

Social Vulnerability in U.S. Communities Affected by Wildfire Smoke

Brooke Lappe¹, Jason Vargo¹, and Kathryn Conlon¹

¹Affiliation not available

February 14, 2023

Social Vulnerability in U.S. Communities Affected by Wildfire Smoke



Brooke Lappe, Jason Vargo, Kathryn Conlon

1 Gangarosa Department of Environmental Health, Rollins School of Public Health, Emory University, Atlanta, GA; 2 Federal Reserve Bank of San Francisco, San Francisco, CA; 3 Department of Public Health Sciences, School of Medicine, University of California Davis, Davis, CA; 4 Department of Veterinary Medicine & Epidemiology, School of Veterinary Medicine, University of California Davis, Davis, CA



PRESENTED AT:



BACKGROUND

Smoke from large, uncontrolled fires, can travel thousands of miles, potentially exposing distant populations, including communities less prepared for smoke and more susceptible to adverse impacts from air pollution (1,2). Certain populations, such as children, older adults, or those who cannot avoid exposure, are especially vulnerable to smoke induced health effects.

Although the risk of wildfire can be clearly defined and used in planning, the movement of wildfire smoke over large areas means that unexpected exposures can occur. As with other ambient climate hazards, such as extreme heat, the characteristics of the local economy and residents play an important role in determining capacity to adapt and in explaining destabilizing impacts of wildfire smoke.

An individual's overall vulnerability is a combination of their exposure, sensitivity, and adaptive capacity—the relative ability to prepare for, respond to, and recover from wildfire smoke exposures. Vulnerability is impacted by a person's demographic and social characteristics such as socioeconomic status, housing situation, employment status, and job type.

We hypothesized that wildfire smoke impacts cut across different sectors, affecting public health and safety, the labor force, housing, property and infrastructure, and education. The following report estimates smoke exposures from 2011-2021 and discusses the impacts of wildfire smoke on communities of concern, including frontline workers, school-aged children, housing-vulnerable households and people experiencing homelessness, and communities eligible for federal investments.

To read the full report, scan the QR code in the top left corner.

METHODS

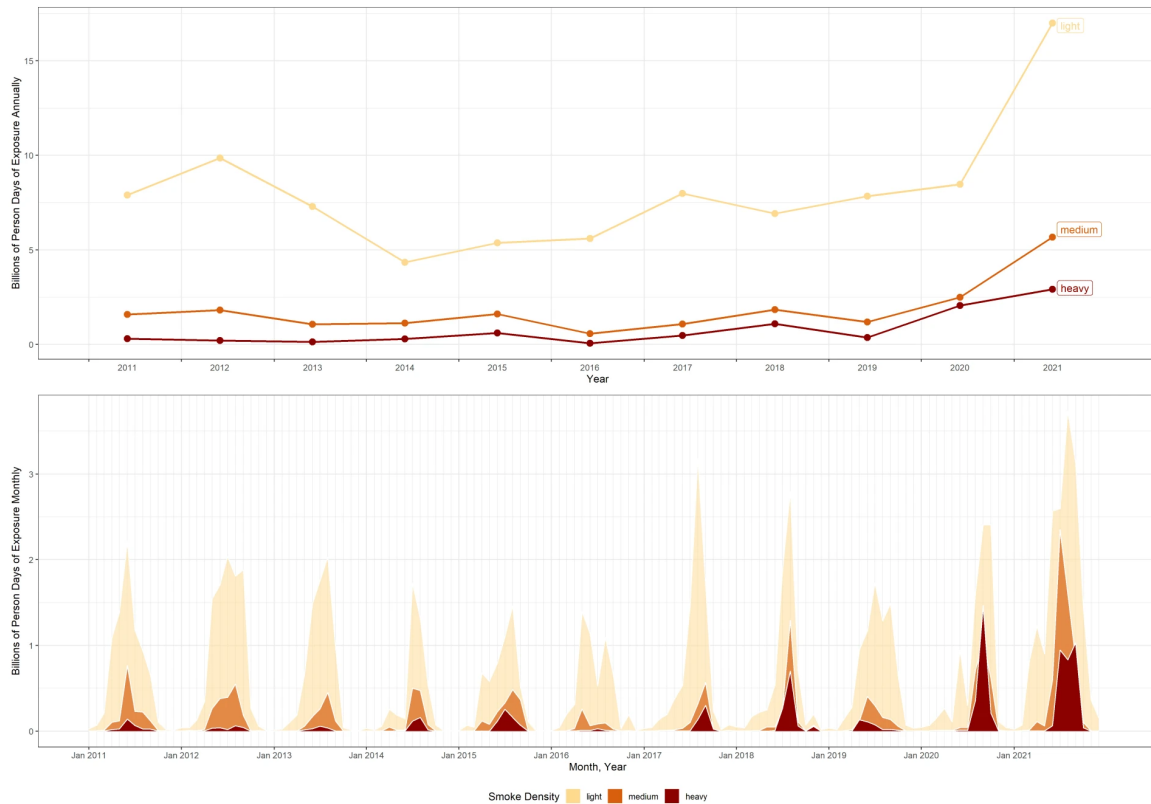
- Satellite data on light-, medium-, and heavy-density wildfire smoke plumes for each day in 2011–2021 to quantify exposure.
- Days of exposure to each type of smoke were linked with data American Community Survey (ACS), and Centers for Disease Control and Prevention (CDC) Social Vulnerability Index (SVI), Comprehensive Housing Affordability Strategy (CHAS) data to describe the co-occurrence of smoke exposure and social disadvantage.
- We used person- days to capture the number of people and the amount of time spent under smoke plumes.
- We characterized smoke exposure for:
 - CDC SVI groups
 - Frontline workers
 - School-aged children and children in poverty
 - Housing vulnerable people and people experiencing homelessness

RESULTS

National Wildfire Smoke Trends 2011-2021

Figure 1. Wildfire smoke exposures of all smoke densities have increased in recent years, with the largest increases in the most dangerous and disruptive category of smoke.

Annual (upper panel) and monthly (lower panel) person-days of smoke exposure, 2011-2021 (billions)



Source: Hazard Mapping System Smoke Product from National Oceanic and Atmospheric Administration (NOAA).

Figure 2. The number of days of heavy smoke experienced annually have increased in most places; increases in the western and northern states were the largest.

Mean number of days of heavy smoke for residents of each state from 2011 to 2021



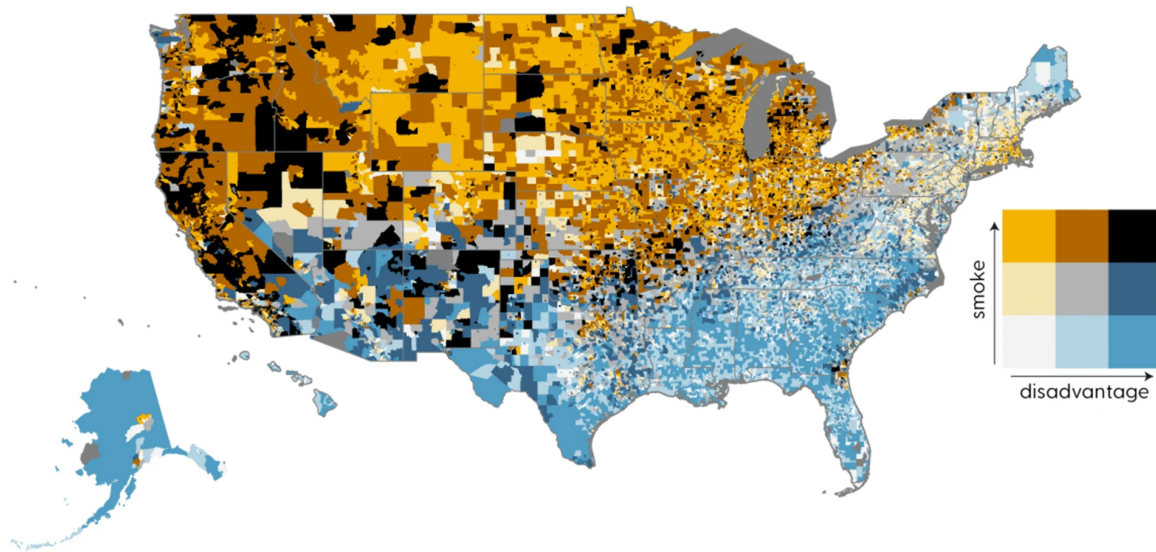
Source: Hazard Mapping System Smoke Product from National Oceanic and Atmospheric Administration (NOAA).

RESULTS

Wildfire Smoke and Social Vulnerability

Figure 3. The largest need for assistance and mitigation occurs where heavy smoke exposures and social vulnerabilities coincide—in the West and Upper Midwest.

Need-based map using heavy smoke exposure and Social Vulnerability Index (SVI)



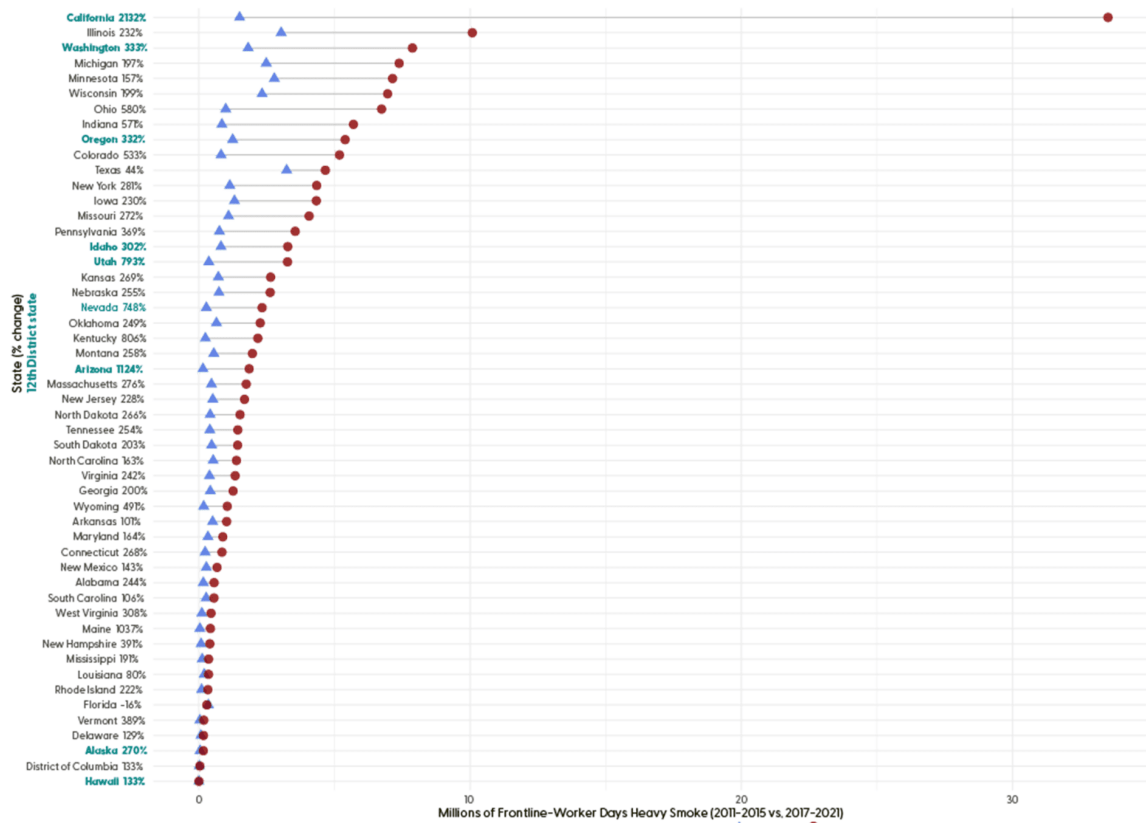
Source: Hazard Mapping System Smoke Product from National Oceanic and Atmospheric Administration (NOAA); Social Vulnerability Index (SVI) Estimates from Centers for Disease Control and Prevention (CDC)

Frontline Workers

Wildfires have uneven impacts across the labor force and especially affect those who work outdoors or in indoor situations lacking adequate air conditioning or ventilation— we define these workers as frontline workers. More than 34 million Americans are frontline workers, representing 23% of the nation's workforce.

Figure 4. The largest percentage increases in frontline worker heavy smoke days occurred in California (2132%) and Arizona (1124%).

Average annual frontline worker person-days of heavy smoke by state from 2011-2015 to 2017-2021



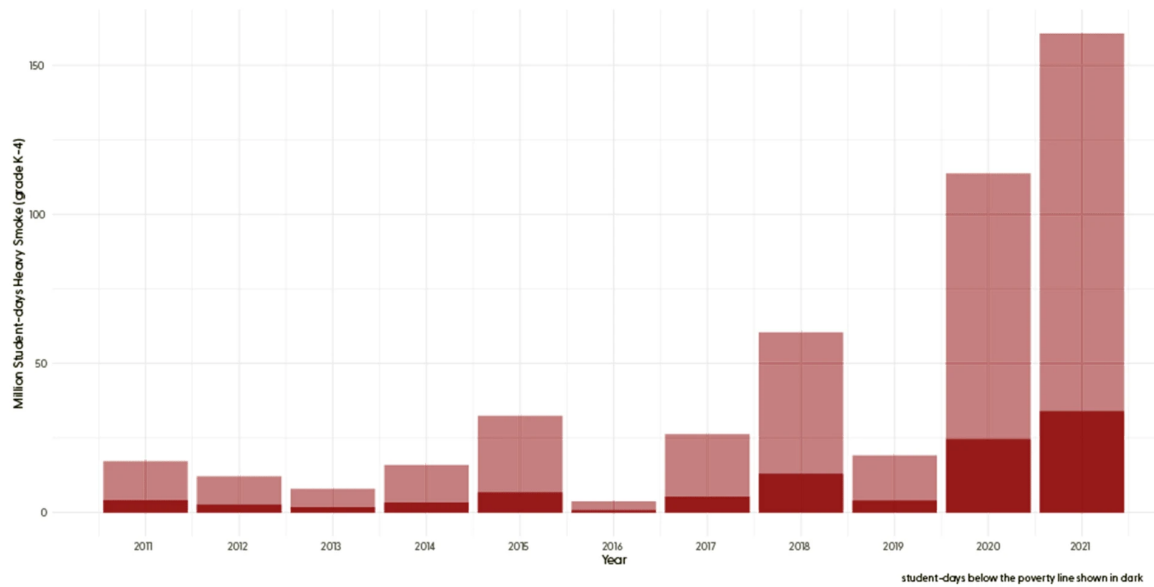
Source: American Community Survey (ACS) 2019, Industry by Occupation for the Civilian Employed Population 16 Years and Over; Hazard Mapping System Smoke Product from National Oceanic and Atmospheric Administration (NOAA).

Students

The development of the brain and organs throughout childhood and adolescence makes wildfire smoke potentially more damaging to children's health, with much more long-lasting permanent effects, compared to adults (WHO 2005). One way in which this exposure can be estimated is through ACS data on enrolled students and students in poverty.

Figure 5. Heavy smoke exposures among vulnerable students have increased dramatically in recent years. Younger students (grades K-4), particularly those in poverty, are most affected academically by school closures.

Student-days of heavy smoke for students above the poverty line (light) and below the poverty line (dark) from 2011 to 2021*

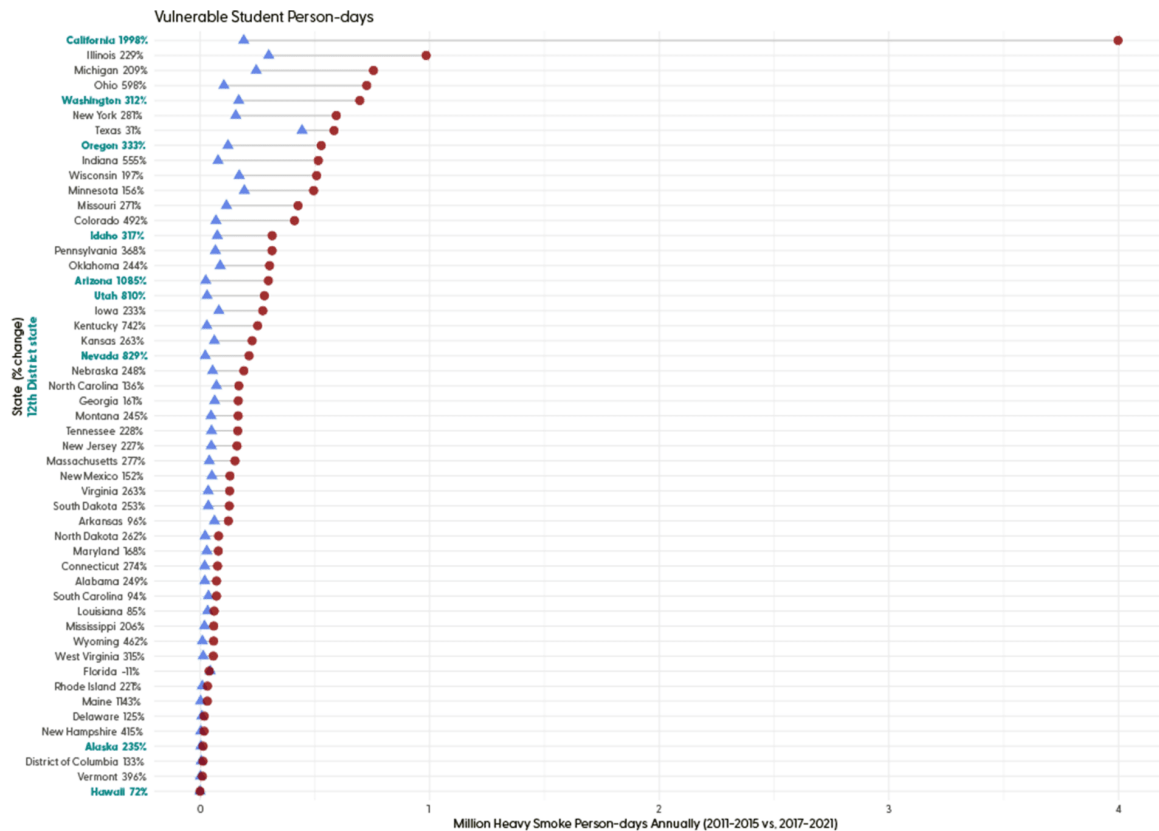


Source: American Community Survey (ACS) Five-Year Estimates 2019; Poverty Status in the Past 12 Months by School Enrollment by Level of School for the Population Three Years and Over (B14006); Hazard Mapping System Smoke Product from National Oceanic and Atmospheric Administration (NOAA).

*Reflects only changes in smoke over the study period and not changes to the number of students or students in poverty.

Figure 6. Heavy smoke exposure among students has increased dramatically in recent years across the United States.

Annual average student-days of heavy smoke by state from 2011-2015 to 2017-2021



Source: American Community Survey (ACS) Five-Year Estimates 2019; Poverty Status in the Past 12 Months by School Enrollment by Level of School for the Population Three Years and Over (B14006); Vargo 2020.

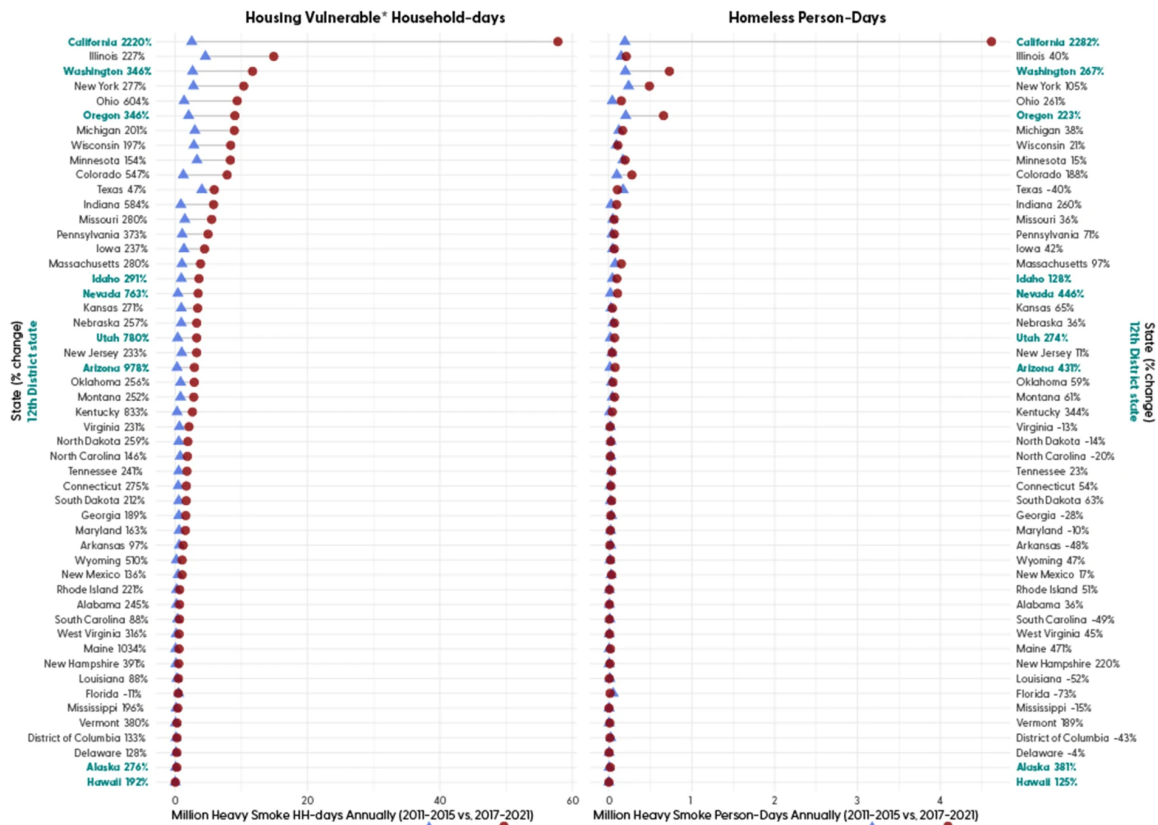
Housing-Vulnerable Populations and People Experiencing Homelessness

Affordable and safe housing is an important factor in dealing with many climate risks, as well as a commodity that is also threatened by climate risks. Homes are places of refuge from outdoor elements, such as wildfire smoke, and at the same time, fires pressure housing markets through loss of housing stock, limiting where new housing can be built, requiring retrofits, and increasing risks to existing properties. Housing tenure is a proxy for improvements and retrofits being installed. Few renters are in the position to invest in such improvements, and landlords are reluctant to pursue such investments.

Additionally, people experiencing homelessness face a lack of regular shelter, as well as access to information and resources to prepare for and respond to wildfires, which amplify their wildfire smoke and health risk. Many people experiencing homelessness are also working in low-wage, frontline jobs and thus represent a portion of the labor force especially vulnerable to disruptions from smoke exposures.

Figure 7. Increases in heavy smoke exposures were observed for housing-vulnerable people (left, including renters and cost-burdened owners in older homes) and for those experiencing homelessness (right) and were largest in western states frequently exposed to wildfires.

Average annual housing-vulnerable household-days (left) and homeless person-days (right) of heavy smoke by state from 2011-2015 to 2017-2021



*housing vulnerable include renter-occupied HHs and cost-burdened (>30% income) owner-occupied HHs built prior to 1980

Source: Comprehensive Housing Affordability Strategy Survey; Annual Homeless Assessment Report to Congress; Hazard Mapping System Smoke Product from National Oceanic and Atmospheric Administration (NOAA).

KEY TAKEAWAYS

- The 5-year annual average of person-days of heavy smoke increased 350% between 2011–2015 and 2017–2021. The increases for person-days of light and medium smoke were 39% and 71%, respectively.
- Over 78% (1,517) of U.S. counties experienced significant decreases in the number of smoke-free days. Similarly, 72%, 75%, and 87% of U.S. counties saw increases in the number of days of light, medium, and heavy smoke, respectively.
- Locations with the greatest health disadvantages (greatest barriers to living healthy lives) experienced a 358% increase in the average annual number of heavy smoke days. Similar increases in heavy smoke were observed when exploring those with the greatest disadvantage specific to socioeconomic status (346%), race/ethnicity/language (449%), household composition and disability (309%), and housing and transportation (357%).
- Frontline worker–days of heavy smoke increased for 49 states. The largest absolute frontline worker–days of heavy smoke were seen in California (33,522,008), Illinois (10,083,191), and Washington (787,526). The largest percentage increase in heavy smoke days for frontline workers occurred in California (2132%) and Arizona (1124%).
- Nationally, there were 569 million heavy smoke student-days (grades K–4), with 100 million (18%) among students in poverty. Heavy smoke days for students increased 300% from 2011–2015 to 2017–2021.
- Many states saw increases of over 200% in homeless person–days of heavy smoke from 2011–2015 to 2017–2021: California, Washington, Oregon, Nevada, Utah, Arizona, and Alaska.
- California, Illinois, Washington, and New York experienced the largest number of housing vulnerable person–days of heavy smoke.

CONCLUSIONS

- Although wildfire smoke has generally increased across the United States, it has not done so equally for all states or regions.
- Certain groups of people and communities are more vulnerable to experiencing the negative impacts of wildfires, based on where they live, work, and go to school, as well as the level of their economic resources and adaptive capacity to cope with hazardous and disruptive environmental conditions, such as heavy wildfire smoke.
- Many communities face a multitude of threat multipliers for wildfire smoke exposure that have been outlined in this report.
- Several populations of concern have experienced large increases in their exposures to dangerous and disruptive wildfire smoke.
- These populations of concern are more likely to experience disruptions from smoke for reasons that include legacies of racial discrimination and economic exclusion.
- Prioritizing these groups in policy and for climate resilience activities may more effectively help prepare local economies for the economically destabilizing effects of climate risks, such as wildfire smoke.

To read the full report, scan the QR code in the top left corner.

DISCLOSURES

The views expressed in this report are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of San Francisco or the Federal Reserve System.

AUTHOR INFORMATION

Brooke Lappe, MPH (<https://www.sph.emory.edu/phd-students/profile/index.php?FID=brooke-lappe-12873>), is a doctoral student in the Environmental Health Sciences program in the Gangarosa Department of Environmental Health at Emory University. Her research focuses on climate change and health, infectious diseases, environmental justice and policy.

Jason Vargo, PhD, MPH, (<https://www.frbsf.org/community-development/about/staff/jason-vargo/>) is a senior researcher in community development focused on understanding the role of climate risks and equity in ensuring an inclusive and prosperous economy for all.

Kathryn Conlon, PhD, MPH (<https://health.ucdavis.edu/phs/team/42374/kathryn-conlon---environmental-and-occupational-epidemiology-davis/>), is an Assistant Professor, jointly appointed in the UC Davis Schools of Medicine Department of Public Health Sciences and School of Veterinary Medicine Department of Medicine and Epidemiology. Her research focuses on characterizing how climate change influences human, animal, and environmental health.

ABSTRACT

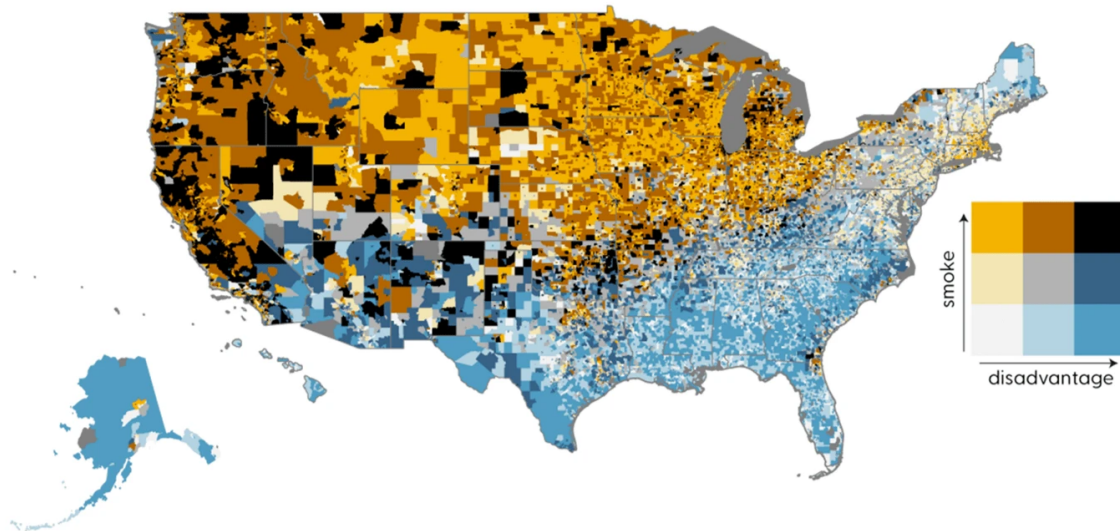
Background: Recent wildfire trends in the United States demonstrate increasing risk of exposure to wildfire smoke, which has well-described impacts on respiratory disease and all-cause mortality. Community social vulnerability, or disadvantage, relates to resources and privileges available to communities to pursue protective adaptation actions and may play an important role in explaining health disparities related to wildfire smoke. We described wildfire smoke exposure from January 2011 to December 2021 across the United States and assessed the extent to which wildfire smoke exposures overlap with social vulnerability.

Methods: We combined satellite-collected data on wildfire smoke from the National Oceanic and Atmospheric Administration (NOAA) Hazard Mapping System with the locations of population centers in the conterminous United States with 2010 U.S. Census data and the CDC's Social Vulnerability Index (SVI) to describe the co-occurrence of light-, medium-, and heavy-density smoke exposure and social disadvantage.

Results: Statistically significant increases in the number of heavy smoke days were observed in communities representing 87.3% of the U.S. population. Exposures to smoke were not distributed equally, with the largest smoke increases in communities characterized by racial or ethnic minority status, limited English proficiency, lower educational attainment, and crowded housing conditions. Census tracts in the highest SVI tertile (i.e., tracts at the greatest overall disadvantage for living healthy lives) experienced a 358% increase in the average annual number of heavy smoke days, from 0.92 (95% CI: 0.91–0.93) days in 2011–2015 to 4.21 (95% CI: 4.18–4.25) days in 2017–2021. Similar increases in heavy smoke were observed for the SVI's four themes: (1) socioeconomic status: 346%, (2) race/ethnicity/language: 449%, (3) household composition and disability: 309%, and (4) housing and transportation: 357%.

Conclusion: As smoke exposure becomes more frequent and intense, interventions that address communities with social disadvantages might maximize their public health impact.

Need-based map using heavy smoke exposure and Social Vulnerability Index (SVI)



REFERENCES

1. Afrin, S., and F. Garcia-Menendez. 2021. "Potential Impacts of Prescribed Fire Smoke on Public Health and Socially Vulnerable Populations in a Southeastern U.S. State." *Science of The Total Environment* 794 (148712).
2. Palaologou, P., et al. 2019. "Social Vulnerability to Large Wildfires in the Western USA." *Landscape and Urban Planning* 189: 99–116.
3. National Oceanic and Atmospheric Administration (NOAA). Office of Satellite and Product Operations. Hazard Mapping System Fire and Smoke Product - Product Information.
4. Centers for Disease Control and Prevention (CDC). Agency for Toxic Substances and Disease Registry (ATSDR). Geospatial Research, Analysis, and Services Program. CDC/ATSDR Social Vulnerability Index (SVI) 2018, U.S. Database.
5. Comprehensive Housing Affordability Strategy (CHAS) Database. 2019. Washington, D.C.: U.S. Department of Commerce, Bureau of the Census, Data User Services Division.
6. Housing and Urban Development (HUD). 2021. "2021 AHAR: Part 1 - PIT Estimates of Homelessness in the United States." U.S. Department of Commerce, Bureau of the Census, Data User Services Division.
7. U.S. Census Bureau. 2010. "Design and Methodology: American Community Survey."
8. Vargo, J. A., et al. 2022. "Social vulnerability in US communities affected by wildfire smoke." *AJPH*, under review.

