Wildfire smoke disproportionately affects California's Indigenous communities, new research shows

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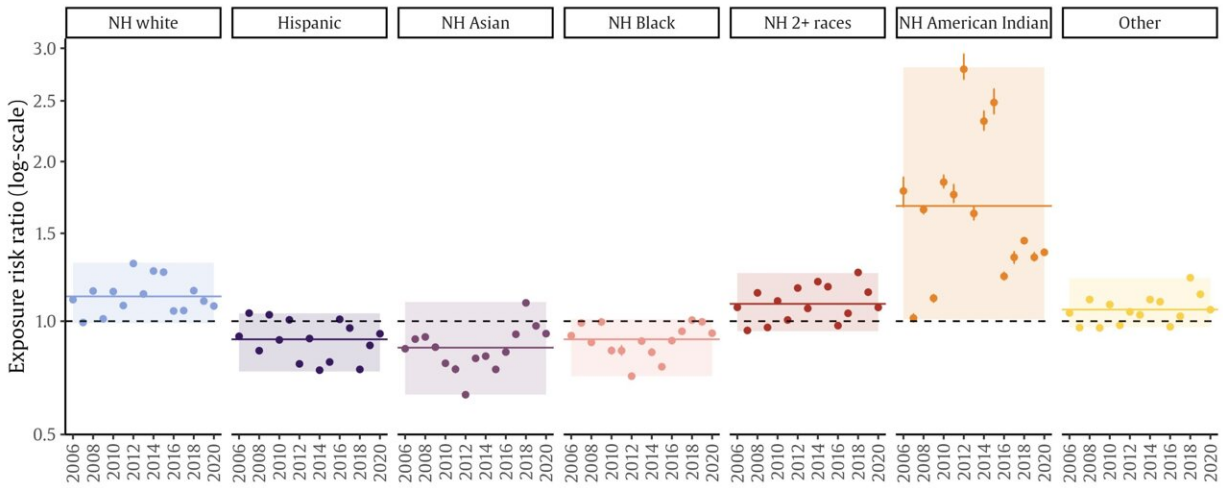

Indigenous communities in California were exposed to about 1.7 times as much wildfire smoke, on average, as would be expected based on their statewide populations. Credit: Joan Casey

Researchers using a novel method of measuring long-term wildfire smoke exposure have found that Indigenous communities in California are exposed to disproportionate amounts of dangerous particulate matter—sometimes far beyond what has been previously known.

Using a novel series of metrics that better reflects prolonged, community-

level smoke exposure, researchers found that these communities were exposed to disproportionate amounts of smoke every year from 2006 to 2020. Indigenous communities were exposed to about 1.7 times as much wildfire smoke, on average, as would be expected based on their statewide populations.

What's more, researchers say their new matrix for measuring exposures will help public health experts better understand the long-term effects of wildfire smoke for both environmental justice and epidemiological studies.

That understanding is critical in vulnerable communities. It's also increasingly important because millions of people nationwide now experience toxic, smoke-filled skies as wildfires worsen due to climate change, said Rachel Morello-Frosch, a University of California, Berkeley, professor of public health and of environmental science, policy and management and co-author of the paper.

"Now that wildfires are coming at us sequentially and clearly are going to be increasing in frequency and intensity, we can't look at them one at a time," Morello-Frosch said. "We have to look at them using a more cumulative exposure framework."

The study, published this month in the journal *Proceedings of the National Academy of Sciences*, is believed to be the first of its kind to take such a robust look at exposure assessment.

Scientists have long studied the pollution that comes out of tailpipes, chimneys, and power plants. Known as particulate matter, those levels of pollution—measured by thousands of EPA monitors around the country—hold relatively steady throughout the year. Those individual pollution daily values are often averaged over the course of a year. That information is then used by researchers to understand a community's or

individual's long-term particulate matter exposure level.

That's how researchers historically have studied how exposure to poor air quality in, for example, California's San Joaquin Valley, might lead to increased rates of chronic obstructive pulmonary disease years later.

There's a problem, though. The data that make those studies possible are usually averaged. That means toxic air from a single mega-fire that blankets a community for a few days in August might be smoothed over in the annual calculation. The average masks the extremes. And the extreme might be what really matters for health, especially when such extremes are becoming more frequent in the context of climate change.

This ultimately makes it more difficult to track the long-term health impacts of wildfire smoke.

Researchers have increasingly done shorter-term analyses to see how a week of smoke drives up emergency room visits. But those fail to evaluate the potential longer-term health effects, particularly when there are repeated wildfire events.

Morello-Frosch likened the current landscape of wildfire smoke research to earlier studies of how industrial incidents, like a chemical plant disaster, affected communities. Researchers used to focus on those individual incidents. Only later did scientists begin understanding how cumulative exposure—rather than individual incidents—was an important predictor of health.

To look for how those individual incidents might be part of a broader health story, the research team proposed five new metrics that can be used together to assess better the duration, frequency and intensity of wildfire smoke exposure. Factors like the number of smoke waves that blanket a specific area for two consecutive days or the peak exposure

week of the year can help researchers spot exposures that might otherwise have been missed.

"That may really matter for certain types of disease processes much more than the average smoothed out over the year," said Joan Casey, an assistant professor of environmental and occupational health sciences at the University of Washington and the paper's lead author.

"Those two things may not be equal," she added. "This paper is one of the first that actually starts trying to contend with this problem."

Researchers have previously documented how California census tracts with a higher proportion of Indigenous people experienced relatively higher amounts of acreage burned. But nobody had looked at repeated smoked exposure year after year in those communities, Casey said.

"People living in California understand one year is a horrible wildfire year, and in another year, maybe there's not that much smoke," Casey said. "But we see every single year in this study period that American Indian/Native American people are disproportionately exposed to wildfire smoke."

Air quality studies typically rely on the EPA's vast network of monitors and sensors. Those sensors don't detail where particulate matter comes from. To overcome that for this study, Tarik Benmarhnia, a co-author and an associate professor at the Scripps Institution of Oceanography at UC San Diego, used satellite images that detect smoke to identify where and when particulate matter spikes in the sensors were caused by fire.

That vast amount of data, combined with machine learning tools, will allow researchers to estimate community exposures in more granular detail and assess potential long-term health risks in new ways for future studies.

"Developing such metrics to capture populations' exposures to such repeated events can help provide a more nuanced and realistic picture of how novel environmental hazards can lead to inequities across various communities," Benmarhnia said. "Focusing on wildfire smoke is particularly timely, as this has become the major source of air pollution in the past few years."

The research raises significant questions about environmental justice, the team said. The scientists also hope it serves as a starting point for others to begin thinking of new ways to quantify human exposure to other hazards—like floods—that may have health effects years down the road.

"The beauty of this paper is that it provides a proof of concept about how we need to be looking at the effects of a wildfire on communities at a granular level," Morello-Frosch said. "It's a really great foundation for how to assess exposures in this long-term framework in order to more accurately assess health effects of perennial fire events that are no longer restricted to the western part of the United States."

More information: Joan A. Casey et al, Measuring long-term exposure to wildfire PM 2.5 in California: Time-varying inequities in environmental burden, *Proceedings of the National Academy of Sciences* (2024). DOI: 10.1073/pnas.2306729121

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