acres burned are considered large fire events. For this data, during some years, some counties had missing values because they did not reach the 300 acres threshold.

Both datasets were inclusive to an 11-year period (January to December, 2005–2015).

Statistical analysis

Statistical analysis was performed with R (version 3.5.0, <https://www.r-project.org/>). California's counties were grouped into regions ([Figure 1](#)). Given the size of the state and no present guidelines for grouping of each county, we grouped counties by proximity into North, Coastal, Central, Motherload, and South regions. This classification was carried out within the R script included in Supplementary File 1. A pairwise t-test, with Bonferroni adjustment, was implemented to compare both the acres burned and the asthma rate, respectively, per region. A linear regression model, adjusted by year and region, was elaborated to evaluate the relationship between acres burned and ED asthma visits. $p < 0.05$ was considered statistically significant.

Figure 1. Counties of California grouped into the regions used by the present study.

Results

Each county was assigned to a region based on geography and proximity. As existing maps were unable to distribute California's counties evenly, we used a breakdown of regions (Figure 1). Table 1 provides the mean acres burned and mean asthma rates per region. The ED asthma visits rates were above 50% except for the South and Motherload regions. A pairwise t-test with Bonferroni adjustment did not detect statistically significant differences in acres burned between the regions ($p = 0.38$ to 1.0 ; Table 2).

Table 1. Mean acres burned and mean asthma rates for each California region between 2006 and 2015.

Region	Mean acres burned	Mean asthma rates (%)
North	26137	53.7
South	17541	48.8
Central	16167	52.2
Coastal	12553	50.1
Motherload	9758	43.0

On the contrary, a statistically significant difference ($p = 0.003$) was found between the South (48.8%) and the Motherload (43.0%) region with regards to asthma rates. A linear regression model, adjusting for years and region, was employed to evaluate the magnitude of relationship between acres burned and ED asthma visits (Figure 2). In this model, and although statistically significant ($p = 0.005$), forest fires only explained less than 5% of the variability of the ED asthma visits between the years 2006 to 2015 ($r^2 = 0.047$). These results suggest that although regions within California may differ in ED asthma visits, forest fires did not explain these differences.

Dataset 1. Forest fires acres burned and emergency department visits due to asthma for California, January-December 2005–2015

<http://dx.doi.org/10.5256/f1000research.15839.d213397>

Discussion

In this study, data on forest fires within the state of California was compiled to address the potential relationship with ED asthma visits. As per our linear regression model, there was no link between the ED asthma visits and acres of forest burned. Future research should account for the additional variables related to asthma as well as forest fires.

Table 2. p -values of pairwise t-test, with Bonferroni adjustment, comparing acres burned and asthma rates by region.

Comparison of acres burned					Comparison of ED rates due to asthma				
Region	Central	Costal	Motherload	North	Region	Central	Costal	Motherload	North
Coastal	1.00	-			Coastal	1.00	-		
Motherload	1.00	1.00	-		Motherload	0.15	1.00	-	
North	1.00	0.78	0.30	-	North	1.00	1.00	0.12	-
South	1.00	1.00	1.00	1.00	South	1.00	0.14	>0.01	1.00

Figure 2. Asthma rate per acres burned in California counties between 2006 and 2015.

In the current study, forest fires barely explained the ED visits from asthma during the years 2006 to 2015. It is possible that these ED asthma visits may have resulted from other stimuli, such as biological and non-biological indoor and outdoor air pollution besides forest fires^{8–10}. Also, California participates in different programs that may reduce ED visits like the [National Asthma Control Initiative](#), which was developed by the US National Institute of Health.

Interestingly, asthma rates varied across all regions. The Motherload region had significantly lower mean asthma rates than the North region. This finding further warrants additional investigations into the asthma rates within states susceptible to natural disasters and diverse geographic and topography, such as the state of California. Future studies may shed light on the interplay of forest fires, environmental variables, and chronic respiratory diseases, such as asthma.

Limitations came in several forms. First, fires are known to often cross county lines, which makes it difficult to assign appropriate values per county. Next, the Alpine county was not included in the dataset due to the lack of data relating to asthma. News coverage on forest fires may warn the population of areas to avoid, which potentially reduces the number of ED visits and could explain the decline in asthma rates as acres of forest burned increase ([Figure 2](#)) because some counties did not report forest fires above the 300 acres threshold. Also, the data on asthma rates was available by year, not by month, thus reducing our ability to match forest fires and asthma rates monthly. Finally, it is possible that ED asthma visits may also be modified by another variable; therefore, tracking the sale and consumption of asthma medication could provide more reliable

information of asthma exacerbation rates as the result of forest fires.

In summary, findings from the current study warrant examination of additional variables that could potentially contribute to environmental air pollution, besides forest fires, and are also linked to exacerbations of asthma. These include sociodemographics, medication sales due to asthma, and others that could shed light on the activities that the people of California implement during forest fires events.

Data availability

F1000Research Dataset 1: Forest fires acres burned and emergency department visits due to asthma for California, January–December 2005–2015. DOI, [10.5256/f1000research.15839.d213397](https://doi.org/10.5256/f1000research.15839.d213397)¹¹

Data for emergency department visits due to asthma: <http://www.cehtp.org/page/asthma/query>

Data for forest fires: http://www.fire.ca.gov/fire_protection/fire_protection_fire_info_redbooks

The full dataset is available as [Dataset 1](#).

R code for performing the analysis is available in [Supplementary File 1](#).

Competing interests

No competing interests were disclosed.

Grant information

The author(s) declared that no grants were involved in supporting this work.

Supplementary material

Supplementary File 1: R code used for analysis of asthma and fires in California.

[Click here to access the data.](#)

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Version 1

Reviewer Report 21 February 2019

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Brian G. Oliver

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This is an interesting pilot study examining the relationship between forest fires and visits to the hospital for asthma.

The main limitation of the study was the data available, in particular large forest fires of above 300 acres were included, and asthma treatment in emergency departments was only available as a yearly figure.

There are many studies which show that the rates of hospital admissions increases in the days/weeks following a woodland fire, so the analysis which was able to be undertaken in the present study may not be sensitive enough to detect increases immediately after fires. This perhaps could have been mitigated if there were several years in which there were no fires and and several with, or counties without any fires versus these with fires.

Another limitation of the study was the inability to be able to predict the "normal" and fire induced PM load in the townships near the fires and explore the impact that this had on admissions for asthma.

I am not familiar with the geography of this region, but do for example people burn wood fires for heating in winter, what effect does this have.

This study could be improved by inclusion of a set of recommendations for the type of data that should be analysed.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: respiratory diseases

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 05 Mar 2019

Felix Rivera-Mariani, Larkin University College of Biomedical Sciences, USA

Reviewer: The main limitation of the study was the data available, in particular large forest fires of above 300 acres were included, and asthma treatment in emergency departments was only available as a yearly figure.

- ***We agree that the magnitude of data was a considerable limitation. For example, it prevented us from presenting visual representation in daily, weekly, or monthly intervals***

Reviewer: There are many studies which show that the rates of hospital admissions increases in the days/weeks following a woodland fire, so the analysis which was able to be undertaken in the present study may not be sensitive enough to detect increases immediately after fires. This perhaps could have been mitigated if there were several years in which there were no fires and several with, or counties without any fires versus these with fires.

- ***We thank the reviewer for this comment. We proceeded to elaborate on possible explanations that would have affected the sensitivity of the statistical analysis.***

Reviewer: Another limitation of the study was the inability to be able to predict the "normal" and fire induced PM load in the townships near the fires and explore the impact that this had on admissions for asthma.

- ***We definitely agree with the reviewer on this point, and we consider this type of analysis. Due to page limitations and the pilot nature of the current study, we were not able to include additional predictive analysis to the current study. We would like to follow up on this in future studies of forest fires and respiratory diseases.***

Reviewer: I am not familiar with the geography of this region, but do for example people burn wood fires for heating in winter, what effect does this have.

- ***Thanks to the reviewer for bringing this point. We won't be able to fully address how***

wood fires for heating in winter may have contributed to the incidence of forest fires. It is possible that the dataset included this cause of fire as "Miscellaneous or Undetermined" -- the other categories were arson, campfire, debris burning, electrical power, equipment use, railroad, smoking, and Vehicle.

Reviewer: This study could be improved by inclusion of a set of recommendations for the type of data that should be analyzed.

- **We thank the reviewer for this suggesting. We proceeded to update the limitation paragraph to include this recommendation.**

Competing Interests: There are no competing interest to disclose.

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