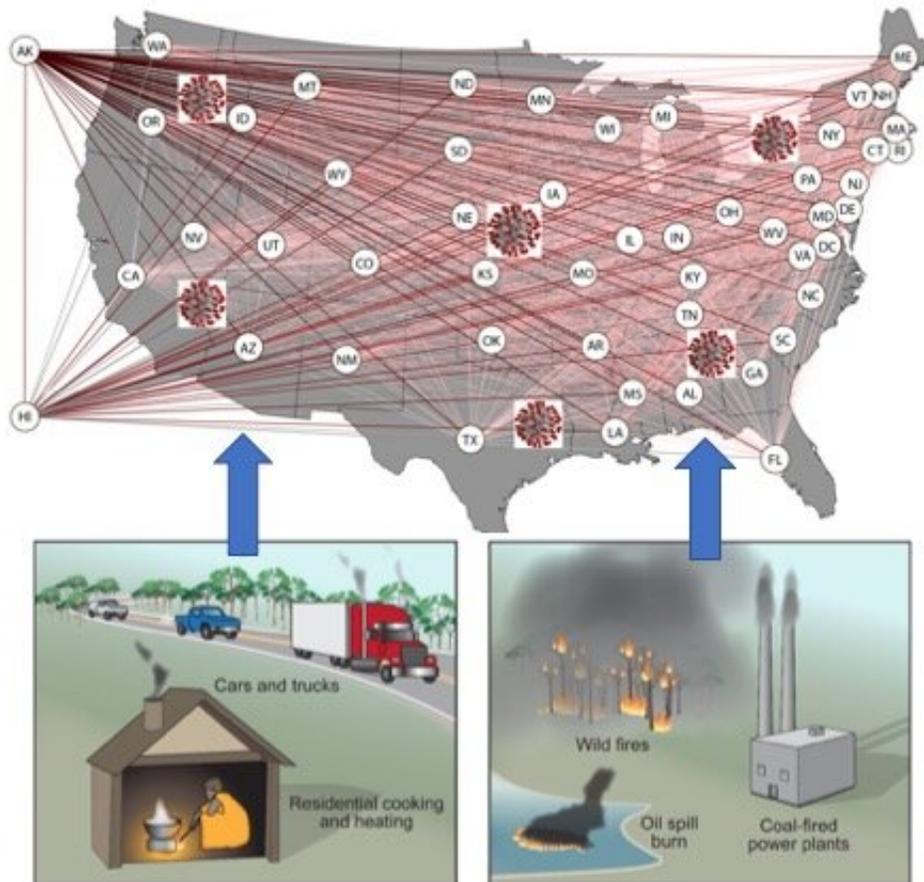


Pollution and pandemics: A dangerous mix

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According to new research from the McKelvey School of Engineering at Washington University in St. Louis, pollution may bear part of the blame for the rapid proliferation in the United States of SARS-CoV-2, the virus responsible for the spread of COVID-19. Credit: Professor Rajan Chakrabarty, Washington University in St. Louis

The United States may have set itself up for the spread of a pandemic without even knowing it.

According to new research from the McKelvey School of Engineering at Washington University in St. Louis, pollution may bear part of the blame for the rapid proliferation in the United States of SARS-CoV-2, the virus responsible for the spread of COVID-19.

The research, from the lab of Rajan Chakrabarty, associate professor in the Department of Energy, Environmental & Chemical Engineering, was published online ahead of print in the journal *Science of The Total Environment*.

When it comes to how ill someone gets after contracting COVID-19, medical professionals believe that a person's health—having certain medical conditions, for example—can play a vital role. When it comes to how fast the virus can spread through the community, it turns out the health of the environment is directly correlated to the basic reproduction ratio R_0 , which denotes the expected number of people each sick person can infect.

The reproduction ratio R_0 of COVID-19 associates directly with the long-term ambient $PM_{2.5}$ exposure levels. And the presence of secondary inorganic components in $PM_{2.5}$ only makes things worse, according to Chakrabarty.

"We checked for more than 40 confounding factors," Chakrabarty said. Of all of those factors, "There was a strong, linear association between long-term $PM_{2.5}$ exposure and R_0 ."

$PM_{2.5}$ refers to ambient particles with a diameter of 2.5 micrometers or less; at that size, they can enter a person's lungs and cause damage. For this reason, $PM_{2.5}$ can be detrimental to respiratory health. But how this

relates to the spread of COVID-19 through a population had yet to be explored.

Chakrabarty and his graduate student Payton Beeler, both aerosol researchers who have done previous coronavirus modeling, became interested in the relationship after two papers were published in quick succession. First, a July paper in the journal *Science* found that levels of susceptibility to COVID-19 is a driving factor for the pandemic; it is more important than temperature, which researchers initially thought might play an outsized role.

Then in August, research published in the *Journal of Infection* found that the highest number of cases of COVID-19 with severe illness were in places with higher pollution levels.

"I was thinking, why, in the majority of the U.S. states, have we had such a rapid spread of the virus?" Chakrabarty said. Particularly in the earlier stages of the pandemic. "We wanted to confine our study to the point in time when the shutdown was in place. For the most part, people did remain confined from early March until the end of April."

The team decided to look at places where R_0 was greater than one—that's the point at which one person can spread an illness to more than one person, and the illness takes off. In those places, they looked at 43 different factors—including population density, age distribution, even time delays in states' stay-at-home orders.

Then, using pollution estimates across the U.S. between 2012 and 2017 published by Randall Martin, professor in the Department of Energy, Environmental & Chemical Engineering, the team looked for any relationships.

Modeling revealed an increase of almost 0.25 in R_0 corresponding to a

10% increase in sulfate, nitrogen dioxide and ammonium, or SNA composition and an increase of $1 \mu\text{g}/\text{m}^3$ in $\text{PM}_{2.5}$ mass concentrations, respectively.

They found these linear correlations to be strongest in places where pollution levels were well below National Ambient Air Quality Standards (NAAQS), the levels of air pollutants that are considered safe for humans.

"Annual mean $\text{PM}_{2.5}$ national standards are set at or below 12 micrograms per cubic meter, below that you are supposed to be safe," Chakrabarty said. "What we saw, the correlation we're seeing is well below that standard." In fact, they saw a rapid increase in R_0 when $\text{PM}_{2.5}$ exposure levels were below 6 micrograms per cubic meter.

Chakrabarty hypothesizes this initial increase in R_0 , which is followed by a plateau once levels hit 6 micrograms per cubic meter, is a result of initial changes in condition; when the air is free of $\text{PM}_{2.5}$, an individual is unaffected. The initial exposure is the catalyst for change in lung health resulting in a change from non-susceptibility to susceptibility, which is reflected in the increasing R_0 .

And although there was no direct correlation between [black carbon](#)—a.k.a. soot—and R_0 , researchers did find a connection.

"Our collaborators at Saint Louis University suggested a mediation/moderation statistical approach," a detailed analysis that looks at the way additional variables affect the outcome of the initial relationship. In this case, researchers looked at soot's effect on R_0 , considering SNA's effect.

"We found black carbon acts as a kind of catalyst. When there is soot present, $\text{PM}_{2.5}$ has more of an acute effect on lung health, and therefore

on R_0 ."

The mediation/moderation study was not superfluous—one of the common ways people are exposed to SNA is through pollution emitted from cars and coal-fired power plants. Both of which also emit soot.

"Although decades of strict air quality regulations in the U.S. have resulted in significant reductions of [nitrogen dioxide](#) levels," the authors wrote in the paper's conclusion, "recent reversal of environmental regulations which weaken limits on gaseous emissions from power plants and vehicles threaten the country's future air quality scenario."

"Instead of working to resolve this issue, these reversals may be setting us up for another pandemic," Chakrabarty said.

More information: Rajan K. Chakrabarty et al, Ambient PM_{2.5} exposure and rapid spread of COVID-19 in the United States, *Science of The Total Environment* (2020). [DOI: 10.1016/j.scitotenv.2020.143391](https://doi.org/10.1016/j.scitotenv.2020.143391)

Provided by Washington University in St. Louis

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