Thank you for your helpful and clarifying comments throughout our paper!

General Comments  
  
1. The specific objective of the study requires some additional clarification. From my understanding, there are at least two unique elements of this analysis: 1) An attempt to assess the impact of 'stress' from wildfire events, as an additional or alternative biological mechanism over wildfire PM2.5 exposure; and 2) a focus on DEM users, who are an understudied population, yet may be uniquely vulnerable to stress during wildfire events because of their reliance on DME. If correct, I suggest clarifying these specific objectives in the last paragraph of the introduction, and thereafter keeping the analysis focused on these. For example, currently you simply indicate that you use the KPSC data 'to examine the relationship between wildfire exposure and healthcare utilization'. However, the objective could be more uniquely focused and highlighted, with an overview of how you attempt to address this with the different exposure metrics.

We really appreciate this piece of feedback, as it is exactly what we also feel is important and novel about our study. We edited the introduction to clarify these ideas:

*Our study has two unique components. First, we focus on a potentially vulnerable population by using 2016-2020 KPSC electronic health records from seven Southern California counties to examine the relationship between wildfire exposure and healthcare utilization in people who use DME. Second, we evaluate exposure to wildfire via (1) wildfire PM2.5 concentrations, and (2a) residential proximity to major active fires, and (2b) residence in an evacuated area. These proximity-based residential exposure estimates attempt to holistically assess the impact of wildfire exposure, including stress, rather than focusing only on air pollution. Our study period includes two major wildfire events in populated areas: the 400km2 Woolsey Fire, which burned from November 8-21, 2018 in Los Angeles and Ventura counties, displacing 295,000 people and killing three36,37, and the 3km2 Getty Fire, which necessitated evacuations in densely populated Los Angeles, and burned from October 28-November 5, 201937,38.*

*Page 3, Introduction, final paragraph.*

We have also changed the methods section to better describe the residential and evacuation zone exposures by adding the following paragraph:

*By measuring proximity to wildfire or residence in an evacuation zone, we aimed to capture an exposure-outcome relationship involving several mediators, including possible visible smoke exposure or extreme wildfire-related air pollution, possible evacuation, community disruption, loss of access to community services and housing, power outages, and stress co-occurring with and resulting from these events (eFigure 3). Though not all people living near a wildfire experience every mediator on the paths between nearby wildfire exposure and health care use, the most common mediator is likely stress.*

*Page 5, Proximity to wildfire, final paragraph.*

We have also edited the following sentences in the discussion to clarify our focus on the DME population only:

*Using electronic health data describing 236,732 Kaiser Permanente DME-using patients from 2016-2020, we found that an increase in wildfire PM2.5 concentration was associated with brief (next-day) decreases in all-cause outpatient visits but increases in all-cause outpatient visits up to two weeks later in this population.*

*Page 9, Discussion, paragraph 1.*

*In models with weekly lags, we observed increased outpatient visits in the two weeks following exposure, suggesting that there is overall an increase in all-cause outpatient visits among DME users following wildfire PM2.5 exposure. Very few prior studies have evaluated lags of short-term exposure to wildfire PM2.5 beyond 7 days,34 but our results indicate that outpatient visits among DME users remained elevated for up to two weeks. A decrease in healthcare utilization has been observed in previous studies of disaster-related exposures, including wildfires75 and extreme storms76.*

*Page 10, Discussion, paragraph 3.*

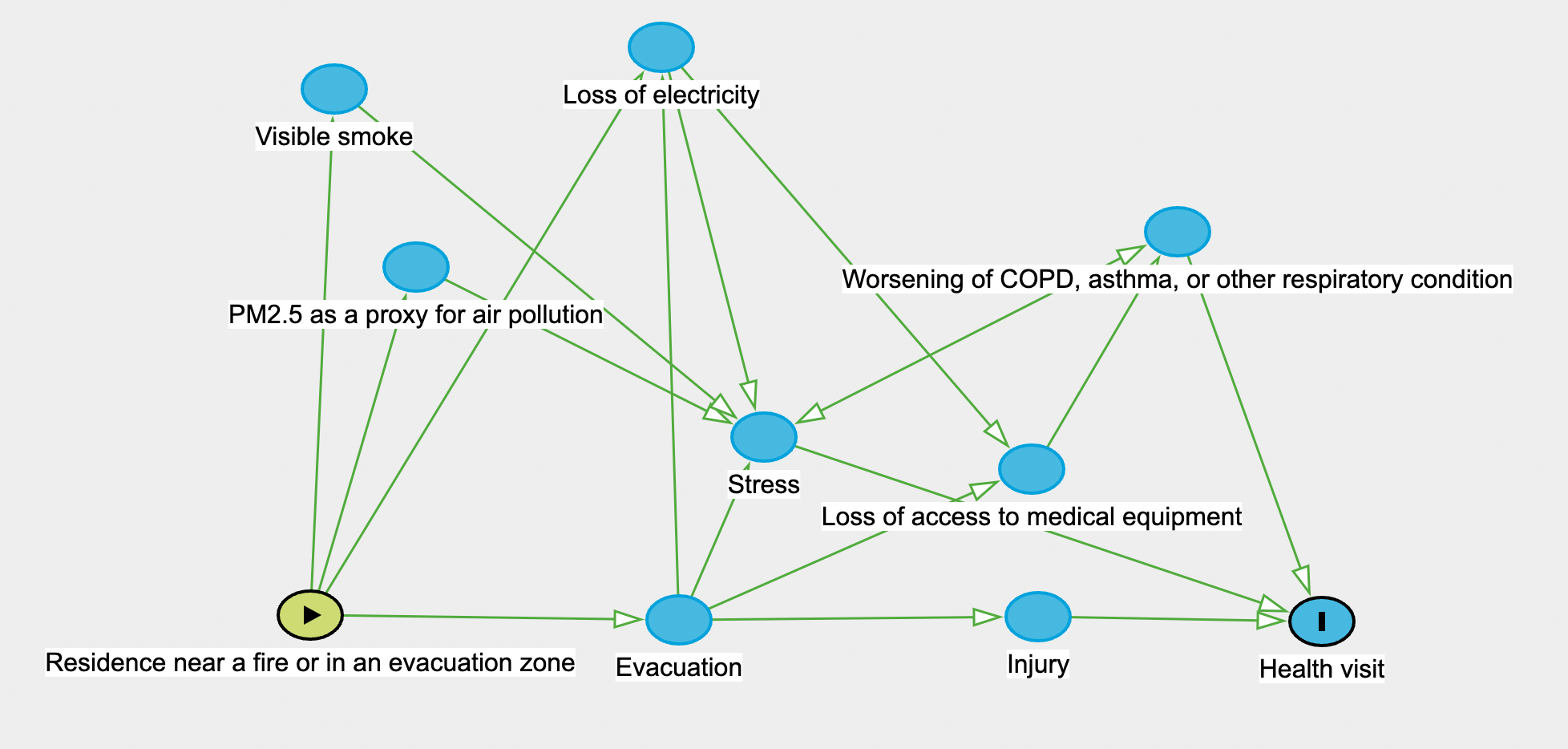
2. It would be helpful to clarify what you intend to measure with the 'proximity to wildfire' metrics. In the exposure definition section, you indicate these metrics 'measure direct exposure to wildfire' and later you motivate the 20 km distance as 'one that could elicit a stress response'. It seems that the proximity measures likely capture the mixture of adverse exposures related to wildfire events, including elevated wildfire PM2.5 exposure and other stressors related to the physical danger; such characterization could be more clearly stated in the manuscript.

With the metrics measuring residential proximity to wildfire and residence in an evacuation zone, we wanted to measure an exposure-outcome relationship involving many mediators. We think that wildfire smoke exposure is one. We do think that stress is probably the most common and therefore important mediator in this web of relationships, but we also wanted to capture other things like very high wildfire-related air pollution exposure, possible power outages or evacuation, and loss of community services. We have changed the methods section to better describe the residential and evacuation zone exposures that we were actually trying to describe by adding the following paragraph and DAG:

*By measuring proximity to wildfire or residence in an evacuation zone, we aimed to capture an exposure-outcome relationship involving several mediators, including possible visible smoke exposure or extreme wildfire-related air pollution, possible evacuation, community disruption, loss of access to community services and housing, power outages, and stress co-occurring with and resulting from these events (eFigure 3). Though not all people living near a wildfire experience every mediator on the paths between nearby wildfire exposure and health care use, the most common mediator is likely stress.*

*Page 5, Proximity to wildfire, final paragraph.*

This is the DAG we created from the supplemental digital content, which is eFigure 3.

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3. The terms 'proximity and evacuation analyses', useful as a shortcut, are difficult to follow for an outside reader. E.g., you are not evaluating the impact of 'evacuation' itself, which the current short-cut phrasing insinuates, but the mixture of exposures that come along with 'residential location in an evacuation zone' (whether a patient actually evacuates or not). I suggest using more specific phrasing when referring to these analyses, such as 'analyses assessing the effects of residential proximity to wildfires and residence within evacuation zones'.

Thank you for this suggestion, we think it’s very helpful. We have changed all examples of this phrasing to other, more descriptive terms:

*As in the wildfire PM2.5 models, we included offsets accounting for the population exposed and controlled for temperature with a penalized spline. We controlled for long-term seasonal trends not caused by exposure with a penalized spline term, as our data in these analyses were at the weekly level. We did not control for wildfire PM2.5 in model describing residence proximate to a fire or in an evacuation zone, as we considered this part of our multifaceted exposure rather than a confounder.*

*Page 7, Proximity to wildfire and evacuation, paragraph 3.*

And this one:

*For analyses measuring residence near a fire on in an evacuation zone, we used ZCTA level daily visit counts aggregated to the weekly level. We aggregated to the weekly level because we used last recorded fire boundaries and last recorded evacuation zones rather than daily PM2.5 concentrations as we had available for our air pollution.*

*Page 5, Outcome definition, paragraph 3.*

And this one:

*We attempted to assess this proximity/evacuation pathway for two major fires in our study area using a difference-in-differences analysis. We found no association between exposure and healthcare visits during the Getty Fire. However, during the Woolsey Fire, we observed an increase in cardiorespiratory inpatient visits and a decrease in all-cause outpatient visits with residential proximity to fire and with residence in an evacuation zone among DME users.*

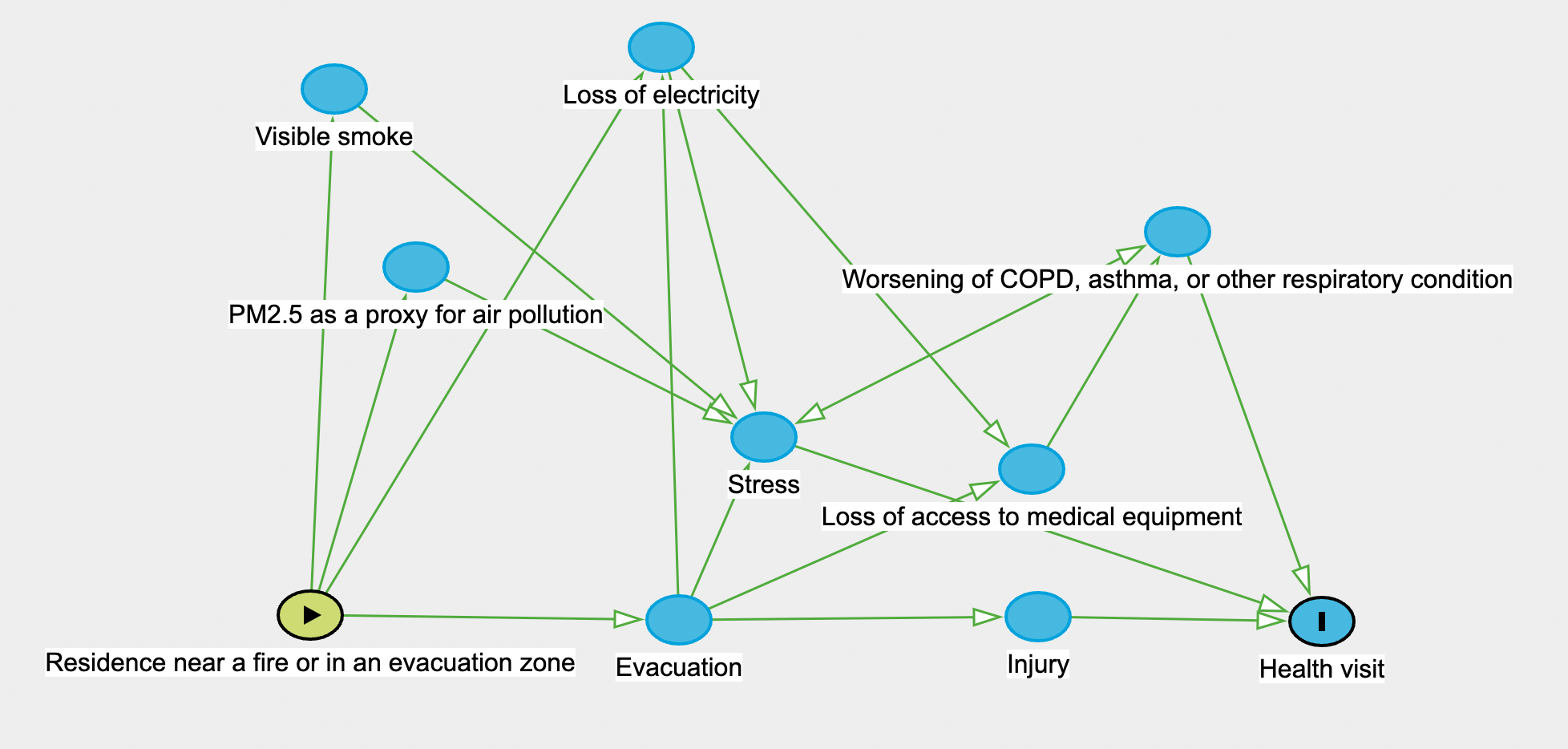
*Page 11, Discussion, paragraph 5.*

4. Following on the above comments, a DAG or conceptual framework might be considered to clarify the specific relationship(s) of interest in this analysis. If I understand the point of this analysis correctly, then I assume that separating out the effects caused by wildfire PM2.5 and other wildfire-related stressors would be important. If such effect separation is not of interest, then the introduction and objectives should be modified and differently motivated. However, if such effect separation is of interest, I'm curious why wildfire PM2.5 was not controlled for in the proximity analyses. In the Analysis section, you indicate that 'We did not control for wildfire PM2.5 in these proximity and evacuation models, as we considered this a mediator rather than a confounder'. I suggest reconsidering this statement. Here are two simplified pathways, based on the current motivations in the manuscript: 1) wildfire event --> increased PM2.5 --> adverse health and 2) wildfire event --> increased stress due to proximity/evacuation --> adverse health, which may be connected between PM2.5 and stress. For the latter pathway, it seems that wildfire PM2.5 could be a confounder either if the pathways are independent or if wildfire PM2.5 is upstream of stress; wildfire PM2.5 is unlikely to be a mediator between stress and adverse health. If wildfire PM2.5 would be controlled for in the proximity analyses, it seems that the effect of the 'additional/alternative' stressors of interest for the DME population could be estimated.

Thank you for this comment, we think it’s an important point! From suggestions in previous comments, we’ve already clarified our descriptions of the residential proximity exposures, to show that we want to capture the mixture of exposures including exposure to wildfire-related air pollution and wildfire PM2.5. We do view wildfire PM2.5 as a mediator in our analyses, and we want to capture the effects of the mixture now described in the methods section:

*By measuring proximity to wildfire or residence in an evacuation zone, we aimed to capture an exposure-outcome relationship involving several mediators, including possible visible smoke exposure or extreme wildfire-related air pollution, possible evacuation, community disruption, loss of access to community services and housing, power outages, and stress co-occurring with and resulting from these events (eFigure 3). Though not all people living near a wildfire experience every mediator on the paths between nearby wildfire exposure and health care use, the most common mediator is likely stress.*

*Page 5, Proximity to wildfire, final paragraph.*



We’ve also modified the introduction to reflect these changes:

*Several studies have documented the health effects of stress, evacuation, property destruction, or injury due to wildfire disasters7,8,21,25-31. We seek to expand on this literature. We hypothesize that residential proximity to wildfire, and evacuations due to wildfire, could influence health outcomes primarily through stress and possibly operate in concert with wildfire PM2.5 exposure. Residents living near wildfires are exposed to smoke, which in addition to biological effects can cause substantial worry,32 but proximate residents also experience the disruption of usual community activities, and face threat of injury, evacuation, or longer-term displacement. Evacuation may also disrupt access to healthcare, possibly resulting in a temporary reduction in utilization.33,34 Together with smoke, these exposures form a mixture that may have significant health effects.*

*Page 2, Introduction, paragraph 4.*

5. A strength of your study is inclusion of different healthcare visit types, however these require some enhanced characterization. For example, what types of visits are captured as outpatient visits (e.g., did these include clinic visits, well-checks, unscheduled primary care visits?), what types of visits are captured as ED visits (e.g., do these counts include those patients ultimately admitted as inpatient or do ED visits only include 'outpatient' ED visits?), and what types of visits are captured as inpatient (e.g., did these include all inpatient visits, or only unscheduled inpatient visits?). In addition, it may be helpful to characterize these visit types in terms of capturing differing outcome severity and types - from less severe for clinic visits to most severe for visits requiring an inpatient stay, which is often how such visit types are characterized. It may be helpful to order your results throughout as such as well.

Thank you for this nuanced question. We agree that characterizing these visits in terms of outcome severity is useful and we have added this framework to the manuscript methods. We also clarify what these visits capture:

*We obtained daily counts of all-cause outpatient visits, all-cause emergency department (ED) visits, and all-cause inpatient admissions, as well as ED visits and inpatient admissions and specifically for circulatory or respiratory disease outcomes made by KPSC members 45 and older who rented DME. Outpatient visits included both in-person and virtual synchronous visits (i.e., video or telephone visit with a provider), ED visits were those that terminated in the ED, and inpatient admissions consisted of all inpatient admissions (scheduled and unscheduled) as well as ED visits ending in an admission. Generally, outpatient visits are considered the lowest acuity, followed by ED visits, and inpatient visits are highest acuity. Recorded visits represent the universe of visits and were not necessarily related to DME use.*

*Page 5, Outcome definition, paragraph 1.*  
  
6. The discussion requires some additional interpretation with respect to implications of your results.  
a. While you found elevated outpatient visits up to two weeks after fires, it seems that there is some inconsistency in the literature regarding direction of effect. If correct, I suggest highlighting this inconsistency, summarizing results found in this analysis, and discussing why (or why not) such effects may be anticipated in this unique DME user population.

Thank you for this feedback – we have improved and clarified our discussion by editing the paragraph below on outpatient care to explain this apparent inconsistency and better interpret our results:

*Limited studies have assessed outpatient care utilization during wildfire smoke exposure and most have focused on outpatient visits for respiratory concerns, reporting increases during smoke exposure62,71–74. None of these studies examined all-cause outpatient care use. Hutchinson et al. 2018 simultaneously reported decreases in all-cause outpatient visits during smoke exposure and increases in visits for respiratory concerns only, during a five-day period following smoke exposure, suggesting that all or routine outpatient care may be disrupted, but respiratory care may be more needed and accessed during these exposures. Similarly, Henderson et al. 2011 found increased physician visits for asthma and all-respiratory outcomes related to same-day wildfire smoke exposure but no increase in physician visits for cardiovascular disease. In models with daily lags, we observed an initial same-day and next-day decrease in all-cause outpatient visits, and then a positive association between wildfire PM2.5 and all-cause outpatient visits among DME users for the week following exposure. In models with weekly lags, we observed increased outpatient visits in the two weeks following exposure, suggesting that there is overall an increase in all-cause outpatient visits among DME users following wildfire PM2.5 exposure. Very few prior studies have evaluated lags of short-term exposure to wildfire PM2.5 beyond 7 days34, but our results indicate that outpatient visits among DME users remained elevated for up to two weeks. A decrease in healthcare utilization has been observed in previous studies of disaster-related exposures, including wildfires75 and extreme storms76. Our findings are consistent with two prior studies and the theory that wildfire smoke may disrupt care immediately18,21, but at the same time exacerbate respiratory conditions leading to increased care use following smoke exposure among people (such as DME users) who have respiratory conditions.*

*Page 10, Discussion, paragraph 4.*

b. In addition, how do you interpret the decrease in outpatient visits and increase in cardiorespiratory inpatient visits with the Woolsey Fire? Are these results just chance, given the number of associations assessed, or is there any meaningful interpretation?

Thank you for this feedback – we’ve added the following interpretation to the discussion of our results:

*We found no association between exposure and healthcare visits during the Getty Fire. However, during the Woolsey Fire, we observed an increase in cardiorespiratory inpatient visits and a decrease in all-cause outpatient visits with both residential proximity to fire and residence in an evacuation among DME users. The 400 km2 Woolsey Fire, which caused $3 billion in damages,80 was much larger than the 3 km2 Getty Fire, which destroyed 10 homes.39 The observed null associations between Getty proximity exposure and all visit types could be due to its smaller size; it may have not been large enough to produce a detectable effect in visit changes. A larger analysis examining several wildfires, rather than two, could be informative. As in our discussion of wildfire PM2.5 exposure, the Woolsey Fire may have decreased outpatient care as has been documented during other disaster scenarios,75, 76 while inpatient visits may have increased because of respiratory disease worsening with exposure.*

*Page 11, Discussion, paragraph 6.*  
  
7. Similarly, the current conclusion is very general. I suggest providing a more nuanced conclusion based on the objectives of the current analysis and resulting findings. I.e., clarify the impact made by this paper.

We have added a new conclusion to the paper:

*This study evaluated the relationship between short-term exposure to wildfire PM2.5 and residential proximity and residence in a disaster zone, as a proxy for a mixture of health-harming exposures such as community disruption, smoke exposure, and stress and outpatient, ED, and inpatient visits among DME users in Southern California. Observed associations pointed to disruption of daily lives among those more exposed to wildfire, with missed outpatient care visits. We observed an association between elevated wildfire PM2.5 concentrations and decreased next-day risk followed by increased risk of all-cause outpatient visits over 4/5 subsequent days as well as reduced all-cause outpatient visits among those living in proximity to the Woolsey Fire. Wildfire PM2.5 was not associated with ED or inpatient visits, but Woolsey Fire proximity was associated with increased inpatient cardiorespiratory visits. This study adds to a literature on the health of vulnerable populations exposed to wildfires, which becomes more critical as wildfires frequency and severity increases with climate change. Protecting vulnerable populations that may be harmed by exposures which others can avoid or endure is essential. More work is needed to understand the timing of health risks for vulnerable populations affected by smoke, fire, and evacuation.*

Specific Comments  
  
1. 'Study population' line 32 - the Koebnick et al. (2012) reference, cited in your response document, should be cited here as well.

Thank you for pointing this out - we have added this citation, it’s number 39.   
  
2. 'Wildfire PM2.5' methods description - please provide the full citation to the Aguilera et al. (2021) article, with online location. When describing the model validation results of R2 of 0.86 and RMSE of 3.44, can you include the comparison? I did not read the Aguilera article in detail, and am interest to know what the gold standard (reference) wildfire PM2.5 data were for the validation. Also, RMSE should be cited with unites of ug/m3. The RMSE of 3.44 ug/m3 seems high, given the range of wildfire PM2.5 up to 25 ug/m3 - can you comment on this? Finally, the Aguilera paper discusses the underprediction of wildfire PM2.5 by the ensemble model, which seems visible in your Figure 2a (of non-wildfire PM2.5 that shows some potential wildfire contributions) and could be highlighted as limitation.

The final version of this paper has been recently published and the reference has been updated accordingly in the revised manuscript. The full reference is: Aguilera, R., Luo, N., Basu, R., Wu, J., Clemesha, R., Gershunov, A., & Benmarhnia, T. (2023). A novel ensemble-based statistical approach to estimate daily wildfire-specific PM2. 5 in California (2006–2020). Environment International, 171, 107719.

The RMSE is related to total PM2.5 as there is no direct measurement nor gold standard measure of wildfire smoke PM2.5 and the RMSE is comparable, and even lower to similar studies on total PM2.5 in California (such as Li et al., 2020 or Reid et al.2021). The RMSE is indeed in ug/m3 and the manuscript has been revised accordingly. Furthermore, in Aguilera et al. 2023, multiple robustness tests have been conducted regarding the validity of wildfire smoke PM2.5 estimates such as the figure below (Figure S5 in Aguilera et al. 2023) showing the clear pattern between wildfire smoke PM2.5 estimates and smoke intensity.

## *Distribution of estimated wildfire-specific PM2.5 concentrations for the three HMS smoke density categories (light, medium and heavy), available starting 2010 up to present. The boxplot below omits outliers and includes wildfire-specific PM2.5 concentrations up to the 99% percentile.*

Chart, box and whisker chart

Description automatically generated

References:

Di, Q., Amini, H., Shi, L., Kloog, I., Silvern, R., Kelly, J., Schwartz, J., 2019. An ensemble based model of PM2. 5 concentration across the contiguous United States with high spatiotemporal resolution. Environ. Int. 130, 104909.

Reid, C.E., Considine, E.M., Maestas, M.M., et al., 2021. Daily PM2.5 concentration estimates by county, ZIP code, and census tract in 11 western states 2008–2018. Sci. Data 8, 112. https://doi.org/10.1038/s41597-021-00891-1.  
  
3. 'Outcome definition' lines 43-46 - suggested revision: "We aggregated visit counts to the weekly level because the last recorded fire boundaries and evacuation zones used to define the proximity exposures were for one specific date only and did not provide information at the daily level."

Thank you for this edit! We have added it.

*For analyses measuring residence near a fire on in an evacuation zone, we used ZCTA level daily visit counts aggregated to the weekly level. We aggregated visit counts to the weekly level because the last recorded fire boundaries and evacuation zones used to define the proximity exposures were for one specific date only and did not provide information at the daily level. By aggregating, we also removed weekend-weekday patterns in outpatient visits, increased power, and reduced zero inflation. We considered a week exposed if the Woolsey or Getty fire burned any day that week.*

*Page 5, Outcome definition, paragraph 3.*  
  
4. 'Analysis' section - for both the daily wildfire PM2.5 and weekly proximity-based epidemiologic analyses, please specify how temperature was controlled in terms of temperature metric used (daily min, max, or mean) and temporal aspects (temperature lags) that were included in the models.

We have edited the analysis section to include this information:

*We controlled for temperature using a penalized spline term, as temperature can predict respiratory and cardiovascular healthcare utilization55 and wildfire56, using daily mean temperature data from the PRISM Climate Group57. We did not include any lags on temperature. We also controlled for long-term seasonal trends not caused by exposure with a natural spline term, and used the number of years in the study period (four) to determine the natural spline flexibility (12 degrees of freedom). We controlled for non-wildfire PM2.5, since non-wildfire PM 2.5 concentrations were high during the study period: mean daily non-wildfire PM2.5 by grouping was 11.0 𝜇𝑔/𝑚3 (SD = 6.69), just under the annual USEPA National Ambient Air Quality Standard of 12 μg/m3 (Figure 2a).*

*Page 6, Analysis Wildfire PM2.5, paragraph 2.*   
  
5. 'Analysis, proximity to wildfire and evacuation', lines 53-57 - please clarify the temporal aspects of the DID estimators, e.g., they subtracted the change in visit frequency during weeks (?) that fires were burning vs. not burning?

Yes, this is weekly visit frequency. We added this:

*The DID estimators subtracted the change in weekly visit frequency when the Getty or Woolsey Fire was burning versus not burning among control ZCTAs (difference 1) from the change in visit frequency when the Getty or Woolsey Fire was burning versus not burning among ZCTAs exposed to the fire or evacuation zone (difference 2).*

*Page 7, proximity to wildfire and evacuation, paragraph 1.*  
  
6. 'Results, Woolsey Fire', line 48 - should this be 'wider confidence intervals'?

Yes, thank you for pointing this out, we’ve changed it.

*We observed similar associations, with wider confidence intervals, between Woolsey Fire evacuation exposure and healthcare visits.*

7. 'Results, Getty Fire proximity', line 58-59 - suggested rephrasing 'We observed no difference in frequency for any visit type during the Getty Fire for those living within 20 km of the fire compared to those living further away.'

Thank you for this edit, we’ve changed it:

*We observed no difference in frequency for any visit type during the Getty Fire for those living within 20 km of the fire compared to those living further away (Figure 3). Residence within an evacuation zone plus 10km was associated with reduced risk of all types of visits, though confidence intervals were very wide (Figure 3).*

8. Please double check references throughout. Some in-text citations show an error.

We have fixed the in-text citations.  
  
9. Please also take a close read through the manuscript for a number of minor typos and phrasing issues.

We have carefully proofread the manuscript.  
  
10. Please note that PM2.5 should be written with subscript 2.5 throughout.

We have subscripted all mentions of PM2.5.  
  
11. Table 1b - should title indicate 'weekly wildfire PM2.5'?

Yes, thank you for pointing this out. We fixed it.   
  
12. It would be helpful to keep ordering of results consistent throughout text and figures. E.g., Figure 3 should be ordered with Woolsey results first, and with visit types as discussed in text (e.g., outpatient visits at top, etc.).

We have reordered Figure 3, and also made certain that everything else is in this order.   
  
13. Figure 3 - suggest revision to x-axis labeling to make more specific, e.g., 'RR for residential proximity to wildfire boundary (left) and evacuation zone (right)'

Thank you for this suggestion. We have relabelled the axes.   
  
14. eFigure 1 blue lines are missing; also please make reference to eFigure 1 in the main text where appropriate. It could be helpful to include as part of the methods section, to help describe the DID assumptions and what the estimator is calculating.

Thank you for pointing this out - we have referenced this figure in the text, and edited the paragraph about the DID assumptions. We have also removed any reference to blue lines, as this referenced a previous iteration of the figure.

*If all models were specified correctly and parallel trends conditions were met, the DID estimator corresponded to the difference in visit frequency attributable to direct wildfire exposure. We assessed the parallel trends assumption visually in eFigure 1 in the supplemental digital content.*

*Page 7, Proximity to wildfire and evacuation, paragraph 1.*