

The Health Effects of Wildfire Smoke

Introduction

The Western United States has seen rapid increases in the length of its fire season, the number of annual fires, and the amount of land burned by wildfires over the last few decades.¹ This trend is expected to continue in the future.² While the fires themselves are a major hazard, exposure to wildfire smoke is also a serious public health concern.

Wildfire smoke contains tiny, partially-combusted particles—those 10 micrometers (μm) in diameter (PM10) or smaller can enter the lungs through the nose or throat, causing irritation or long-term damage.³ The most dangerous are the smaller particles (PM2.5 or smaller) which can enter the bloodstream.³ PM2.5 exposure from all sources is a significant environmental risk factor for human health effects across the globe.⁴

Smoke from wildfires can travel long distances and increase PM2.5 levels in the air far from the source.⁵ During wildfire events, the average indoor concentration of PM2.5 has been shown to nearly triple, even with measures taken to reduce infiltration from outside air.⁶ Under high-emissions scenarios, wildfire smoke could be the primary source of global PM2.5 exposure as early as 2100.⁷ It is vitally important to understand how wildfire smoke affects human health. This factsheet provides an overview of the health impacts of wildfire smoke exposure as represented in the current literature.

Vulnerable Populations

In addition to the increasing severity of wildfire seasons, our expanding wildland-urban interface (where human settlement runs up against undeveloped land) is increasing the number of communities at risk.⁸ Those most vulnerable to wildfires are those with existing chronic conditions (particularly heart or lung disease), such as asthma, chronic obstructive pulmonary disease (COPD), emphysema, heart failure, angina, or ischemic heart disease.^{7,16,17} Women with asthma and COPD tend to be more severely impacted than men.^{9,10} Finally, older adults, young children, teenagers, pregnant women, and individuals of low socioeconomic status have all been shown to be at increased risk of smoke exposure and/or associated health impacts.^{1,17,18}



A Note on Responders

Despite evidence that continuous exposure to wildfire smoke in an occupational setting may have more pronounced health impacts than in the general public, responders (especially non-traditional responders like civilians and prison inmates) are understudied.¹¹⁻¹⁶ A few of the occupational health impacts include:

- Impaired lung functioning, though the duration of impairment is less well established^{11,13,16}
- Increased risk for developing severe COVID-19¹²
- Mental health impacts, such as PTSD and impaired sleep quality and quantity¹⁴

What's in Wildfire Smoke?

The chemical composition and toxicity of wildfire smoke varies by the landscape, stage of the wildfire's combustion (open flames versus smoldering), and fuel type.¹⁷ Wildfire-specific PM2.5 may be up to ten times more harmful to human health than PM2.5 from any other source.¹⁸ In addition to PM2.5, wildfire smoke may also contain the following pollutants of concern:¹⁹

- Greenhouse gasses, including carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O)
- Carbon monoxide (CO)
- Nitrogen dioxide
- Ozone
- Polycyclic aromatic hydrocarbons (PAHs)
- Photochemically reactive compounds (e.g., CO, nonmethane volatile organic carbon, nitrogen oxides)
- Volatile organic compounds (VOCs)
- HCN, HF, HCl, isocyanates,
- Dioxins and furans
- Toxic organic compounds (e.g., benzene toluene, xylenes, styrene, formaldehyde, etc.)
- Metals (e.g., Cr, Cd, As, etc.)
- Acrolein
- Benzene

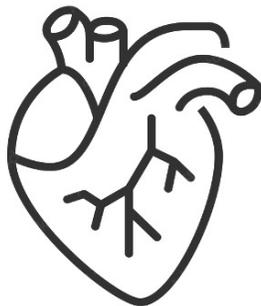




Acute Impacts

Exposure to wildfire smoke can immediately produce several unpleasant short-term health effects, even in healthy individuals. The most commonly reported health impacts are:²⁰

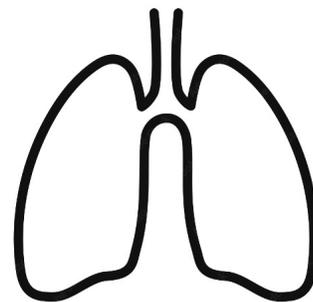
- Physiological: stinging eyes, scratchy throat, runny nose, irritated sinuses, headaches, tiredness
- Respiratory: coughing, trouble breathing, wheezing, asthma attacks
- Cardiovascular: chest pain, rapid heartbeat



Cardiovascular Impacts

Compared to respiratory impacts, less research has been done on the cardiovascular and cerebrovascular health impacts of smoke exposure. However, plausible biological pathways have been established.^{21,24} Some studies have associated wildfire smoke exposure with cardiovascular mortality and all-cause cardiovascular disease emergencies for up to a week after the event.^{10,23,25-28}

The most commonly reported cardiovascular issues are hypertension, non-traumatic intracranial hemorrhage, stroke, heart failure, ischemic heart disease, dysrhythmia, and pulmonary embolism.^{24,25}



Respiratory Impacts

Most studies agree that wildfire smoke is associated with an increase in respiratory morbidity. In the days following exposure, asthma and COPD can be exacerbated and may result in medical emergencies.^{7,13,21-23} Even otherwise-healthy adults may experience reduced lung functioning for years after exposure.^{13,22} There is some evidence that smoke exposure results in increased rates of respiratory infection (e.g., bronchitis and pneumonia), though this is inconclusive.^{8,10,13}



Other Impacts

There are numerous other adverse health impacts associated with wildfire smoke exposure. These include:

- Neurological impacts. Neurological aging and increased incidence of Alzheimer's disease and dementia have been linked to wildfire-derived PM2.5 exposure.²⁵ Some groups may experience increased risk of cerebrovascular conditions, but more research is needed.²⁹
- Gestational health outcomes. In-utero exposure to wildfire smoke has been linked to reduced birthweights, increased preterm births, and long-term stunted growth.^{7,10,15,30,31} Exposed pregnant mothers are also at heightened risk of gestational diabetes and gestational hypertension.⁷
- Cancer. Exposure to hazardous air pollutants (HAPs) released during wildfires increases the risk of cancer development, especially lung cancer; wildfires have been described to account for a third of the excess risk of cancer due to HAPs.³⁰
- Other general health outcomes. Multiple studies have shown adverse association between smoke exposure and bone marrow content, systemic inflammation, ability to exercise, physical strength, and overall health.^{10,32}

Mortality

There is significant evidence that exposure to wildfire smoke increases all-cause mortality for a few days after the exposure.^{21,33,34} Respiratory mortality risk is particularly high after smoke exposure.³⁴ Given lag time and the fact that the exposure primarily exacerbates existing conditions, it can be difficult to attribute deaths to wildfire smoke exposure. A commonly cited study estimates that 33,510 all-cause deaths a year are attributed to wildfire smoke exposure.³⁴ This number is reported from a study that had limited study sites, and was meant to estimate comparative mortality rates, not counts. As such, this statistic likely severely underestimates the actual number of deaths a year globally.³⁴

Mental Health*

Wildfire smoke exposure impacts mental health. Persistent smoke exposure and/or having to shelter indoors from wildfire smoke may have mental health impacts such as stress, depression, heightened anxiety, isolation/loneliness, and a lack of motivation.^{14,32} A high number of smoky days may also contribute to the development of solastalgia, or grief related to environmental change.¹⁴

*For more on the mental health impacts of disasters, see "Mental Health Impacts of Natural Hazards" factsheet

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*Content by Matias Kormacher and Ashley Moore
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