Author’s response to reviews

Title: Particulate matter and emergency visits for asthma: a time-series study of their association in the presence and absence of wildfire smoke in Reno, Nevada, 2013-2018

Authors:

Daniel Kiser (daniel.kiser@dri.edu)
William J. Metcalf (jim.metcalf@dri.edu)
Gai Elhanan (gai.elhanan@dri.edu)
Brendan Schnieder (BSchnieder@washoeCounty.us)
Karen Schlauch (karen.schlauch@dri.edu)
Andrew Joros (andrew.joros@dri.edu)
Craig Petersen (cpetersen@washoeCounty.us)
Joseph Grzymski (joe.grzymski@dri.edu)

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Reviewer #1: Comments:
L. 69-106. The introduction concisely describes the foundation and background of the study and provides a rationale for the study design.

Thank you. No changes were made based on this comment.

L. 81-85. The justification for the study and its relevance to public health in Reno, Nevada specifically is explained based on annual impacts by wildfire smoke and climate change and projections of much more smoke inundating Reno in the future. While these are important justifications for the study, there is another which is important to note. It is critically important to have accurate effect estimates of wildland fire smoke on the health of the public so that forest management policies and practice can reasonably reflect the effect of smoke on the population impacted.

Yes, this is a valuable point to clarify. We agree that it is important to link our research question to the applications for which it is most relevant, in this case forest management policy. We modified the introduction on L. 81-82 to include the following statement: “An accurate understanding of the impacts of wildfire smoke on population health is critical if forest management policies are to effectively mitigate those impacts.” We also made some minor changes to the wording in the
following lines (L. 86-89), as adding the above statement required some changes in the logical flow of the paragraph.

L.107-228. The methods are appropriate.

Thank you. No changes were made based on this comment.

L. 140-143. There is limited data in the literature that links sub-24-hour exposures to health effects of wildland fire smoke, and virtually no published data on one-hour exposures which in some cases in this study were used to define a "wildfire day". Using your definition of a "wildfire day" is it possible to show a histogram plot the distribution of wildfire days over the course of the study period based on the number of hours of smoke within the 24-hours.

Thank you for your valuable suggestion. We recognize that it is indeed important to report on the daily hours of smoke exposure during a typical wildfire day, as brief exposures to smoke are likely to have very different effects than sustained exposures. We thus included a histogram of daily hours of recorded wildfire smoke exposure (Figure S1), and we reported on the number of wildfire days for which exposure to wildfire smoke was more or less than 20 hours (in the results section on L. 236-241). 172 out of 188 days were affected by wildfire smoke for more than 20 hours, while only 6 out of 188 days were affected by wildfire smoke for less than 20 hours. Since the primary information communicated by the histogram was that nearly all of the wildfire days were affected by smoke for more than 20 hours, and it was otherwise somewhat uninformative, we placed the histogram in the supplement rather than in the main manuscript.

L. 139-141. While at the present time your decision to combine the two major categories of wildland fire smoke, wildfire and prescribed fire into one exposure metric is appropriate, going forward it is definitely important to consider that the health effects might be different between smoke originating from a wildfire versus a prescribed fire given the differences in combustion conditions and fuels. The US Department of the Interior, USDA US Forest Service, and state forestry agencies recognize the need for more prescribed fire in the western US to manage fuel loads. As such, an important goal in future research will be to better define whether health effects differ between wildland fire smoke versus prescribed fire smoke on a µg/m³ to µg/m³ basis. Your present manuscript is a good foundation for such a study because your methodological approach would allow for a comparison of prescribed fire versus wildfire at comparable concentrations.

This is a good point. We had indeed neglected to note that the health effects of wildfire smoke may differ from the health effects of smoke from prescribed fires, and that such a difference could have important implications for forest management policy. We thus expanded on our suggestions for future work in the discussion on L. 418-421, suggesting that the difference in the health effects of prescribed fires versus wildfires be investigated.

L. 302. The discussion is well written and places the finding into the broader context of the current literature. The discussion is an appropriate place to provide a general paragraph that describes from where the wildfire smoke originates that impacts the region around Reno, and what type of fuel is burning. For example, emissions originating the forests west of Reno are probably largely from the combustion of pine, fir and grasslands. Consequently, the findings of the study are most
relevant to Reno and perhaps populations in the vicinity of the eastern slopes of the Sierra Nevada mountains. It's not clear how these results would relate to the Southeastern US where the predominate forest tree type is pine, or the Appalachian Mountains where hardwoods dominate, or eastern NC with its pine and peat bogs. A comment should therefore be made about the generalizability of the data and conclusions.

Thank you for pointing this out. It is clearly important to describe the origins of the wildfire smoke in our study, since the origins have major implications for the applicability of our study to other regions of the world. We thus added a paragraph describing where the wildfires occurred and the predominant types of fuel that was burned in those wildfires (in the discussion on L. 351-357).

L. 254. The clinical endpoints of interest were emergency department and urgent care center visits for asthma. Two recent publications (Lipner EM, O'Dell K, Brey SJ, Ford B, Pierce JR, Fischer EV, Crooks JL. The Associations Between Clinical Respiratory Outcomes and Ambient Wildfire Smoke Exposure Among Pediatric Asthma Patients at National Jewish Health, 2012-2015. Geohealth. 2019 Jun 3;3(6):146-159. doi: 10.1029/2018GH000142; Gan RW, Liu J, Ford B, O'Dell K, Vaidyanathan A, Wilson A, Volckens J, Pfister G, Fischer EV, Pierce JR, Magzamen S. The association between wildfire smoke exposure and asthma-specific medical care utilization in Oregon during the 2013 wildfire season. J Expo Sci Environ Epidemiol. 2020 Feb 12. doi: 10.1038/s41370-020-0210-x) bring up another issue for the authors to note and that is that the findings of the study could be affected by the behaviors of the individuals with asthma and how they use their bronchodilator medication. Also the current paper refers only the emergency department and urgent care center visits rather than effects on well-being or lung function, and as such doesn't fully reflect the full spectrum of the adverse impacts of air particle pollution. Behavioral influences are recognized in the form of possibly being modified by outdoor temperature, however, rates health care utilization and the appearance of a patient in the ED or UC Center could also be influenced by their knowledge of their disease and the application of their asthma management plan. It is probably more likely that a patient with asthma will activate their asthma management plan with a forecast of impending smoke rather than with non-wildfire PM because the former is more likely to be advertised in the media. Consequently, the differences between wildfire smoke related PM$_{2.5}$ and non-wildfire PM$_{2.5}$ reported in this study are probably attenuated to some degree by use of inhaled medications in advance of and during wildfire smoke exposure. This is obviously speculative but a reasonable consideration.

Thank you for bringing this to our attention. We had not considered the possible influence of medication on health outcomes, but the papers you referenced provide good evidence that the use of medication changes during a smoke event. We thus included a paragraph in the discussion (L. 390-399) which cited the papers you mentioned and described how the use of rescue medications could possibly have ameliorated the effects of wildfire smoke, which we measured as ED and UC visits. Because of the inclusion of this paragraph, it was also deemed necessary to add a “patient behavioral changes” as a third possible mechanism for modifying the harmfulness of wildfires (L. 358-361 in the discussion). Since medication use would appear to make wildfire PM less harmful, we also modified L. 358 to say “mechanism which could make wildfire PM more OR LESS harmful…”
L. 411-421. The conclusion summarizes the key points presented in the paper are well done, however it is recommended that the authors include a statement that reflects a very important aspect of the study, i.e. the findings represent differences at comparable concentrations of PM associated with wildfires smoke and non-wildfire sources and at relatively low concentrations.

Thank you for pointing this out. We agree that our method of comparing the effects of wildfire and non-wildfire smoke at similar PM concentrations was an important part of our study, and that this was not adequately emphasized in our conclusions. We thus expanded our conclusion (L. 445-451) to clarify why we feel we can reasonably conclude that the additional harmful effects of wildfire PM cannot be attributed only to higher concentrations of PM: namely, that we compared the harmful effects of wildfire PM and non-wildfire PM at similar concentrations, which were relatively low.

We also made a few other minor changes to the manuscript:
1) In the methods section on L. 144-145, we clarified that the qualifier data which we used to define wildfire days was taken from the Reno3 monitor in downtown Reno. Other monitors in the area would have their own qualifier data for their hourly measurements. While the qualifier data from different monitors are usually in agreement, there are occasions on which air quality at one monitor might be affected by wildfire smoke while air quality at another monitor is unaffected. However, the Reno3 monitor is centrally located and provides the best indicator of when wildfire smoke is prevalent across the whole area.
2) L. 243-246 in the results section were slightly reworded for clarity.
3) One of our references (Rosenquist et al. [19]) that had not yet been published at the time of writing has since been published, and the citation was updated accordingly.
4) Figures S5 and S6 in the supplement were modified so that the order of their legend elements matched the order of the legend elements of Figure 4 in the main manuscript.