Please note: This report has been corrected.

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Notes from the Field

Serum Concentrations of Perfluoroalkyl and Polyfluoroalkyl Substances Among First Responders to the Maui Wildfires — Hawaii, September 2023

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The United States is currently experiencing higher fire activity than in past years with an increase of the acreage burned, and that includes more destructive wildland urban-rural interface fires, potentially exposing first responders and communities to hazardous chemicals in the air and debris (*1*). Exposures to perfluoroalkyl and polyfluoroalkyl substances (PFAS), which are present in fire effluents, PFAS-containing dust, some firefighting foams, protective clothing worn by firefighters, and contaminated gear or equipment, are associated with cancer, cholesterol level changes, and other adverse health outcomes (*2*). Wildfires in Maui, Hawaii in August 2023 destroyed thousands of structures, vehicles, and parcels of land (*3*), and 102 persons lost their lives. Maui County employees (firefighters, police, ocean safety officers, and public works employees) responded and engaged in fire suppression, structure protection, evacuation, water rescue, and urban search and rescue. This report describes first responders' exposures to PFAS as measures after responding to those fires.

Investigation and Outcomes

Request for Assistance

In August 2023, Maui County requested technical assistance from CDC's National Institute for Occupational Safety and Health (NIOSH) to evaluate first responders' exposures to selected chemicals during the 2023 Maui wildfires, through a mission assignment from the Federal Emergency Management Agency. In September 2023 (approximately 1 month after the initial wildfire response), NIOSH medical and exposure assessment personnel and a CDC logistician traveled to Maui County to evaluate potential exposures in firefighters and other responders.

Data Collection

All Maui County employees who were involved in the first 5 days (August 8–12, 2023) of the wildfire response were invited to participate in the evaluation. NIOSH collected spot urine and blood specimens and demographic and workplace information via questionnaires. Biologic specimens were analyzed at CDC's National Center for Environmental Health Division of Laboratory Sciences. Among other chemicals, PFAS were selected as analytes, because they can be expected in the wildland urban-rural interface environment and have relatively long elimination half-lives, which can facilitate detection in serum weeks after an event. This activity was reviewed by CDC, deemed not research, and was conducted consistent with applicable federal law and CDC policy.*

Data Analysis

Individual serum PFAS concentrations were compared with the National Health and Nutrition Examination Survey (NHANES) 95th percentile concentrations for persons aged ≥20 years during survey years 2017–2018.† The sum of seven PFAS was compared with the National Academies of Sciences, Engineering, and Medicine (NASEM) clinical threshold, above which NASEM recommends that clinicians prioritize screening

* 45 C.F.R. part 46.102(l)(2), 21 C.F.R. part 56; 42 U.S.C. Sect. 241(d); 5 U.S.C. Sect. 552a; 44 U.S.C. Sect. 3501 et seq.

† https://www.cdc.gov/environmental-exposure-report/data-tables/index.html

Continuing Education examination available at https://www.cdc.gov/mmwr/mmwr_continuingEducation.html

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for cancer and other adverse health outcomes.[§] ANOVA of log-transformed continuous values was used to compare levels between occupational subgroups. R (version 4.3.3; R Foundation) statistical software was used to conduct analyses.

In total, 258 Maui County employees, including 178 (69%) firefighters, submitted blood samples. Significant differences in concentrations of perfluorohexane sulfonic acid (PFHxS), one of the most biologically persistent PFAS examined, were identified by occupational subgroup ($p<0.01$), with the highest concentrations detected among firefighters (median = 1.2 μg/L; [IQR = 0.8–1.7 μg/L]). The highest detected PFHxS concentration (9.3 μg/L) was in a firefighter; this level was approximately 2.5 times the NHANES 95th percentile (3.8 μg/L) while levels of PFHxS for the other participants range from not detectable to 3.8 μg/L. For the other PFAS chemicals, 2–40% of all Maui County employees, including firefighters, were over the NHANES 95th percentile.

Among firefighters, the median sum serum concentrations of seven PFAS was 7.0 μg/L (Figure). The firefighter with the highest serum PFHxS concentration also had a summed serum PFAS concentration above the NASEM clinical threshold of 20 μg/L. This firefighter was advised to consult a health care provider for additional medical screening and follow-up. All other Maui County participants were below the clinical threshold. The median sum serum concentrations of seven PFAS for other occupational subgroups ranged from 5.7 μg/L to 6.9 μg/L. In general, higher median summed PFAS concentrations were detected among firefighters with longer job tenure (≥30 years) than in those with shorter tenures, although multiple outliers were present in the <5 years of work category (Figure). For longer-term surveillance, firefighters were offered the opportunity to enroll in the National Firefighter Registry for Cancer, which provides long-term tracking of cancer outcomes.[¶]

The median age of the 259 Maui County employees who responded to the questionnaire was 40.0 years (range = 20.6–68.7 years), and 94% were male. Respondents, who could select multiple racial groups, most commonly identified as non-Hispanic White (54%), non-Hispanic Asian (48%), or non-Hispanic Native Hawaiian or other Pacific Islander (46%);

[§] The NASEM clinical threshold is the sum of seven PFAS ≥20 μg/L, above which NASEM recommends that clinicians prioritize additional screenings (i.e., for cancer, cholesterol level changes, and other adverse health outcomes) in addition to the usual standard of care. NASEM states that concentrations between 2–20 μg/L are associated with possible adverse effects, especially in sensitive populations. The seven PFAS were PFHxS, perfluorooctane sulfonic acid (PFOS), perfluorooctanoic acid (PFOA), perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA), perfluoroundecanoic acid (PFUnDA), and 2-(n-methyl-perfluorooctane sulfonamido) acetic acid (MeFOSAA). https://nap.nationalacademies.org/resource/26156/PFAS%20Guidance%20Highlights.pdf

[¶] The National Firefighter Registry for Cancer is the largest effort undertaken by the nation to support and advance understanding of cancer in the fire service. While participation is voluntary, all U.S. firefighters, with or without cancer, are encouraged to join the National Firefighter Registry for Cancer. https://www.cdc.gov/niosh/firefighters/registry/index.html

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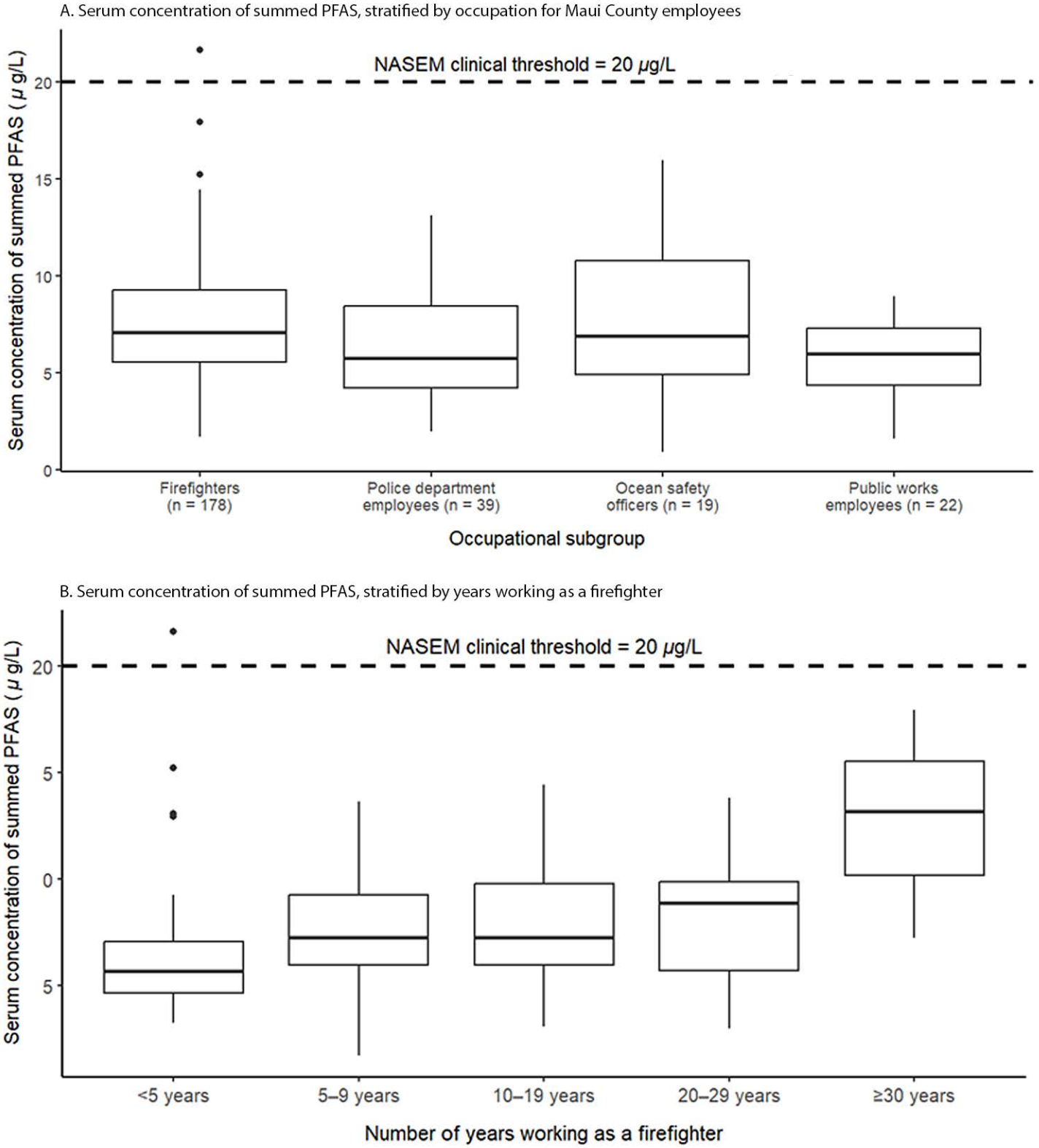
FIGURE. Serum concentrations* of the sum of seven perfluoroalkyl and polyfluoroalkyl substances in (A) all county employees (N = 258), by occupation, and (B) firefighters (N = 178), by number of years working in the profession† — Maui County, Hawaii, September 2023



Abbreviations: NASEM = National Academies of Sciences, Engineering, and Medicine; PFAS = perfluoroalkyl and polyfluoroalkyl substances.

* Median values represented by the center horizonal line of each box; top and bottom lines represent the IQR, the vertical lines represent the minimum and maximum values that fall into 1.5 times the IQR, and the dots represent outliers that are more or less than 1.5 times the IQR.

† Firefighters only (N = 178).

Summary

What is already known about this topic?

Perfluoroalkyl and polyfluoroalkyl substances (PFAS), present in some firefighting foams and routine firefighting activities, can increase the risk for occupational PFAS exposure among firefighters and are associated with cancer and other adverse health outcomes.

What is added by this report?

Median summed concentrations of selected PFAS among Maui County, Hawaii employees approximately 1 month after the 2023 Maui wildfires were higher among firefighters than among other responder groups. Sources other than the wildfires could have contributed to the levels.

What are the implications for public health practice?

Further research is needed to better understand the occupational risk among groups responding to wildfire disasters. Rostering responders, tracking response activities and personal protective equipment use, and monitoring health could improve the understanding of chemical exposures and guide prevention strategies.

7% identified as non-Hispanic American Indian or Alaska Native, and 1% as non-Hispanic Black or African American. Reported use of respiratory protection varied widely during the response, according to activities performed and among occupational subgroups, and was more commonly used by those who responded to active fires (approximately 40% of firefighters) than those who did not (4% to 33% of other responders).

Preliminary Conclusions and Actions

Sources of PFAS exposure for firefighters include fire effluents and dust containing PFAS, PFAS contamination on gear or equipment, PFAS in textiles that constitute the protective clothing worn by firefighters, or PFAS-containing firefighting foams (*2*). Previous studies have shown that firefighters have elevated serum concentrations of some PFAS, including PFHxS, compared with the general population and other working populations (*4*). Large wildfire disasters that encroach upon urban areas present a challenging environment for first responders.

Firefighters in this assessment had higher serum concentrations of some PFAS than employees from other occupations, but sum serum concentrations were mostly below a recommended threshold indicating the need to perform additional medical screenings. Because specimen collection occurred approximately 1 month after the initial response without any baseline measurements, the relative contribution of PFAS from the 2023 Maui wildfires compared with other sources is unclear. Inconsistent use of respirators and other personal protective equipment could increase the risk for exposure to PFAS and other chemicals. In July 2024, NIOSH published a Health Hazard Evaluation Report summarizing the comprehensive biologic monitoring results and recommendations for limiting exposures (*5*). These findings are useful to advancing understanding of health implications and guiding public health decision-making for ongoing and future fires. To protect first responders during disasters, it is essential to continue providing strategies for characterizing and reducing exposures, including through the rostering of responders, tracking response activities and use of personal protective equipment, and health monitoring, such as implementing the Emergency Responder Health Monitoring and Surveillance framework.**

** The Emergency Responder Health Monitoring and Surveillance (ERHMS) program is a framework that provides recommendations for protecting emergency response and recovery workers. https://www.cdc.gov/niosh/erhms/about/index.html

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Notes from the Field

Emergency Department Use During the Los Angeles County Wildfires, January 2025

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On January 7, 2025, wildfires erupted in the Pacific Palisades and in Eaton Canyon in Los Angeles County (LAC), California. Fueled by dry weather conditions and Santa Ana winds with speeds of 60–80 mph (97–129 kph) and gusts up to 100 mph (161 kph), the fires burned approximately 40,000 acres, destroyed approximately 16,000 structures, and killed at least 29 persons (*1*). Near real-time surveillance of health outcomes during and after wildfires can estimate effects on health care use, serve as an early warning for acute health impacts, and identify opportunities for intervention.

Investigation and Outcomes

Data Sources and Analysis

The LAC Department of Public Health's Syndromic Surveillance program receives and analyzes data from 90% of emergency departments (EDs) in LAC, representing 94% of all LAC ED encounters. For this study, syndromic surveillance data were reviewed to examine trends in all-cause and wildfire-associated ED encounters contemporaneous with the LAC wildfires. Encounters were classified as wildfire-associated if fire or smoke inhalation–related terms (*2*) were present in chief complaints and diagnoses.* Three periods were analyzed: December 17, 2024–January 6, 2025 (baseline: a 3-week period before the wildfires began); January 7, 2025–January 12, 2025 (phase 1: the first 6 days of the wildfires); and January 13, 2025–January 19, 2025 (phase 2: the following 7 days). These periods were designated retrospectively and selected based on the largest changes in all-cause and wildfire-associated ED encounters. The average number of all-cause ED encounters and the average percentage of ED encounters that were wildfire-associated were calculated for each period. Analyses of burn-, eye-, cardiovascular-, and respiratory-related ED encounters were conducted using local queries adapted from cross-jurisdictional collaborations (*3*). Air quality index (AQI) data were obtained from one Environmental Protection Agency (EPA) air quality monitoring station located in downtown Los Angeles.† This study was reviewed by the Los Angeles County Department of Public Health, and was deemed nonresearch public health surveillance and exempt from Human Research Protection Office review.§

Changes in AQI and Distributions of All-Cause and Wildfire-Associated ED Encounters

The average number of daily all-cause ED encounters decreased an absolute 9% from baseline to phase 1 (representing 91% of baseline encounters), and then increased to 95% of baseline encounters in phase 2. The average percentage of ED encounters that were wildfire-associated increased eightfold, from 0.06% at baseline to 0.52% in phase 1, and then decreased but remained elevated at 0.20% in phase 2. The percentage of wildfire-associated ED encounters peaked at 1.01% on January 8, 2025 (Figure). The increase in average daily AQI aligned with the increase in average percentage of wildfire-associated ED visits: average daily AQI increased from 75 (moderate AQI level of concern) at baseline to 110 (unhealthy for sensitive groups) during phase 1 and returned to moderate (58) in phase 2.

Types of ED Encounters and Injuries

Small differences were noted among baseline, phase 1, and phase 2 in the average percentages of burn-related injuries (0.97%, 1.30%, and 1.04%, respectively) and eye-related ED encounters (1.09%, 1.46%, and 1.17%, respectively). No patterns of increase were noted in cardiovascular or asthma and other respiratory subcategories such as respiratory distress, acute bronchitis, shortness of breath, cough, or sore throat.

Preliminary Conclusions and Actions

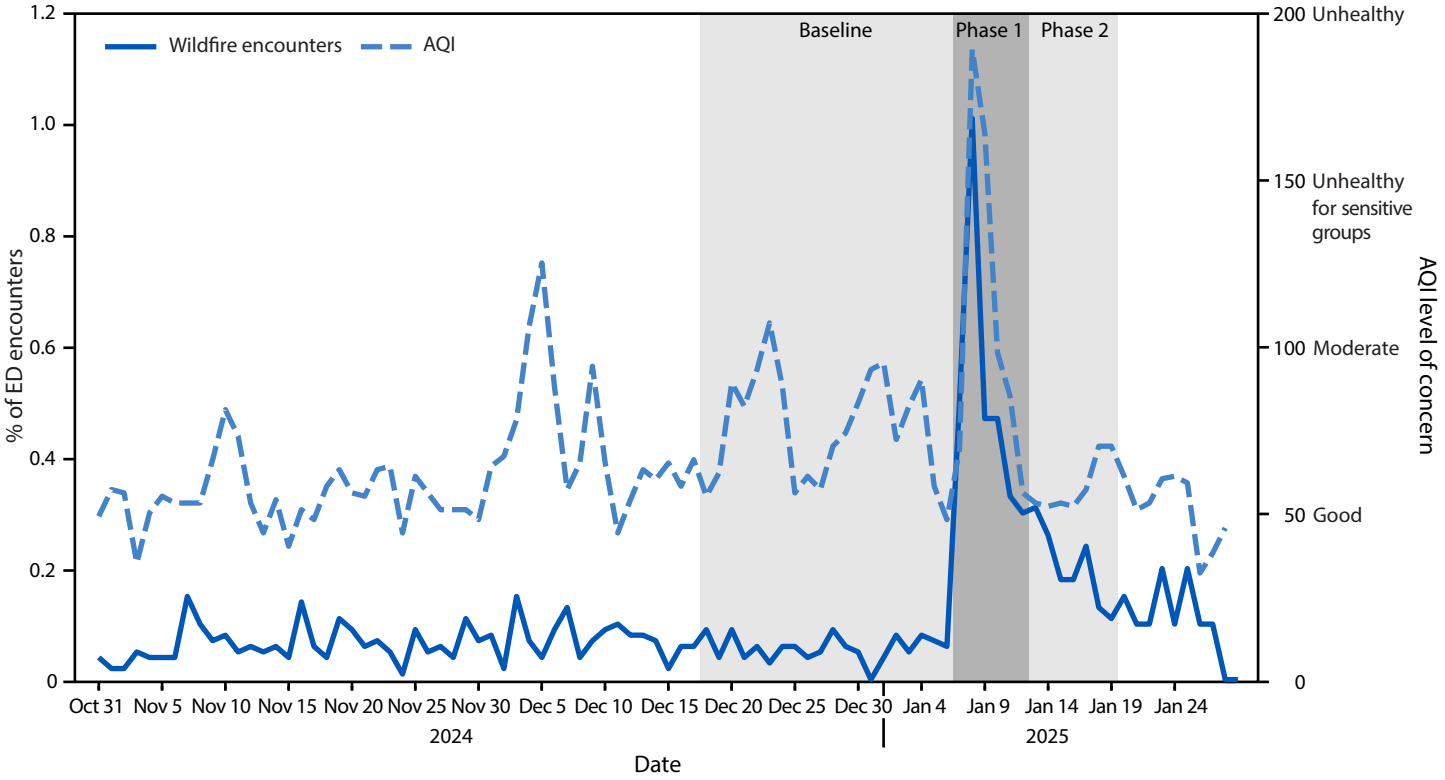
Although the overall percentage of wildfire-associated ED encounters increased with the onset of the LAC fires, all-cause ED encounters initially decreased. These findings align with studies demonstrating similar decreases in ED encounters

*The LAC adaptation of the "fire and smoke inhalation V1" Council of State and Territorial Epidemiologists' query includes additional exclusion terms to counter misclassifications due to unrelated references to fire and smoke.

† AQI is calculated using the concentrations of pollutants in parts per million ($\mu g/m^3$); for this report, unitless AQI levels of concern were categorized and defined as follows: 0–50 = good; 51–100 = moderate; 101–150 = unhealthy for sensitive groups; 151–200 = unhealthy; 201–300 = very unhealthy; and ≥301 = hazardous. Data are available from EPA. AirNow, an Internet database, is available at https://airnowapi.org/ (Accessed February 26, 2023). Data from the selected monitor (Los Angeles – North Main Street, AQI ID: 060371103) represent a surrogate for trends and do not reflect peak measurements observed in all wildfire-impacted areas. EPA monitors do not measure all toxic pollutants released in urban wildfires and would have been subject to planned and unplanned power outages occurring in wildfire adjacent communities.

§ 45 C.F.R part 46.102(l)(2).

FIGURE. Daily percentage of emergency department encounters that were wildfire-associated and air quality index values* during three periods related to wildfires† — Los Angeles County, California, October 31, 2024–January 28, 2025



Abbreviations: AQI = air quality index; ED = emergency department.

* Unitless AQI levels of concern depicted are defined as follows: good = 0–50; moderate = 51–100; unhealthy for sensitive groups = 101–150; unhealthy = 151–200; very unhealthy = 201–300; and hazardous = ≥301.

† Baseline period = 3 weeks before the onset of the fires (December 17, 2024–January 6, 2025); phase 1 = first 6 days of the fires (January 7–12, 2025); and phase 2 = 7 days after phase 1 (January 13–19, 2025).

Summary

What is already known about this topic?

Syndromic surveillance provides timely information about the health impacts associated with the occurrence of natural disasters.

What is added by this report?

Immediately after the 2025 Los Angeles County wildfires began, all-cause emergency department (ED) encounters decreased by 9%, concomitant with an eightfold increase in the average percentage of ED encounters classified as wildfire-associated. During the analysis period, no differences were observed in the average percentage of ED encounters for cardiorespiratory illnesses.

What are the implications for public health practice?

Jurisdictions can use syndromic surveillance in real time to estimate effects of wildfires on health care use to identify opportunities for intervention, such as sharing communications with the general public about the importance of minimizing exposures to wildfire smoke, especially during the first few days of wildfire events.

immediately after natural disasters, including heavy smoke events due to wildfires (*4*). The observed decrease could be due to evacuations leading to displacements, alterations in activity patterns (e.g., school and business closures) as well as increased avoidance of or challenges accessing health care or EDs. LAC residents might have sought care in clinics, urgent care centers, or EDs in neighboring counties as an alternative to visiting LAC EDs, and those encounters would not be recorded in these data.

Although increases in ED encounters related to asthma and other cardiorespiratory subcategories have been reported by other local health jurisdictions after wildfire events even a considerable distance away (*5*), LAC data did not demonstrate similar increases. Small differences might not be detectable for wildfires occurring during peak viral respiratory activity, and smoke distribution might be affected by the unique topography of the Los Angeles basin and recurring Santa Ana winds. Small numbers of encounters might also be attributed to inconsistent coding by clinicians of terms related to smoke or fire exposures.

In light of these limitations, the data likely underestimate the prevalence of wildfire-associated ED encounters. These data demonstrate that the wildfires were associated with a decrease in total ED encounters across LAC, and that wildfire-associated ED encounters were temporally associated with worsening air quality. Further analyses are planned to identify which illnesses have most affected specific populations. Additional data elements could be incorporated to further characterize short- and long-term health consequences. In anticipating wildfires and preparing for responses, developing timely communications about wildfire smoke, including risk for exposure and precautions could mitigate risk.

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