The Effect of Smoke on Human's Respiratory and Cardiovascular Health: A short-term analysis of 2017 Thomas Wildfire in Ventura and Santa Barbara, Southern California

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Introduction

- Wildfires have been increasing in frequency and severity in western America
- Occur in summer and fall seasons when the temperature is high and the humidity is low
- The risk of wildfires is predicted to increase due to climate change
- Smoke pollutants: nitrogen dioxide, ozone, carbon monoxide, polycyclic aromatic hydrocarbons, aldehydes, and particulate matter PM_1, $PM_{2.5}$, and PM_{10}
- Concerns about the potential adverse health impacts of exposure to wildfire smoke

The negative impact of smoke on health

- Respiratory – Sheldon and Sankaran (2017), Holm et. al. (2020) in children, Swiston et. al. (2008) in firefighters
- Cardiovascular – Johnston et. al. (2014), Chen at. al. (2021)
- Cardiorespiratory – Mott et al. (2005), Kochi et. al. (2012)
- Reid et. al. (2016) mentioned that smoke can cause other health problems such as lung diseases, asthma, pneumonia and bronchitis, and health-related problems. It can also cause morbidity and mortality.

California has the highest risk

Table 1. Top 10 States For Wildfires Ranked By Number Of Fires And By Number Of Acres Burned, 2020

Rank	State	Number of fires	Rank	State	Number of acres burned
1	California	10,431	1	California	4,092,151
2	Texas	6,713	2	Oregon	1,141,613
3	Arizona	2,524	3	Arizona	978,568
4	Montana	2,433	4	Washington	842,370
5	Florida	2,381	5	Colorado	625,357
6	North Carolina	2,364	6	Montana	369,633
7	Oregon	2,215	7	Wyoming	339,783
8	New Jersey	1,981	8	Utah	329,735
9	Georgia	1,699	9	Idaho	314,352
10	Washington	1,646	10	Nevada	259,275

Source: National Interagency Fire Center.

Top 20 largest California wildfires

FIRE NAME (CAUSE)	DATE	COUNTY	ACRES	STRUCTURES	DEATHS
1 AUGUST COMPLEX *(Lightning)*	August 2020	Mendocino, Humboldt, Trinity, Tehama, Glenn, Lake, & Colusa	1,032,648	935	1
2 DIXIE *(Under Investigation)*	July 2021	Butte, Plumas, Lassen, Shasta & Tehama	963,309	1,329	1
3 MENDOCINO COMPLEX *(Human Related)*	July 2018	Colusa, Lake, Mendocino & Glenn	459,123	280	1
4 SCU LIGHTNING COMPLEX *(Lightning)*	August 2020	Stanislaus, Santa Clara, Alameda, Contra Costa, & San Joaquin	396,624	222	0
5 CREEK *(Undetermined)*	September 2020	Fresno & Madera	379,895	853	0
6 LNU LIGHTNING COMPLEX *(Lightning/Arson)*	August 2020	Napa, Solano, Sonoma, Yolo, Lake, & Colusa	363,220	1,491	6
7 NORTH COMPLEX *(Lightning)*	August 2020	Butte, Plumas & Yuba	318,935	2,352	15
8 THOMAS *(Powerlines)*	December 2017	Ventura & Santa Barbara	281,893	1,063	2
9 CEDAR *(Human Related)*	October 2003	San Diego	273,246	2,820	15
10 RUSH *(Lightning)*	August 2012	Lassen	271,911 CA / 43,666 NV	0	0
11 RIM *(Human Related)*	August 2013	Tuolumne	257,314	112	0
12 ZACA *(Human Related)*	July 2007	Santa Barbara	240,207	1	0
13 CARR *(Human Related)*	July 2018	Shasta County & Trinity	229,651	1,614	8
14 MONUMENT *(Lightning)**	July 2021	Trinity	223,124	50	0
15 CALDOR *(Under Investigation)*	August 2021	Alpine, Amador, & El Dorado	221,835	1,003	1
16 MATILIJA *(Undetermined)*	September 1932	Ventura	220,000	0	0
17 RIVER COMPLEX *(Lightning)**	July 2021	Siskiyou & Trinity	199,343	122	0
18 WITCH *(Powerlines)*	October 2007	San Diego	197,990	1,650	2
19 KLAMATH THEATER COMPLEX *(Lightning)*	June 2008	Siskiyou	192,038	0	2
20 MARBLE CONE *(Lightning)*	July 1977	Monterey	177,866	0	0

There is no doubt that there were fires with significant acreage burned in years prior to 1932, but those records are less reliable, and this list is meant to give an overview of the large fires in more recent times.
This list does not include fire jurisdiction. These are the Top 20 regardless of whether they were state, federal, or local responsibility.
*Numbers not final.

10/25/2021

Thomas Wildfires

- Started on December 4, 2017 → North of Santa Paula and south of Thomas Aquinas College
- Affected Ventura and Santa Barbara
- Burned 281,893 acres – the largest wildfires in California at the time
- Caused by powerlines coming into contact during high winds

Motivation of the research

- In general, the research is motivated by the stated problems:
  1. Wildfires caused a serious problems on health of respiratory system and cardiovascular
  2. Implement a research in California using a massive wildfires incident in 2017 to see the effect of smoke on health outcomes

Research questions

1. Does the wildfires incident increase the number of Emergency Department (ED) visits for respiratory problem?
2. Does the wildfires incident increase the number of Emergency Department (ED) visits for cardiovascular health problem?
3. What gender and age groups are mostly affected by the wildfires incident?

Literatures

- Many studies use $PM_{2.5}$ or PM_{10} as an indicator of air pollution level that can cause the health outcome (Kunzli et. al., 2006, Doubleday et. al. 2020)
- Some studies compares the health outcomes of smoky and non-smoky days (Johnston et. al., 2011, Faustini et. al., 2015)
- Estimating health effect of air pollution sometimes can be tricky due to endogeneity problem of policy changes and macroeconomic trends (Sheldon and Sankaran, 2017)
- 2SLS regressions were usually applied to estimate the effect of smoke on health by using predicted $PM_{2.5}$ or PM_{10} as an instrument for air pollution level.
- Studies using DiD approach to estimate the effect of smoke on health outcome in California are rarely found. I found one study using DiD by Kochi et. al. (2012). They studies the case of California wildfires in 2003 about the effect of smoke on cardiopulmonary morbidity.
- This study will take advantage of a discrete timing of Thomas Wildfires incident in December 2017 to implement a DiD approach

Literatures

- Raid et. al. (2016) found significant increases in asthma hospitalizations, asthma ED visits, and COPD ED visits as $PM_{2.5}$ exposure increases during 2008 northern California wildfires
- DeFlorio-Barker et. al. (2019) discovered an increase in cardiopulmonary hospitalizations among older group ≥ 65 years old caused by smoke in the US 2008-2010
- Kunzli et. al. (2006) found the effect of 2003 smoke on children health including nose, eyes, and throat irritations; cough; bronchitis; cold; wheezing; and asthma attacks
- Most studies were collected data from wildfires incident before 2017. This study will bring a fresh case of 2017 wildfires to see health impact of wildfires smoke.

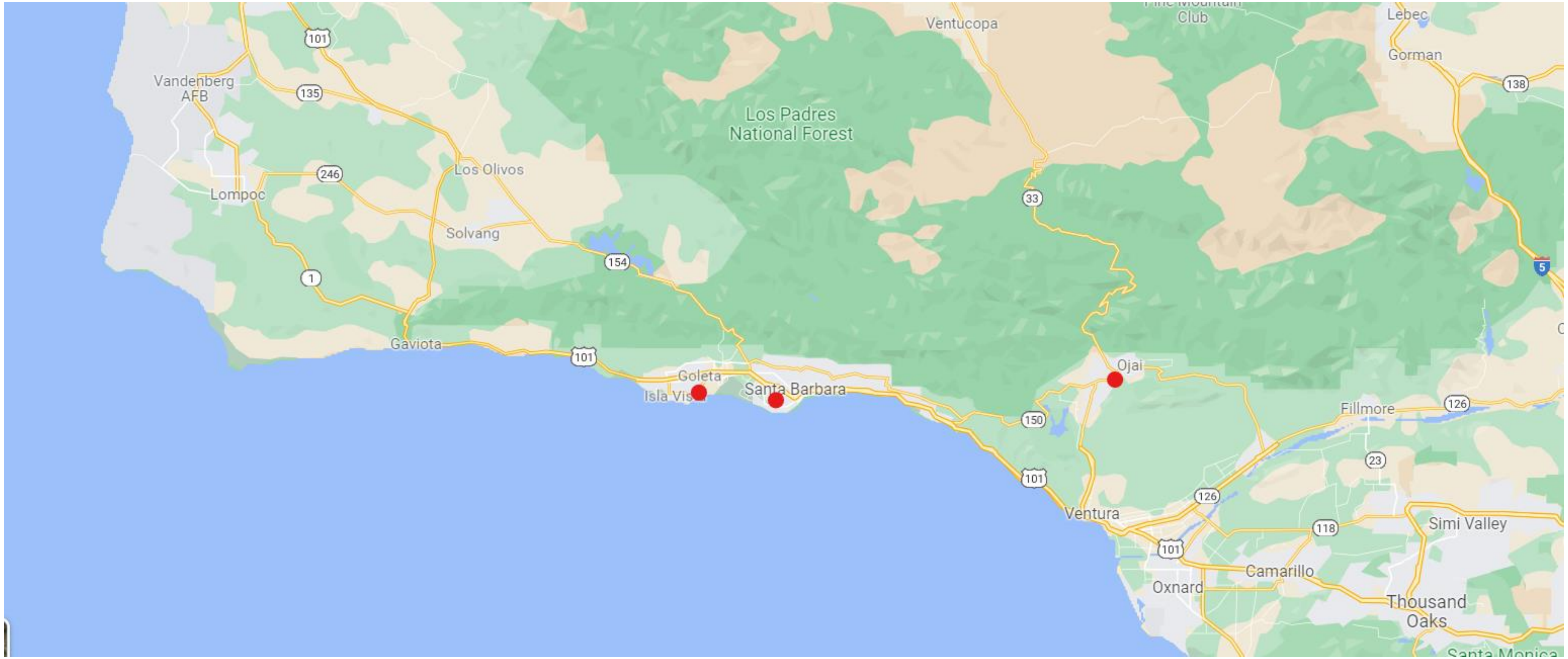
Main contributions

1. Using a DiD approach to assess the effect of smoke on health outcomes
2. Analyzing a newer case of 2017 wildfires in Southern California
3. Presenting the effect of smoke on health outcomes across different gender and age groups

Data collection

- Number of daily ED visits from respiratory and cardiovascular-related causes → Generated from California Department of Health Care Access and Information (hcai.ca.gov)
- County level data of Daily $PM_{2.5}$ from Environmental Protection Agency (EPA)

Treatment group



*Control groups will be decided after getting the complete data of daily ED visits

Model

$$Health = \beta_0 + \beta_1 \, Time + \beta_2 \, Area + \beta_3 \, Time \times Area + \varepsilon \qquad (1)$$

Where:

- Health = number of daily ED visits from respiratory or cardiovascular-related causes
- Time = 1 if the observation is from after the incident or the study period (12/5/2017 – 12/18/2017), and 0 is otherwise (before)
- Area = 1 if the observation falls in the affected area such as Ojai, Santa Barbara and Goleta (treatment group), and 0 is otherwise (control group)
- Time x Area = interaction term between time and the treatment group
- ε = error term

*I will also compute regression based on gender and age groups

Potential issues

- Seasonal endogenous variable such as weather:
  - Use a control period immediately before the wildfire event started
  - Use 2-week reference (before and after) because the $PM_{2.5}$ daily levels after the incident is between those two periods can be more than 3 times higher.
  - Initial assumption: ED visits had risen two weeks after the event. I need to make sure the jump of respiratory and cardiovascular ED visits during that period.

- There might be a lagged health effect of smoke:
  - I will also calculate the regression using 1 week and 2 week after the study period

Calculate lagged health effects

$$Health = \delta_0 + \delta_1 \text{Post1} + \delta_2 Area + \delta_3 Post1 \times Area + \mu$$

$$Health = \Upsilon_0 + \Upsilon_1 \text{Post2} + \Upsilon_2 Area + \Upsilon_3 Post2 \times Area + \theta$$

Where:

- Post1 = 1 if the observation is in a week after the study period and 0 is otherwise
- Post2 = 1 if the observation is in two week after the study period, and 0 is otherwise

Preliminary findings

Data of $PM_{2.5}$

- 1 out of 5 $PM_{2.5}$ monitoring stations will be used in Ventura, while 2 out of 5 $PM_{2.5}$ monitoring stations will be used in Santa Barbara
- A high jump in the $PM_{2.5}$ levels for 9-13 days in Ojai (Ventura), Santa Barbara, and Goleta (Santa Barbara)

Table 3. Daily mean $PM_{2.5}$ levels in Ojai, Santa Barbara, and Goleta

Ojai

Date	Daily Mean
11/28/2017	9.7
11/29/2017	10.2
11/30/2017	10.8
12/1/2017	10.2
12/2/2017	11.8
12/3/2017	13
12/4/2017	10.5
12/5/2017	149.5
12/6/2017	557
12/7/2017	186.5
12/8/2017	529.4
12/9/2017	178.8
12/10/2017	47
12/11/2017	49.4
12/12/2017	175.3
12/13/2017	130
12/14/2017	64.3
12/15/2017	88.1
12/16/2017	100.7
12/17/2017	34.1

SB

Date	Daily Mean
11/28/2017	8
11/29/2017	8.7
11/30/2017	8.1
12/1/2017	10.7
12/2/2017	13.3
12/3/2017	13
12/4/2017	10
12/5/2017	54.8
12/6/2017	139.4
12/7/2017	231.6
12/8/2017	105.1
12/9/2017	96
12/10/2017	96.3
12/11/2017	91.2
12/12/2017	90.2
12/13/2017	81.2
12/14/2017	63
12/15/2017	54.6
12/16/2017	72.5
12/17/2017	40.7
12/18/2017	19.2

Goleta

Date	Daily Mea
11/20/2017	6.5
11/21/2017	3.1
11/22/2017	2.5
11/23/2017	6.8
11/24/2017	10.5
11/25/2017	10.9
11/26/2017	11.7
12/6/2017	72.6
12/7/2017	130.5
12/8/2017	77.2
12/9/2017	59.1
12/10/2017	84.9
12/11/2017	78.5
12/13/2017	60.9
12/14/2017	40.2
12/15/2017	40
12/16/2017	14.7

Preliminary findings

Data of ED visits

- For now, I got the yearly aggregate data on the ED visits of
- From this data, there is a rise in the respiratory ED visits from 2016 to 2017 in hospitals in Ojai, Santa Barbara, and Goleta
- I need to get *the daily ED visits* for both respiratory and cardiovascular problems to be able to do the regressions

Table 4. Number of ED Visits from Respiratory Problems

Hospital Name	2016	2017	Increase (%)
OJAI VALLEY COMMUNITY HOSPITAL	729	885	21%
SANTA BARBARA COTTAGE HOSPITAL	2809	2894	3%
GOLETA VALLEY COTTAGE HOSPITAL	1752	2113	21%

*Note: This yearly data do not represent the increase of ED visits before and after the incident

Future research

- Conduct the similar research using different cases to get a comparison analysis
- Allow an open area to estimate the economic cost of health impact from this research

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