Chronic Obstructive Pulmonary Diseases:
Journal of the COPD Foundation

Journal Club

Journal Club: Respiratory Impact of Wildfire Smoke

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Abbreviations: particulate matter, **PM**; chronic obstructive pulmonary disease, **COPD**; American Thoracic Society, **ATS**

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Introduction

The 2021 wildfire season is underway in many areas in the United States, and in the past 4 decades, the area burned has quadrupled.[1] In addition to the direct and indirect financial costs, there is significant social, ecological, and health morbidity associated with wildfires. It is estimated that an average of 339,000 people worldwide die from fire-related smoke.[2,3] Respiratory effects of wildfire smoke in healthy individuals are typically short-lived upper respiratory symptoms. However, older adults and those with chronic lung diseases are at exceptionally high risk for respiratory events when exposed to wildfire smoke.[4-7] Toxic components of wildfire include carbon monoxide, polycyclic aromatic hydrocarbons, and fine particulate matter (PM) with an aerodynamic diameter of 2.5µm or smaller ($PM_{2.5}$). Toxins in wildfire smoke promote inflammation, oxidative stress, and higher infection risk with alteration of immune function.[8-11] The size of $PM_{2.5}$ enables these particles to bypass the protective barriers of the upper airway, and some evidence suggests that they enter the bloodstream.[12,13] Chronic $PM_{2.5}$ exposure is associated with increased risk for respiratory disease, hospitalizations due to respiratory concerns, and increased risk for lung cancer.[12,14-17] Recent data show that components of $PM_{2.5}$ from fire smoke result in differential toxicity and more significantly impairs the host defense when compared to ambient biomass.[3,18,19] These effects are primarily by impairment of pulmonary macrophage function and by promoting neutrophilic inflammation.[10,20-22] The meteorological and ignition causes of wildfires vary by region; however, the impact of climate change, coupled with increasing urban development in wildfire-prone areas, are major drivers.[23-25] The landmark Paris Agreement, signed in 2015, sought to curb human contribution to climate change, and this treaty on climate change and similar environmental policies have positively impacted environmental pollution. Despite recent regulatory changes, we have still had 5 of the hottest years ever recorded, with recent data showing that 2020 was in the top 3 hottest years on record.[26,27] The effect of climate change on wildfires is tangible.[3,28] A climatological risk analysis showed that in the period between 2016 to 2019, there was an increase in the risk of wildfire in 58% of countries evaluated (114/196) compared to the period between 2001 and 2004.[29] The countries with the most significant increases in wildfire risk were Lebanon, Kenya, and South Africa. The impact of urban development, most evident in the western United States, has been associated with the expansion of cities into regions prone to wildfire and urban development encroaching on wildland without preserving separation between wildland vegetation and adjacent developed land.[29,30] Additionally, global weather extremes directly impact wildfire risk, as evidenced by the 2019/2020 Australian bushfire season that occurred during a combination of record

high temperatures and low rainfall. Significant changes in policy and human behavior are desperately needed to mitigate the adverse effects of the climate, and climate change, on human health. It is essential to increase awareness among health care providers and the public about the largely preventable impact this has on respiratory health.[31]

Older adults, and those with chronic lung diseases, particularly chronic obstructive pulmonary disease (COPD) and asthma, are at the highest risk for respiratory events when exposed to wildfire PM.[6,32,33] Wildfires greatly and suddenly increase $PM_{2.5}$ concentrations, frequently exceeding the upper limits of safety ($35\mu g\ m^{-3}$)and in many cases reaching hazardous levels ($>250\mu g\ m^{-3}$) as defined by the United States Environmental Protection Agency's Air Quality Index.[32,34] One extensive epidemiological study evaluating the health risks of wildfire-specific fine particulate matter was conducted by Liu and colleagues, evaluating the risk of hospitalizations in adults over 65 years of age.[18] They assessed the risk of hospitalized events over a 6-year time span comparing the risk for individuals in rural and urban counties on the West coast of the United States. They found a 7.2% increase in the risk of hospitalization for respiratory conditions during "smoke days," where $PM_{2.5}$ concentrations exceeded the safety limit from wildfire smoke compared to days with similar levels of $PM_{2.5}$ from ambient biomass.[18] Similarly, in a bidirectional case-crossover study assessing health care utilization in San Diego during the 2007 fire season, the number of emergency department visits increased by 34%, with a 112% increase in visits for asthma.[32] Additionally, the number of outpatient visits for acute bronchitis was 72% above average for the 5 days after the peak fire period.[32]

In this Journal Club, we review a workshop report from the American Thoracic Society (ATS) Environmental Health Policy Committee and the ATS Assembly on Environmental, Occupational, and Population Health regarding respiratory impacts of wildland fire smoke. The taskforce recommends several harm reduction strategies and emphasizes the need for a multidisciplinary and integrated approach to address this growing health problem. This ATS workshop report emphasizes the importance of the effect of both planned and unplanned wildland fires. The report also highlights that unique and regional considerations for fire management need to be adapted to the ecosystem, considering issues such as increased fire risk due to overgrowth of fire-prone vegetation. The taskforce urges a unified approach involving policymakers and public health bodies to create progressive policy reform that empowers and informs the public. In this Journal Club, we will also review some of the most recent studies examining the respiratory morbidity of wildfire smoke exposure.

Note: Abstracts are presented in their original published format and have not been edited to match JCOPDF style.

Abstract 1
Respiratory Impacts of Wildland Fire Smoke: Future Challenges and Policy Opportunities. An Official American Thoracic Society Workshop Report

Rice MB, Henderson SB, Lamber AA, et al. *Ann Amer Thorac Soc*. 2021;18(6):921-930.
doi: https://doi.org/10.1513/AnnalsATS.202102-148ST

Abstract: Wildland fires are diminishing air quality on a seasonal and regional basis, raising concerns about respiratory health risks to the public and occupational groups. This American Thoracic Society (ATS) workshop was convened in 2019 to meet the growing health threat of wildland fire smoke. The workshop brought together a multidisciplinary group of 19 experts, including wildland fire managers, public health officials, epidemiologists, toxicologists, and pediatric and adult pulmonologists. The workshop examined the following four major topics: 1) the science of wildland fire incidence and fire management, 2) the respiratory and cardiovascular health effects of wildland fire smoke exposure, 3) communication strategies to address these health risks, and 4) actions to address wildland fire health impacts. Through formal presentations followed by group discussion, workshop participants identified top priorities for fire management, research, communication, and public policy to address health risks of wildland fires. The workshop concluded that short-term exposure to wildland smoke causes acute respiratory health effects, especially among those with asthma and chronic obstructive pulmonary

disease. Research is needed to understand long-term health effects of repeated smoke exposures across fire seasons for children, adults, and highly exposed occupational groups (especially firefighters). Other research priorities include fire data collection and modeling, toxicology of different fire fuel sources, and the efficacy of health protective measures to prevent respiratory effects of smoke exposure. The workshop committee recommends a unified federal response to the growing problem of wildland fires, including investment in fire behavior and smoke air quality modeling, research on the health impacts of smoke, and development of robust clinical and public health communication tools.

Comments

This ATS workshop report, published in June of 2021, is a thorough yet concise summary of the most pertinent issues regarding the respiratory health risks of wildland fire exposure. This report is an excellent introduction to the field with a balanced analysis of the areas where there is the most opportunity for improvement. The authors provide key insights such as discussion of wildfire suppression in increasing wildfire-prone vegetation, which later increases wildfire risk. They offer concrete recommendations to this and similar issues pertinent to disaster mitigation, particularly in the United States. The committee offers concise and informative commentary on the current state of events and targeted recommendations for the most pertinent stakeholders. They offer actionable recommendations for clinicians, priorities for wildfire scientists and funding agencies, and suggested public policy, including targeted public health interventions and smoke preparedness.

Abstract 2
Mortality Associated with Wildfire Smoke Exposure in Washington State, 2006-2017: A Case-crossover Study

Doubleday A, Schulte J, Sheppard L, et al. *Environ Health*. 2020;19:4.
doi: https://doi.org/10.1186/s12940-020-0559-2

Background: Wildfire events are increasing in prevalence in the western United States. Research has found mixed results on the degree to which exposure to wildfire smoke is associated with an increased risk of mortality.

Methods: We tested for an association between exposure to wildfire smoke and non-traumatic mortality in Washington State, USA. We characterized wildfire smoke days as binary for grid cells based on daily average $PM_{2.5}$ concentrations, from June 1 through September 30, 2006-2017. Wildfire smoke days were defined as all days with assigned monitor concentration above a $PM_{2.5}$ value of 20.4μg/m^3, with an additional set of criteria applied to days between 9 and 20.4μg/m^3. We employed a case-crossover study design using conditional logistic regression and time-stratified referent sampling, controlling for humidex.

Results: The odds of all-ages non-traumatic mortality with same-day exposure was 1.0% (95% CI: -1.0- 4.0%) greater on wildfire smoke days compared to non-wildfire smoke days, and the previous day's exposure was associated with a 2.0% (95% CI: 0.0-5.0%) increase. When stratified by cause of mortality, odds of same-day respiratory mortality increased by 9.0% (95% CI: 0.0-18.0%), while the odds of same-day COPD mortality increased by 14.0% (95% CI: 2.0-26.0%). In subgroup analyses, we observed a 35.0% (95% CI: 9.0-67.0%) increase in the odds of same-day respiratory mortality for adults ages 45-64.

Conclusions: This study suggests increased odds of mortality in the first few days following wildfire smoke exposure. It is the first to examine this relationship in Washington State and will help inform local and state risk communication efforts and decision-making during future wildfire smoke events.

Comments

Several previous reports show an increased risk of mortality in the period immediately following significant wildfire smoke exposure. Studies from across the world have shown that the elderly in particular are at increased risk of mortality, with increased risk of out-of-hospital cardiac arrest and higher respiratory mortality, particularly in individuals over 75 years of age.[34-36] This study provides new

data from the Western United States demonstrating the significant mortality impact of wildfire smoke in the state of Washington. The study found an increased risk of death the day of wildfire exposure and the day after in all age groups. They noted a 14% increase in the risk of COPD-related mortality on wildfire smoke days which was higher than other respiratory conditions. This study adds to the existing literature about the significant health impacts of wildfire smoke and should heighten the awareness of clinicians.

Abstract 3
Wildfire Smoke Impacts Respiratory Health More than Fine Particles from Other Sources: Observational Evidence from Southern California

Aguilera R, Corringham T, Gershunov A, Benmarhnia T. *Nat Commun*. 2021;12:1493.
doi: https://doi.org/10.1038/s41467-021-21708-0

Abstract: Wildfires are becoming more frequent and destructive in a changing climate. Fine particulate matter, PM2.5, in wildfire smoke adversely impacts human health. Recent toxicological studies suggest that wildfire particulate matter may be more toxic than equal doses of ambient PM2.5. Air quality regulations however assume that the toxicity of PM2.5 does not vary across different sources of emission. Assessing whether PM2.5 from wildfires is more or less harmful than PM2.5 from other sources is a pressing public health concern. Here, we isolate the wildfire-specific PM2.5 using a series of statistical approaches and exposure definitions. We found increases in respiratory hospitalizations ranging from 1.3 to up to 10% with a 10μg m^{-3} increase in wildfire-specific PM2.5, compared to 0.67 to 1.3% associated with non-wildfire PM2.5. Our conclusions point to the need for air quality policies to consider the variability in $PM_{2.5}$ impacts on human health according to the sources of emission.

Comments

In this observational study, the authors examined the respiratory impact of particulate matter from wildfires over more than a decade. The methods allowed them to separate the effects of $PM_{2.5}$ from wildfires from $PM_{2.5}$ derived from other sources. The evaluation focusing on California allowed for an evaluation of the effect of the Santa Ana winds, the episodic reversal (going onshore) of dry, gusty winds that propagate wildfires in Southern California. The authors demonstrate the differential toxicity observed based on the source of $PM_{2.5}$, highlighting the need for focused pollution reduction efforts targeting wildfires. Additionally, the impact of Santa Ana winds underscores how intervention efforts should be targeted to the specific ecosystem.

The Bottom Line

The global impact of wildland fires is increasing, and so is the associated respiratory morbidity and mortality. The short-term effects are evident particularly in vulnerable populations, notably children, the elderly, and those with asthma and COPD. Our understanding of their long-term health impact, as well as ecological impact, is minimal. Unfortunately, there is very little that individuals with respiratory conditions can do to minimize the effects of a wildfire in their vicinity. Present guidelines recommend limiting smoke exposure through avoidance by staying indoors as much as possible during periods of poor air quality, wearing masks outdoors when in close proximity, and avoiding activities that lower indoor air quality. Strategic solutions to the problem of wildfires will need the buy-in of all from policymakers to the general public. Hopefully, other respiratory societies will follow suit in making statements and advocating for wildfire prevention and management.

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