

Asthma medication usage after environmental exposure to wildfire smoke: A systematic review

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Aims

The aim of this review was to understand how exposure to wildfire smoke impacts asthma medication dispensations, giving a more comprehensive picture of the health impacts of wildfires and planning effective health system responses when extreme fire events occur.

Background

With predictions of increasing frequency and intensity of wildfires (IPCC, 2022), information about the health impacts of exposure to the smoke from these fires becomes more critical from a health system planning perspective.

Asthma is a chronic condition that is characterised by reversible inflammation in the airways, leading to the obstruction of airflow, wheezing, breathlessness or coughing (Porsbjerg et al., 2023). Asthma deterioration can be triggered by several factors, including air pollution. In particular PM_{2.5}, which is prominent in wildfire smoke, may influence asthma-related outcomes.

Most research on asthma outcomes after wildfire smoke exposure has concentrated on emergency department visits and hospitalizations (Liu et al., 2015, Reid et al., 2016, Borchers et al., 2019). However, these represent only a small portion of potential asthma exacerbation markers. Including changes in medication usage after wildfire events is crucial for understanding the milder impacts and management of asthma following exposure to PM_{2.5} from wildfire smoke.

PECO Statement

Population:	Human population
Exposure	Exposure to PM _{2.5} from wildfires
Comparators	Lower exposure groups and unexposed groups or matched-subject exposure during reference periods (e.g., time-series or case-crossover studies).
Outcome	Asthma-related medication dispensations and usage

Methodology

Relevant studies were identified from a systematic search of three online databases (Web of Science, Scopus and PubMed).

The search was limited to English-language articles relating to epidemiological studies published up to March 2024.

Search terms

(dispens* OR medication OR corticosteroids OR salbutamol OR) AND (asthma OR wheez* OR pulmon* OR pulmon* OR respire*) AND (wildfire* OR bushfire OR "landscape fire" OR fire* OR fire*) AND (smoke OR "particulate matter" OR PM)

Inclusion criteria

- Observational epidemiological studies quantifying associations between exposure to wildfire smoke and asthma-related medication demand outcomes
- Published in English
- Published before April 2024

Exclusion criteria:

- The study investigated the health effects of indoor biomass burning, such as exposure to woodfire heaters.
- The study focused on health outcomes in animals rather than humans.
- The study lacked data on medication usage among the study population.
- The study focused on occupational exposure to wildfire smoke.
- The study did not provide a measure of whether PM_{2.5} exposure was specifically attributable to wildfires.

Results

Study locations

The 12 studies were conducted in USA (n=3), Canada (n=3) and Australia (n=6).

Study populations

Populations investigated in the studies varied. Several examined outcomes for entire populations in the study area (n=7), while others looked at outcomes for a subset. These included:

- 1 study examined outcomes for people in their mid-20s
- 1 study examined outcomes for people for people with asthma
- 1 study examined outcomes for children with asthma aged 5-17 years
- 1 study examined outcomes for adults with severe asthma
- 1 study examined outcomes for women with asthma

Study designs

A variety of study designs were found in the literature, including : retrospective cohort studies (n=5), cross-sectional studies (n=2), time-series (n=2), time-stratified case-crossover (n=1), prospective cohort (n=1) and ecological (n=1).

Key findings

There was a consistent increase in the use of a range of asthma medications reported after exposure to wildfire smoke.

Article	Health outcomes
Beyene et al. (2022a)	73% of severe asthma patients used more reliever medication after wildfire smoke exposure, and 44% started, restarted, or increased their dosage of inhaled corticosteroids.
Beyene et al. (2022b)	82% of women with asthma increased their reliever use and 55% increased their dosage or frequency of usage of their preventer medication.
Elliot et al. (2013)	Rate ratio = 1.06 (95% CI 1.04, 1.07) for salbutamol dispensations per 10mg/m ³ increase in PM _{2.5} (from ground station readings)
Gan et al. (2020)	OR of SABA2 dispensations 1.077 per 10mg/m ³ increase in wildfire-related PM _{2.5} concentration.
Haikerwal et al. (2021)	6% increased respiratory medication usage after exposure to wildfire smoke.
Howard et al. (2021)	48% increase in salbutamol doses in the 2014 fire season relative to the 2012 and 2013 seasons
Johnston et al. (2006)	OR for commencing oral steroids was 1.31 per 5mg/m ³ increase in PM _{2.5} and 1.12 per 5mg/m ³ increase in PM _{2.5} for commencing reliever medications
MacIntyre et al., 2021	4.4% of respondents increased their use of oral corticosteroids, 21.7% used more reliever medication, and 15.8% increased their use of controller or combined controller/reliever medication.
Mnatzaganian et al. (2015)	OR= 2.46 (95% CI 1.2, 4.8) for dispensing asthma medications in larger fires in the (i.e.108 acres or larger)
Tse et al. (2017)	No statistically significant increase in salbutamol dispensations for those affected by fire compared with those not affected by fire
Yao et al. (2018)	Relative risk of 1.04 per 10mg/m ³ increase in PM _{2.5} using modelled exposure data for the same population as Elliot et al. (2013)
Zhu et al. (2024)	136% increase in SABA2 dispensations in January 2020 compared with January 2019.

Conclusion

Despite differences in study designs, exposures, medications, locations and target populations across the reviewed studies, they consistently reported an uptake in the use of asthma-related medications following exposure to PM_{2.5} in smoke from wildfires. The largest associations reported were for uptake in the use of the reliever medication salbutamol. Increases in other asthma management medications were also consistently identified.

While further studies are needed to resolve the magnitude of the association in a variety of settings, we found compelling evidence for the existence of a positive association between exposure to PM_{2.5} in wildfire smoke and increased use of asthma-related medications.

Public health responses should anticipate increased demand for asthma-related medications in response to wildfire events, and plan to secure the supply of asthma-related medications.

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References

- Borchers Arriagada, N., Horsley, J. A., Palmer, A. J., Morgan, G. G., Tham, R., & Johnston, F. H. (2019). Association between fire smoke fine particulate matter and asthma-related outcomes: Systematic review and meta-analysis. In *Environmental Research* (Vol. 179). <https://doi.org/10.1016/j.envres.2019.108777>
- Intergovernmental Panel on Climate Change (IPCC). (2023). *Climate Change 2022 – Impacts, Adaptation and Vulnerability*. Cambridge University Press. <https://doi.org/10.1017/9781009325844>
- Liu, J. C., Pereira, G., Uhl, S. A., Bravo, M. A., & Bell, M. L. (2015). A systematic review of the physical health impacts from non-occupational exposure to wildfire smoke. *Environmental Research*, 136, 120–132. <https://doi.org/10.1016/j.envres.2014.10.015>
- Porsbjerg, C., Melén, E., Lehtimäki, L., & Shaw, D. (2023). Asthma. *The Lancet*, 401(10379), 858–873. [https://doi.org/10.1016/S0140-6736\(22\)02125-0](https://doi.org/10.1016/S0140-6736(22)02125-0)
- Reid, C. E., Brauer, M., Johnston, F. H., Jerrett, M., Balmes, J. R., & Elliott, C. T. (2016). Critical Review of Health Impacts of Wildfire Smoke Exposure. *Environmental Health Perspectives*, 124(9), 1334–1343. <https://doi.org/10.1289/ehp.1409277>

