
SFE Fact Sheet 2012-8

# Case Studies on the Impacts of Wildfire Smoke on Public Health

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## KEY RESULTS

Due to the composition and dispersion of wildland fire smoke, particulate matter is the principal pollutant of public health concern. Effects will vary based on the source of smoke but predominantly impact local communities in the same way. Studies of the effects of PM from non-fire sources show that long-term exposure can reduce lung function and cause the development of chronic bronchitis. Short-term exposure (hours or days), typical of wildland fire events, can aggravate lung disease, leading to asthma attacks and acute bronchitis. These effects can also increase the susceptibility to respiratory infections. Healthy children and adults may not suffer serious effects from short-term exposures, although temporary minor irritation may occur when particulate matter levels are elevated. Short-term exposure effects on cardiovascular health outcomes are more variable and may be related to previous diagnoses of heart disease. Pre-mature mortality cannot be ruled out as a possible health outcome, but in a study evaluating a population of over two million people, there was no significant correlation between such mortality and increased smoke exposure.

## OVERVIEW

Exposure to smoke from wildland fire is an important public health concern. While fire managers can minimize prescribed fire smoke impacts by identifying smoke-sensitive areas and using appropriate burn techniques, smoke exposure is an inevitable side effect of some prescribed fires and many wildfires. People who come in contact with smoke often have questions about what they are breathing and how it will affect their health.

Federal and state agencies and public health organizations, such as the Environmental Protection Agency (EPA), Departments of Public Health, the National Institute of Environmental Health Sciences, and the American Lung Association provide valid and credible information to answer these questions (See Additional Resources section for examples).

In addition, a variety of research studies have explored these questions to gain a better understanding of how smoke exposure affects public health. These studies have evaluated physician visits and hospital admission records during or following several wildland fire events to monitor the diagnosis of respiratory and cardiovascular illness for individuals exposed to smoke. Several studies also looked at the relationship of premature mortality and exposure to smoke. To provide insight on the health effects of exposure to wildland fire smoke, this fact sheet briefly describes the pollutants in wildland fire smoke and then summarizes five studies that have documented health effects of wildland fire smoke in the United States, Canada, and Australia.

## SMOKE AND OTHER AIR POLLUTANTS

Questions about smoke and its effects on health are common during both prescribed burns and wildfires.
PHOTO BY SC FORESTRY COMMISSION.

The components of wildland fire smoke that are most hazardous to human health are carbon monoxide, a group of gases called aldehydes, and particulate matter (PM)—tiny particles of solid matter that are small enough to be inhaled. Particulate matter is the main pollutant of concern, as carbon monoxide, aldehydes, and the hundreds of other compounds emitted by wildland fires are found in very low concentrations at short distances away from a fire. People with heart or lung disease, children, and older adults are the most likely to be affected by breathing particulate matter. However, even healthy individuals may experience temporary symptoms from exposure to elevated levels of particle pollution. Forest fire smoke is a prominent source of particulate matter pollution, but its public health effects are challenging to assess because smoke exposure is sporadic, short-lived, and rare in densely-populated areas.

## HEALTH EFFECTS

Five case studies were chosen to evaluate and identify the health effects associated with the exposure to wildland fire smoke. The selected studies provide insight to the chronic and acute health effects of multiple fires and fire seasons. The first are from three widely separated locations in the United States. The last two add an international perspective to the general results and conclusions.

### Case 1: Peat Bog Wildfire Smoke Exposure in Rural North Carolina

For a six-week period in 2008, a lightning-ignited wildfire in dry peat swamps in eastern North Carolina produced heavy smoke that mostly drifted off the coast. However, in one 3-day period winds reversed and created dense smoke exposures across 18 counties, with several ground monitors recording particulate matter concentrations over 200 $\mu g/m^3$. The National Ambient Air Quality Standard for $PM_{2.5}$ (particles 2.5 micron diameter or less) is 35 $\mu g/m^3$ for a 24-hour period.

In 2008, researchers investigated health effects of wildfire smoke exposure from peat bogs burning in eastern North Carolina. PHOTO BY US FISH AND WILDLIFE SERVICE.

Research professionals used this fire as an opportunity to investigate associated health effects of wildfire smoke exposure, collecting data on emergency room (ER) visits for cardiac and respiratory conditions. Relative risk for the 3-day exposure window was compared to adjacent counties that were not exposed to the smoke and to periods before and after in the affected counties.

The North Carolina study found that exposure to particulate matter from the peat bog smoke increased ER visits for asthma, chronic obstructive pulmonary disease (COPD), pneumonia, acute bronchitis, and heart failure in the affected counties. Similar to other studies, asthma-related outcomes were most prevalent (44% of all respiratory ER admissions), especially among adult women. The study also demonstrated a significant association between smoke exposure in the 3-day period and an increase in ER visits for heart failure. It was not clear if this unique finding was due to the high particulate matter concentrations, or peat as the source of the smoke, or some other combination of factors that might have made this fire different from more typical forest fires where health effects have been studied.

### Case 2: Respiratory and Cardiovascular Hospital Admissions during the 2003 Southern California Wildfires

This study evaluated the relationship of cardiorespiratory hospital admissions to wildfire-related particulate matter ($PM_{2.5}$) concentrations during a series of catastrophic wildfires that occurred in California in October 2003. Exposure to smoke was estimated using many different methods to understand particulate matter concentrations in affected areas. During the fires, there was a strong association between smoke exposure and respiratory admissions. Communities experienced average increases in $PM_{2.5}$ of 70 $\mu g/m^3$ during heavy smoke conditions. These conditions were compared with $PM_{2.5}$ concentrations in the pre-wildfire period and showed an increase of 34% in asthma admissions.

The strongest associations between $PM_{2.5}$ in smoke and hospital admissions were for people over 65 years old (10% increase per 10 $\mu g/m^3$ $PM_{2.5}$) and under 5 years old (8% per 10 $\mu g/m^3$ $PM_{2.5}$ ). Acute bronchitis admissions increased across all ages by 10% for every 10 $\mu g/m^3$ in wildfire-related $PM_{2.5}$. Chronic obstructive pulmonary disease admissions for ages 20–64 years also increased by 7% and pneumonia admissions for ages 5–18 years increased by 64%. There was limited evidence of a small impact of wildfire-related $PM_{2.5}$ on cardiovascular admissions. Ultimately, the findings showed that wildfire-related $PM_{2.5}$ led to increased respiratory hospital admissions, especially asthma. These results highlight the need for better preventive measures to decrease smoke exposure and respiratory ailments among vulnerable populations during wildfires.

### Case 3: Wildfire Air Pollution and Daily Mortality in a Large Urban Area

The two previous studies looked at both respiratory and cardiovascular health effects from wildland fire smoke, while excluding premature mortality from analyses. The United States Department of Environmental and Occupational Health Science, along with the University of Wash-

ington School of Public Health and Community Medicine, explored whether acute increases in PM concentrations from wildfire smoke caused acute increases in daily mortality. The daily occurrence of non-accidental deaths and daily cardio-respiratory deaths for June of 2002 in the Denver metropolitan area were examined and compared to those in two nearby counties in Colorado that were not affected by wildfire smoke.

Abrupt increases in particulate matter concentrations in Denver occurred on two different days in June as a result of wildfire smoke drifting over the Denver area. One-hour measurements indicated peak concentrations of $PM_{10}$ and $PM_{2.5}$ were 372 μg/m$^3$ and 200 μg/m$^3$, respectively, on June 9$^{th}$ and 316μg/m$^3$ and 200 μg/m$^3$, respectively, on June 18$^{th}$. Small peaks in mortality corresponded to both of the PM peaks, but the first mortality peak also corresponded to a peak of mortality in the control counties, and cardio-respiratory deaths began to increase on the day before the second peak. This point details the probability that other weather related factors may have contributed to these mortality peaks. Further, there was no detectable increase in cardio-respiratory deaths in the hours immediately following the PM peaks.

Although the findings from this study do not rule out the possibility of small increases in mortality due to abrupt and dramatic increases in PM concentrations from wildfire smoke, in a population of over 2 million people no observable increases in daily mortality could be attributed to such events.

### Case 4: Three Measures of Forest Fire Smoke Exposure and Their Associations with Respiratory and Cardiovascular Health Outcomes in British Columbia

During the summer of 2003, numerous wildfires burned in British Columbia, Canada, with significant smoke incursions in residential areas. The School of Environmental Health and the School of Population and Public Health at the University of British Columbia conducted a study to examine the associations between respiratory and cardiovascular physician visits and hospital admissions using three measures of smoke exposure over a 92-day study period.

The study monitored exposure utilizing air quality monitors, a smoke-related dispersion model, and a smoke exposure metric for plumes visible in satellite images. These measures sought to gain insight into the effects of increases in the total concentration of particulate matter and the presence or absence of exposure to smoke on all respiratory and cardiovascular physician visits and hospital admissions during the study period. More specific analyses were also conducted for physician visits for asthma, acute upper respiratory infections, and non-hypertensive cardiovascular diagnoses. The study assessed the effect of age, sex, socioeconomic status, and possible pre-existing sensitivity (based on numbers of respiratory or cardiovascular physician visits in the prior year).

Scientists use specialized equipment to measure fire emissions and air quality. PHOTO BY TIMOTHY MOLO.

Overall, the study found that increased particulate matter exposure was associated with increased respiratory physician visits and hospital admissions, but not with cardiovascular physician visits or hospital admissions. Of the 34,771 respiratory physician visits, 5,496 (16%) were coded as "asthma" and 21% were coded as "acute bronchitis" or "acute upper respiratory infection." This study observed a 5% increase in hospital admissions and a 6% increase in respiratory physician visits related to a 10μg/m$^3$ increase in $PM_{10}$ (particles 10 micron diameter or less) from a wildland fire event. In the most similar study to date (Case 2, above), a 10 parts per million increase in $PM_{2.5}$ produced a 3% increase in the rate of respiratory hospital admissions. Hospital visits and related health outcomes were significant only in cases where there was a drastic increase in particulate matter exposure (greater than or equal to 30 μg/m$^3$).

Days of smoke coverage ranged from 1 to 24 (out of 92) within the study group. The majority of study areas had particulate matter values close to zero, on most days, while observations of high values were observed in study areas very near active fires. This study observed no clear differences by sex, socioeconomic status, or possible pre-existing sensitivity. Results indicating effects of fire smoke on respiratory ailments are consistent with previous studies. Short-term exposure effects on cardiovascular health outcomes are more variable and may be related to previous diagnoses of heart disease.

### Case 5: Vegetation Fire Smoke, Indigenous Status and Cardio-Respiratory Hospital Admissions in Darwin, Australia, 1996–2005: A Time-Series Study

Air pollution in Darwin, Northern Australia, is dominated by smoke from seasonal fires in the surrounding savanna that burn during the dry season from April to November. This repeated exposure has garnered much interest in better understanding related health effects and led to a collaborative study involving research professionals from Charles Darwin University, University of Tasmania, The

North Coast Area Health Service, and Department of Rural Health.

The study focused on the association between particulate matter and daily emergency hospital admissions for cardio-respiratory diseases for each fire season from 1996 to 2005. The study also investigated whether the relationship differed in indigenous Australians—a population sub-group. There were 2,410 days in the ten dry seasons of the study period. During the study period there were 8,279 hospital admissions.

Despite indigenous people representing 11% of the population of Darwin, they comprised 23% of hospital admissions in the study. This study observed a 4.8% increase in total respiratory related admissions associated with a 10 $\mu g/m^3$ increase in ambient $PM_{10}$. The relationship between vegetation fire smoke and daily hospital admissions for respiratory diseases was stronger in indigenous people, with an increase of 15% in respiratory related admissions compared with only a 0.7% increase among non-indigenous people. While this study was limited by the use of estimated rather than measured exposure data, the results are consistent with the currently small evidence base concerning this source of air pollution.

These studies found a positive relationship between particulate matter and total respiratory admissions, asthma and respiratory infections especially among indigenous people. However, this study found no relationships between PM and Chronic Obstructive Pulmonary Disease or cardiovascular outcomes in both population groups.

## REFERENCES


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## ADDITIONAL RESOURCES

Center for Disease Control and Prevention: The National Institute for Occupational Safety and Health
http://www.cdc.gov/niosh/

Center for Disease Control and Prevention: Wildfire Smoke https://www.cdc.gov/disasters/wildfires/smoke.html

Center for Disease Control and Prevention: Protect Yourself from Wildfire Smoke
https://www.cdc.gov/air/wildfire-smoke/default.htm

Wildfire Smoke: A Guide for Public Health Officials
https://www.airnow.gov/sites/default/files/2020-06/wildfire-smoke-guide-revised-2019.pdf


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