



Exposure to air pollution and COVID-19 mortality in the United States: A nationwide cross-sectional study

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Abstract

Objectives: United States government scientists estimate that COVID-19 may kill tens of thousands of Americans. Many of the pre-existing conditions that increase the risk of death in those with COVID-19 are the same diseases that are affected by long-term exposure to air pollution. We investigated whether long-term average exposure to fine particulate matter (PM_{2.5}) is associated with an increased risk of COVID-19 death in the United States. **Design:** A nationwide, cross-sectional study using county-level data. **Data sources:** COVID-19 death counts were collected for more than 3,000 counties in the United States (representing 98% of the population) up to April 22, 2020 from Johns Hopkins University, Center for Systems Science and Engineering Coronavirus Resource Center. **Main outcome measures:** We fit negative binomial mixed models using county-level COVID-19 deaths as the outcome and county-level long-term average of PM_{2.5} as the exposure. In the main analysis, we adjusted by 20 potential confounding factors including population size, age

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account for potential correlation in counties within the same state. We conducted more than 68 additional sensitivity analyses. Results: We found that an increase of only 1 $\mu\text{g}/\text{m}^3$ in $\text{PM}_{2.5}$ is associated with an 8% increase in the COVID-19 death rate (95% confidence interval [CI]: 2%, 15%). The results were statistically significant and robust to secondary and sensitivity analyses. Conclusions: A small increase in long-term exposure to $\text{PM}_{2.5}$ leads to a large increase in the COVID-19 death rate. Despite the inherent limitations of the ecological study design, our results underscore the importance of continuing to enforce existing air pollution regulations to protect human health both during and after the COVID-19 crisis. The data and code are publicly available so our analyses can be updated routinely.

Competing Interest Statement

The authors have declared no competing interest.

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Author Declarations

All relevant ethical guidelines have been followed; any necessary IRB and/or ethics committee approvals have been obtained and details of the IRB/oversight body are included in the manuscript.

Yes

All necessary patient/participant consent has been obtained and the appropriate institutional forms have been archived.

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OR SIGN UP WITH DISQUS **Rita Van Dingenen** • a month ago

Although more confounding factors have been taken into account in the revised version, I am not convinced that they can capture the specific dynamics of the COVID-19 epidemic where the spreading seems to be strongly driven by sparse super-spreading events, taking place under specific circumstances (e.g. relatively crowded social/cultural/sports events involving shouting, singing, strong breathing). The number and frequency of such events (or infrastructure) could be an important determinant of which PM2.5 may just be a proxy. Further, in stead of mortality rate, case fatality rate would be the more appropriate indicator to establish a possible impact of air pollution, removing a lot of noise from confounding factors.

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**fennudepidan** → Rita Van Dingenen • a month ago • edited

Thank you for your thorough comments and thoughts. For your first comment regarding the sparse super-spreading events, we would like to provide the evidence that we ran the analysis using the cumulative COVID-19 data daily, and found the effect size is stable. This findings could potentially eliminate the impacts of super-spreading events at random time. Also, we would like to emphasize our PM2.5 exposure is a long-term historical exposure, thus would not be affected by those events. For sure, one can argue the super-spreading events could be highly correlated with PM2.5 level, yet the underlying reason is that both likely happen in the areas with high population density, the confounding factors we have taken into account. For your second comment regarding the mortality and case fatality rate, in the midst of pandemic, the most accurate statistics regarding to the population is the population size (from Census), and the second may be confirmed deaths (although some evidences show there are a proportion of excess deaths in certain states). However, to compare, the confirmed cases is much more inaccurate to characterize the total number of infected cases (up to 86% are undocumented, Li et al. 2020, Science), and it highly depends on many other factors, e.g., testing capacity and even the distance from county to a testing site since only a few counties have testing site. This is also the reason that in our paper we did not look at the association between PM2.5 and infection rate since using the number of confirmed cases to characterize total number of infections is inaccurate, and this logic also applies to CFR since its denominator is inaccurate. The studies using CFR can only be done after the pandemic and the infection rate has been corrected by CDC.

Last, I agree that it is important to note that unmeasured confounding can never be completely ruled out in all observational studies, and your suggestions are very helpful as we should continue to do our best to collect more relevant data and try to adjust for confounding factors as complete as possible to obtain valid scientific conclusions.

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breathing polluted air before we become vulnerable to a virus like COVID-19?

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fennudepidan → deirdre alexandra platt • 2 months ago

Long-term exposure is called chronic exposure, which is continuous or repeated contact with a toxic substance over a long period of time (months or years). Per EPA National Ambient Air Quality Standards, "long-term exposure to PM2.5" often refers to annual mean. In this paper, we were looking at annual mean both from 2000-2016 and 2016 only, and found positive associations between PM2.5 and COVID-19 mortality. Further study is needed to quantify the exact length of time window for the air pollution exposure that can impact the vulnerability of a human body to a virus like COVID-19.

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fennudepidan • 3 months ago

Notice: In the revision on April 24, 2020, we have updated our analysis using data up to April 22, and importantly in which we have adjusted for additional confounding factors that also reflect the timing of the epidemic's spread, the timing of the social distancing policies and the population age distribution. Consequently, we revised our finding as that an increase of 1 µg/m3 in PM2.5 is associated with an 8% increase in the COVID-19 death rate (95% confidence interval [CI]: 2%, 15%).

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