Wildfire smoke and human health in the County of San Diego under Climate Change

Regional convenings on climate & health

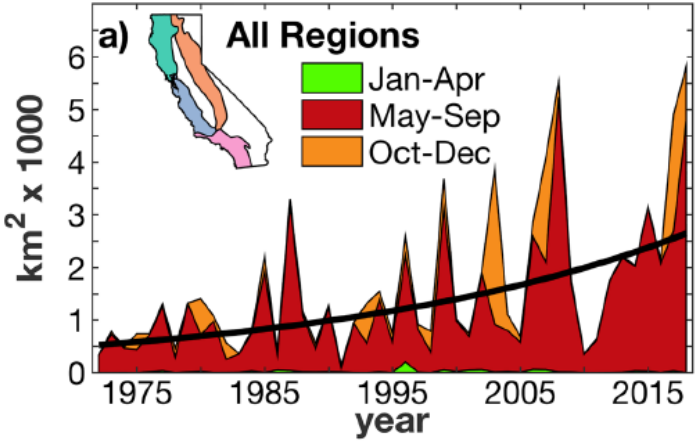
UC San Diego | SCRIPPS INSTITUTION OF OCEANOGRAPHY

OBJECTIVES

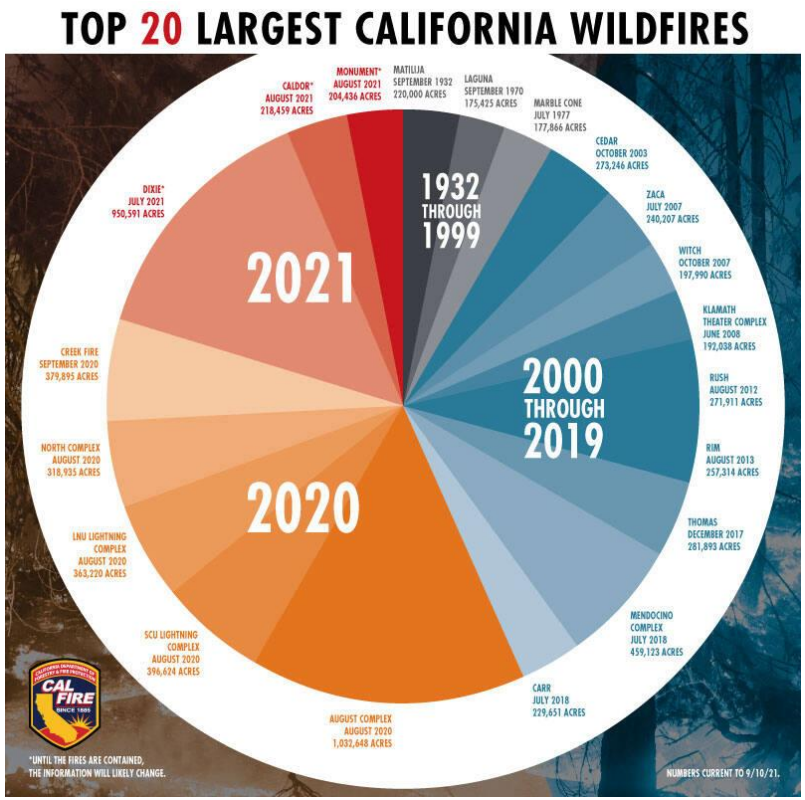
- Describe why wildfires are becoming more frequent and severe in the context of climate change
- Document the health impacts associated with wildfire smoke in San Diego

CALIFORNIA WILDFIRES

- Wildfires are becoming more frequent and severe in the context of CC
- But why?



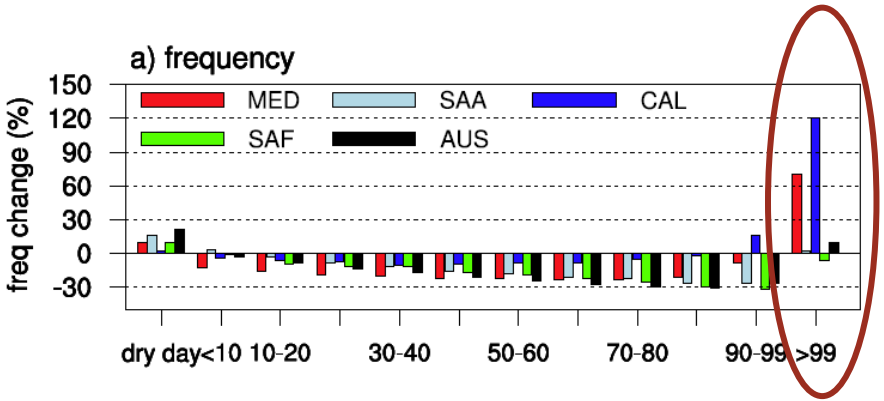
Williams, A. P., Abatzoglou, J. T., Gershunov, A., Guzman-Morales, J., Bishop, D. A., Balch, J. K., & Lettenmaier, D. P. (2019). Observed impacts of anthropogenic climate change on wildfire in California. *Earth's Future*.



Cal-Fire: https://www.fire.ca.gov

CHANGES IN PRECIPITATION REGIME IN CALIFORNIA

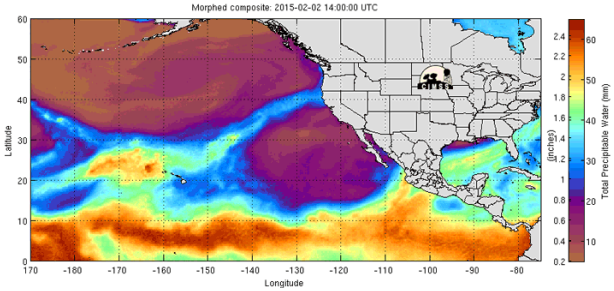
- Less raining days overall
- More extreme events (mostly due to atmospheric rivers)
- With a strong seasonality (in winter months)
- No change in the amount of rainfall. It is simply concentrated in fewer events



Precipitation in a warming world: Assessing projected hydro-climate changes in California and other Mediterranean climate regions

Suraj D. Polade[1], Alexander Gershunov[1], Daniel R. Cayan[1], Michael D. Dettinger[2] & David W. Pierce[1]

atmospheric rivers



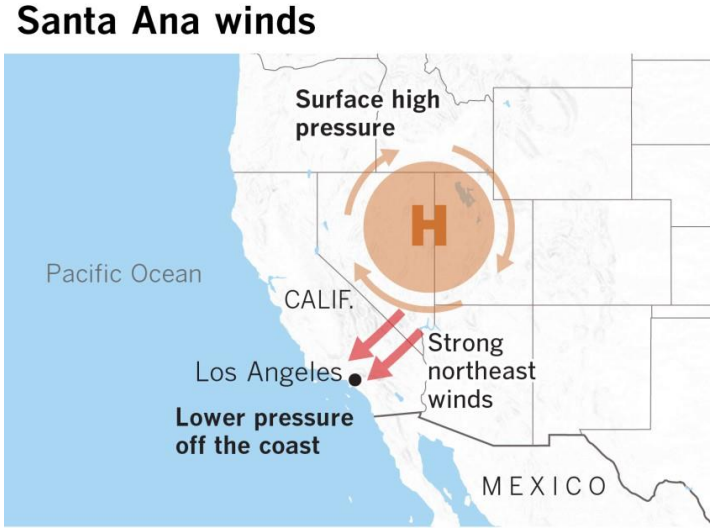
https://www.climatecentral.org/news/global-warming-atmospheric-rivers-18645

Polade, S. D., Gershunov, A., Cayan, D. R., Dettinger, M. D., & Pierce, D. W. (2017). Precipitation in a warming world: Assessing projected hydro-climate changes in California and other Mediterranean climate regions. *Scientific reports*, *7*(1), 10783.

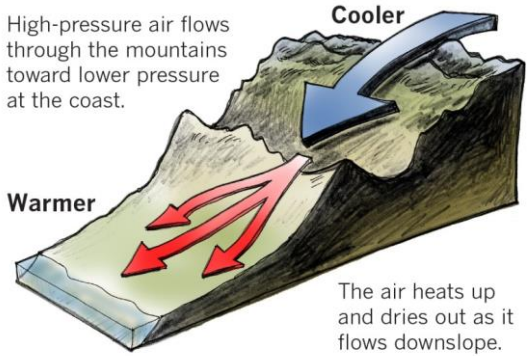
THE ROLE OF WINDS

- Conditions are ideal for wildfires to start in the Fall/late Summer
- This is when the **Santa Ana Winds** and Diablo Winds season also start
- Santa Ana and Diablo winds are strong, dry downslope winds in Southern California and northern Baja California
  - Brings hot temperatures
  - Trigger and expand wildfires
  - Transport smoke from wildfire to the coast

https://slate.com/news-and-politics/2017/12/southern-california-wildfires-santa-ana-winds.html

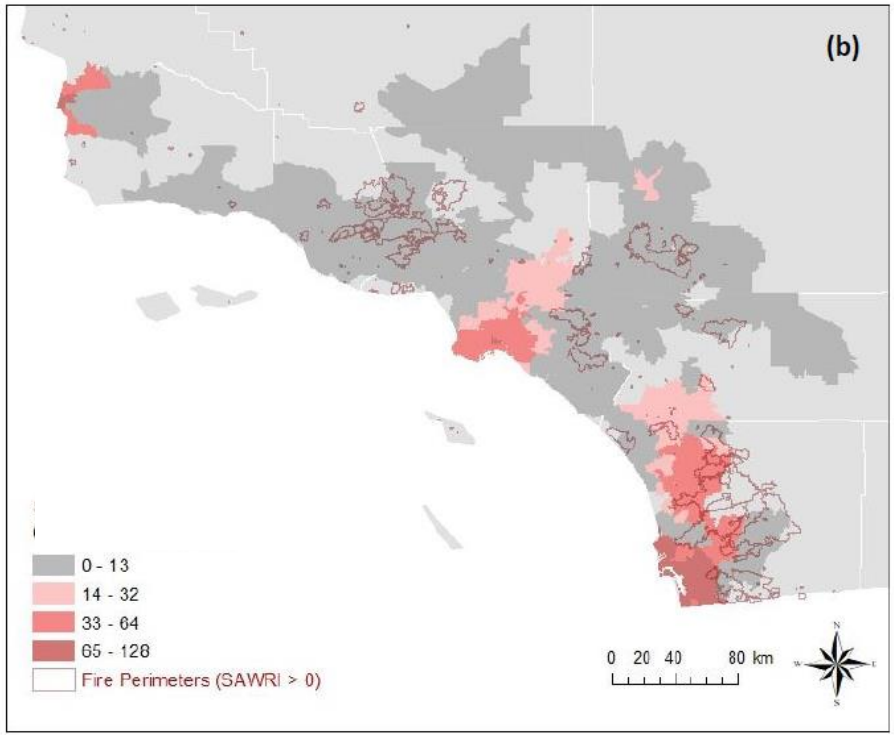


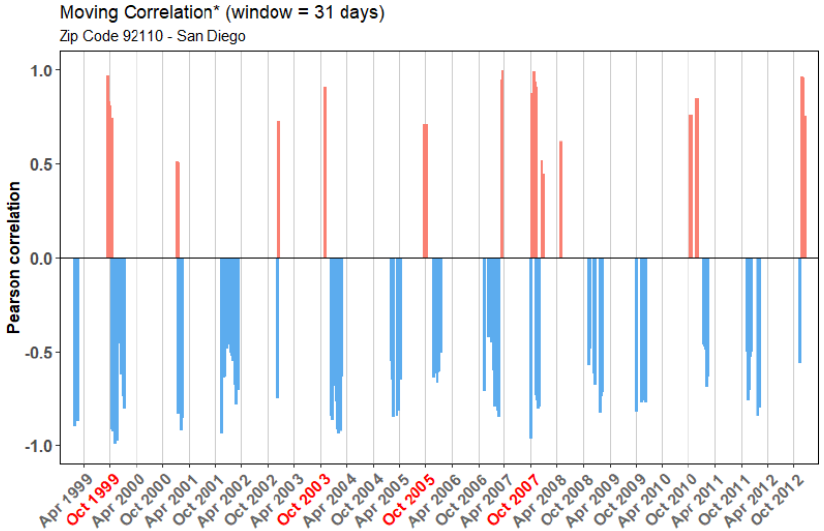
https://www.latimes.com/california/story/2019-10-09/what-makes-the-santa-ana-winds-blow



Santa Ana Winds of Southern California Impact $PM_{2.5}$ With and Without Smoke From Wildfires

Rosana Aguilera[1], Alexander Gershunov[1], Sindana D. Ilango[2,3], Janin Guzman-Morales[1], and Tarik Benmarhnia[1,2]





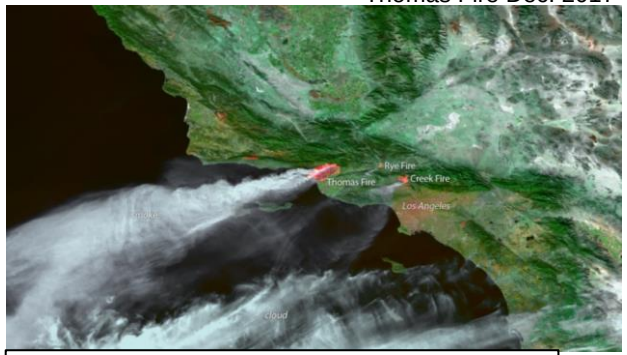
Key Points:

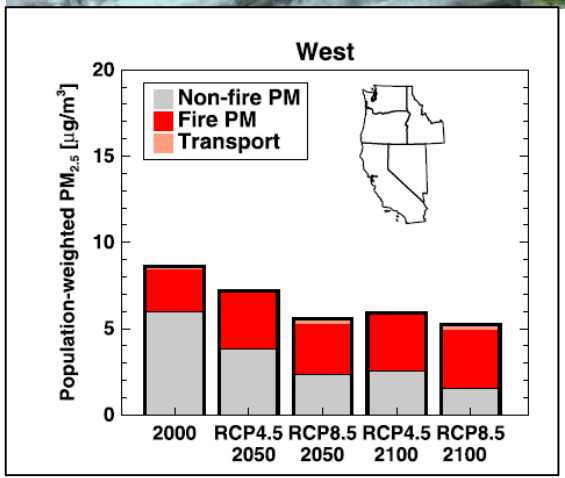
- Santa Ana winds have a predominant ventilation effect as background $PM_{2.5}$ is transported offshore from highly polluted areas
- A polluting effect occurs when SAWs spread smoke PM2.5 from wildfires in backcountry areas towards the coastal region
- Statistical approaches that relate wind and $PM_{2.5}$ over space and time can help in identifying wildfire $PM_{2.5}$

WILDFIRES, SMOKE AND PUBLIC HEALTH

- Wildfires have direct impacts (intoxication from CO, and other air pollutants from incomplete combustion, economic loss and mental health…) near affected zones
- Wildfires also generate **smoke** that can be transported over a long distance
- Air pollution, (mainly PM 2.5, but not only), generated by wildfire smoke events is associated with many health issues
- Smoke impacts may lead to a higher burden as large populations will be exposed to WF smoke PM2.5
- Overall PM2.5 is decreasing in CA, but PM2.5 from WF smoke is expected to increase (Ford et al. 2018)

Thomas Fire Dec. 2017

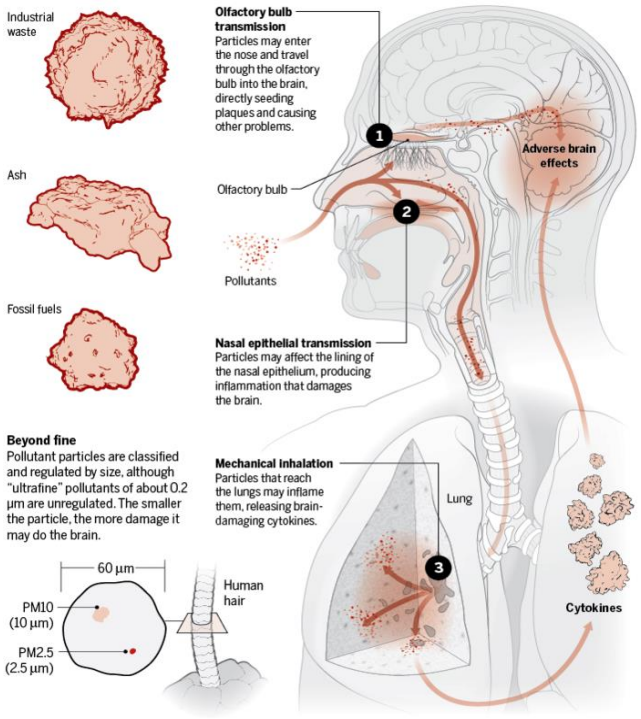




Ford, B., et al (2018). Future fire impacts on smoke concentrations, visibility, and health in the contiguous United States. *GeoHealth*, *2*(8), 229-247.

PM2.5 AND HEALTH IMPACTS

- Mechanisms are well documented and include :
  - pulmonary inflammation that may reduce lung function through bronchoconstriction
  - Oxidative Stress
  - Alteration of the pulmonary immune system



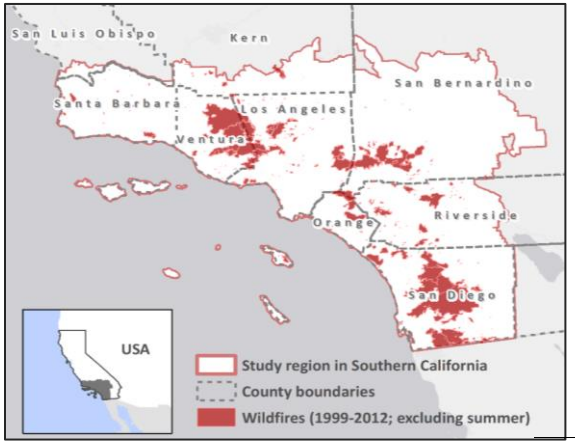
Source: Underwood, Science 2017

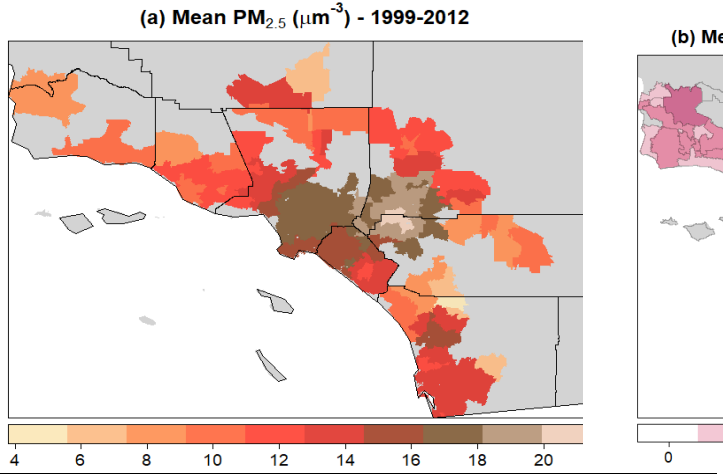
ARTICLE

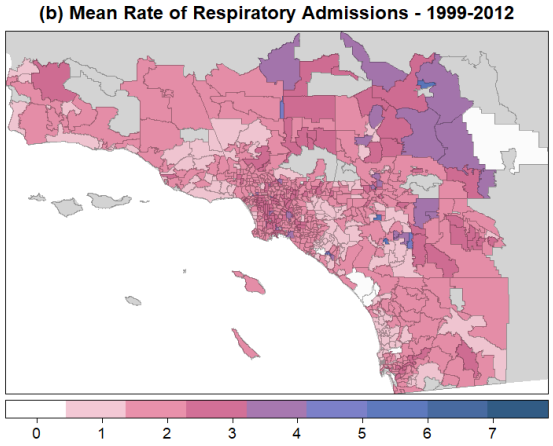
https://doi.org/10.1038/s41467-021-21708-0 OPEN

Wildfire smoke impacts respiratory health more than fine particles from other sources: observational evidence from Southern California

Rosana Aguilera[1,3✉], Thomas Corringham[1,3], Alexander Gershunov[1] & Tarik Benmarhnia[1,2]



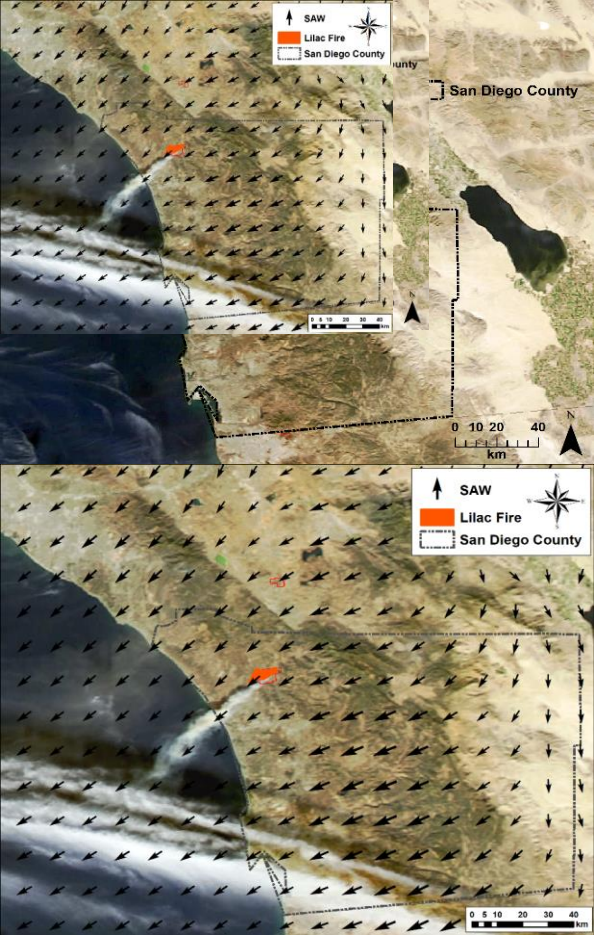




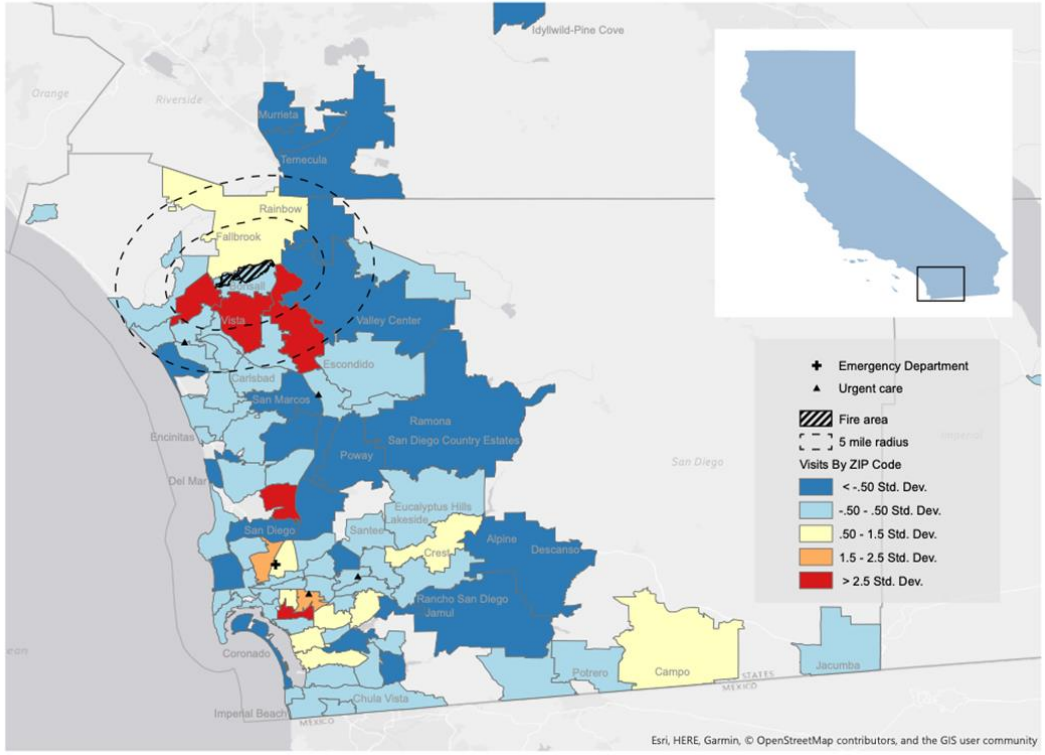
Regression Model for Respiratory Admissions (rate per 100,000 people)

Fire Upwind + Strong SAW (1999-2012)	**Aggregated sources** (smoke and non-smoke)	*Approach used to isolate wildfire-specific $PM_{2.5}$*						
		IV	**Imputation**		**Interaction**		**Seasonal Interpolation**	
		Wildfire-specific	Non-smoke	Wildfire-specific	Non-smoke	Wildfire-specific	Non-smoke	Wildfire-specific
% change with 10 ug m^{-3} $PM_{2.5}$ (95% CI)	**0.90 (0.59, 1.2)**	**12.5 (5.1, 19.9)**	**0.87 (0.55, 1.2)**	**9.8 (3.3, 16.3)**	**0.67 (0.48, 0.86)**	**1.28 (0.37, 2.19)**	**1.3 (0.94, 1.6)**	3.0 (-0.34, 6.3)

THE LILAC FIRE, 2017



Age-Adjusted Respiratory Visits During Lilac Fire, 2017



THE IMPACT OF THE LILAC FIRE ON PEDIATRIC HEALTHCARE UTILIZATION IN SAN DIEGO COUNTY

- The Lilac Fire in December 2017

	Average Daily Respiratory Hospitalizations (SD) (2014-2017)	Excess Daily Respiratory Hospitalizations during the Lilac Fire (95%CI)*	Excess Daily Respiratory Hospitalizations during the control period** (95%CI)
All	30.47 (17.69)	16.58 (11.55, 21.61)	-2.43 (-6.56, 1.71)
0-6 Years	22.46 (13.20)	7.67 (4.06, 11.27)	0.04 (-3.07, 3.15)
6-12 Years	5.24 (4.03)	3.58 (2.32, 4.85)	-1.10(-2.29, 0.08)
12+ Years	2.77 (2.45)	3.26 (2.32, 4.20)	- 1.22 (-1.98, 0.45)
English Language	22.18 (12.88)	10.02 (6.28, 13.76)	- 2.11 (-5.52, 1.30)
Other Language	8.29 (5.90)	4.19 (2.69, 5.68)	- 0.36 (-1.85, 1.14)

falsification test

Leibel, S. (2020). Increase in pediatric respiratory visits associated with Santa Ana wind–driven wildfire smoke and PM2. 5 levels in San Diego County. Annals of the American Thoracic Society, 17(3), 313-320.

SPATIAL VARIABILITY OF WILDFIRE SMOKE IMPACTS

Respiratory hospitalizations and wildfire smoke: a spatiotemporal analysis of an extreme firestorm in San Diego County, California

Rosana Aguilera[a,*§], Kristen Hansen[b,§], Alexander Gershunov[a], Sindana D. Ilango[b,c], Paige Sheridan[b,c], Tarik Benmarhnia[a,b]

Background: Wildfire smoke adversely impacts respiratory health as fine particles can penetrate deeply into the lungs. Epidemiological studies of differential impacts typically target population subgroups in terms of vulnerability to wildfire smoke. Such information is useful to customize smoke warnings and mitigation actions for specific groups of individuals. In addition to individual vulnerability, it is also important to assess spatial patterns of health impacts to identify vulnerable communities and tailor public health actions during wildfire smoke events.

Methods: We assess the spatiotemporal variation in respiratory hospitalizations in San Diego County during a set of major wildfires in 2007, which led to a substantial public health burden. We propose a spatial within-community matched design analysis, adapted to the study of wildfire impacts, coupled with a Bayesian Hierarchical Model, that explicitly considers the spatial variation of respiratory health associated with smoke exposure, compared to reference periods before and after wildfires. We estimate the signal-to-noise ratio to ultimately gauge the precision of the Bayesian model output.

Results: We find the highest excess hospitalizations in areas covered by smoke, mainly ZIP codes contained by and immediately downwind of wildfire perimeters, and that excess hospitalizations tend to follow the distribution of smoke plumes across space (ZIP codes) and time (days).

Conclusions: Analyzing the spatiotemporal evolution of exposure to wildfire smoke is necessary due to variations in smoke plume extent, particularly in this region where the most damaging wildfires are associated with strong wind conditions.

Key Words: California, Respiratory health, Spatiotemporal, Wildfire

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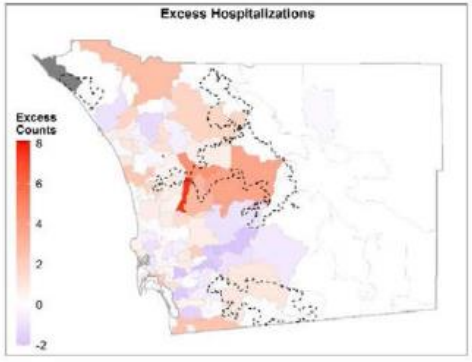
October 22, *Exposed Day 1*

D



October 26, *Exposed Day 5*

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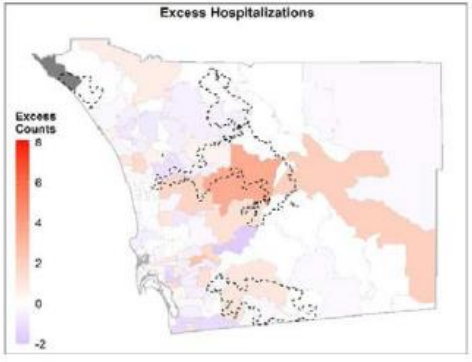

THANK YOU

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