JAMA Network Open

Invited Commentary | Environmental Health

Should Schools Be Made Clean Air Spaces for Wildfire Smoke Episodes?

John R. Balmes, MD

+ Related article

Author affiliations and article information are listed at the end of this article.

Primarily due to drought and extreme heat caused by climate change, massive wildfires are becoming increasingly common in the US[1] and many other areas of the world. California has seen many such fires, in part due to a legacy of fire suppression, a build-up of fuel on the forest floor, and an aging electricity transmission infrastructure. In addition to the immediate danger they pose to communities, wildfires produce copious amounts of smoke that can travel long distances and can have adverse health outcomes. Wildfire smoke is a complex mixture of particulate matter and irritant gases that is somewhat analogous to tobacco smoke without the nicotine. The best studied component of wildfire smoke in terms of health outcomes is fine particulate matter 2.5 μm or smaller in diameter ($PM_{2.5}$). The increased frequency of large wildfires in the western US is undermining the improvement in outdoor $PM_{2.5}$ air quality from regulatory policies instituted by federal and state governments, which require major investments across multiple economic sectors.[2]

Velasquez and colleagues[3] report the results of an analysis quantifying exposure to wildfire-specific $PM_{2.5}$ among school-aged children in California during the years 2006 to 2021. They used a publicly available data set of average daily wildfire $PM_{2.5}$ levels at zip code resolution to isolate wildfire-specific $PM_{2.5}$ from ambient $PM_{2.5}$. They combined those data with a recently published study[4] to estimate the infiltration of wildfire smoke into buildings in California and the number of student-days that wildfire $PM_{2.5}$ exposure was greater than 5, 12, and 35 $\mu g/m^3$ in schools. These exposure metrics are health-based values from the World Health Organization annual average concentration guideline,[5] the US Environmental Protection Agency (EPA) annual average concentration national ambient air quality standard, and the EPA 24-hour average standard,[6] respectively. The authors' analysis showed that the average number of student-days with exposures greater than 12 $\mu g/m^3$ per year during the study period was more than 5 000 000, with a small fraction of schools accounting for the majority of exposure days.[3] There was also a disproportionate impact of wildfire smoke days on children from indigenous backgrounds.

Velasquez et al[3] only assessed exposures to wildfire $PM_{2.5}$, and there was no attempt to associate health outcomes with the estimated exposures. The study[3] also has several limitations, including an ecological design (ie, there were no individual-level covariate data available to better support the analysis), no actual measurements of indoor $PM_{2.5}$ in schools during wildfire days, and no consideration of exposure to wildfire $PM_{2.5}$ of children when not in school. Why, then, is this article of considerable interest to health care practitioners? It is precisely because the risk of exposure to wildfire smoke appears to be disproportionately high in a sizable fraction of schools in California, many of which serve racial and ethnic minority populations of generally low socioeconomic status. The outcomes of exposure to wildfire smoke on the respiratory health of children are well described,[7] and recently reported evidence suggests that the relative respiratory toxicity of wildfire $PM_{2.5}$ may be considerably higher than outdoor $PM_{2.5}$ from non-wildfire sources, such as transportation and electricity generation.[8] On the basis of prior knowledge of health outcomes and the vulnerability of the children with the greatest exposure, the authors[3] make a call for equitable interventions to reduce exposures and thereby improve children's health.

What interventions at schools make sense? Because children spend a large fraction of their day in school, the buildings need to be made clean spaces through improved filtration.[9] Where feasible, central ventilation systems should be fitted with high-efficiency particle (HEPA) filters with a minimum efficiency reporting value (MERV) rating of 13 or higher. In schools without central ventilation or where installation of a MERV 13 filter is infeasible, reduction of $PM_{2.5}$ exposures in

individual classrooms can be achieved with portable HEPA filtration devices. With the implementation of adequate filtration, the air quality of schools can often be made safer than that of homes during wildfire smoke events. Given that children from low-income, racial and ethnic minority communities often have greater exposure and vulnerability than those from more affluent communities, an equitable approach to reducing children's exposures should focus on school filtration interventions rather than on individual behavior-dependent interventions such as wearing masks. In the long-run, school filtration interventions may even be cost-effective because supplying masks repeatedly to large numbers of students in wildfire-prone areas could be expensive.

School districts should evaluate school buildings for the ability to establish clean air shelter schools and prioritize funding for upgraded air handling systems using this information.[9] School staff could monitor wildfire risk to air quality using either data from the EPA's AirNow Fire and Smoke Map tool[9] or low-cost $PM_{2.5}$ sensors to assess the levels of $PM_{2.5}$ in their area. Given the projected increased frequency and severity of mega-wildfires with ongoing global warming, proactively working to make schools safe for children during poor air quality episodes caused by such fires makes good public health sense.

ARTICLE INFORMATION

Published: April 5, 2023. doi:10.1001/jamanetworkopen.2023.5780

Corresponding Author: John R. Balmes, MD, Department of Medicine, University of California, San Francisco, Box 0843, San Francisco, CA 94143-0843 (john.balmes@ucsf.edu).

Author Affiliations: Department of Medicine, University of California, San Francisco; Division of Environmental Health Sciences, School of Public Health, University of California, Berkeley.

Conflict of Interest Disclosures: Dr Balmes reported serving as a physician member of the California Air Resources Board, a state agency, during the conduct of the study.

REFERENCES

1. Zhuang Y, Fu R, Santer BD, Dickinson RE, Hall A. Quantifying contributions of natural variability and anthropogenic forcings on increased fire weather risk over the western United States. *Proc Natl Acad Sci U S A*. 2021;118(45):e2111875118. doi:10.1073/pnas.2111875118

2. Childs ML, Li J, Wen J, et al. Daily local-level estimates of ambient wildfire smoke $PM_{2.5}$ for the contiguous US. *Environ Sci Technol*. 2022;56(19):13607-13621. doi:10.1021/acs.est.2c02934

3. Velasquez EE, Benmarhnia T, Casey JA, Aguilera R, Kiang MV. Quantifying exposure to wildfire smoke among schoolchildren in California, 2006-2021. *JAMA Netw Open*. 2023;6(4):e235863. doi:10.1001/jamanetworkopen.2023.5863

4. Liang Y, Sengupta D, Campmier MJ, Lunderberg DM, Apte JS, Goldstein AH. Wildfire smoke impacts on indoor air quality assessed using crowdsourced data in California. *Proc Natl Acad Sci U S A*. 2021;118(36):e2106478118. doi:10.1073/pnas.2106478118

5. World Health Organization. WHO global air quality guidelines: particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. 2021. Accessed February 26, 2023. https://apps.who.int/iris/bitstream/handle/10665/345329/9789240034228-eng.pdf

6. US Environmental Protection Agency. NAAQS table. Updated April 5, 2022. Accessed February 26, 2023. https://www.epa.gov/criteria-air-pollutants/naaqs-table

7. Holm SM, Miller MD, Balmes JR. Health effects of wildfire smoke in children and public health tools: a narrative review. *J Expo Sci Environ Epidemiol*. 2021;31(1):1-20. doi:10.1038/s41370-020-00267-4

8. Aguilera R, Corringham T, Gershunov A, Leibel S, Benmarhnia T. Fine particles in wildfire smoke and pediatric respiratory health in California. *Pediatrics*. 2021;147(4):e2020027128. doi:10.1542/peds.2020-027128

9. US Environmental Protection Agency. AirNow: Wildfires. Accessed February 22, 2023. https://www.airnow.gov/wildfires/