2025 SOUTHERN CALIFORNIA WILDFIRE EXPOSURE REPORT

Multiple wildfires broke out in Southern California on Jan. 7, 2025, and were mostly contained by Feb. 1, 2025. Over those 24 days, the Los Angeles, California, metropolitan areas, including the Pacific Palisades, Altadena, and Sierra Madre, were impacted with over 57,636 acres burned and 16,255 structures destroyed. Fire fighters and EMS services were dispatched during this time to contain the fire and rescue individuals who were caught in the path of these devastating fires.

Due to the size and duration of these fires, it is important to note that those who responded are at an increased risk of being exposed to numerous fire ground contaminants – known and unknown – and fatigue due to the unique Wildland-Urban Interface (WUI) fire conditions and minimal time off to sleep, rest, and recover.

This document will dive into the known exposures of those responding to a WUI fire, but it is important to note that this is not an all-inclusive report as each responder's duration of work and what they were exposed to may vary. Additional research in WUI fires fuels may identify additional toxins present in today's fuel load that have not yet been identified.

WILDLAND AND URBAN INTERFACE (WUI) SMOKE

In 2022, the National Academies of Science Engineering and Medicine released a report on the Chemistry of Fires at the Wildland-Urban Interface, where researchers looked at components of WUI fires and their impact on the environment and associated health effects. Their report found that WUI fires can lead to greater human health exposures than wildland fires due to the combination of wildland and structural firefighting exposures. The smoke produced by WUI fires have a unique chemistry because the burning of natural and human-made fuels release toxic emissions not found in purely wildland fires.

Additionally, the fuels burned in WUI fires have different components, concentrations, and amounts of combustible materials than wildland fires. Combustion reactions for materials found at the WUI environment, such as household contents and construction components including, but not limited to, siding, insulation, textiles, PVC piping, plastics, as well as the additional combustion of vegetative biomass, result in significant emission of known and potential toxicants to the surrounding environment.

WUI EXPOSURES

WUI fires can negatively impact human health and quality of life, not only where the fire is burning, but the winds can also carry the smoke plumes and emissions hundreds to thousands of miles downwind. Additionally, even once the fires are fully contained, smoldering gases from vegetation and structures continue to be released, further impacting the health of all those exposed to them.

The National Academies 2022 report identified that the effects of smoke inhalation can result in numerous health effects including myocardial infarction, ischemic heart disease, dysrhythmia, heart failure, pulmonary embolism, ischemic stroke, and transient ischemic attack. Wildfire smoke can also significantly exacerbate asthma, chronic obstructive pulmonary disease (COPD), and other respiratory illnesses.

The National Academies' 2022 report includes a table (see the following page) that highlights "Examples of Chemical Pollutants Related to WUI Fire Events and Human Exposures." These are several known chemicals of concerns, but this is not an exhaustive list as research is continuing to evaluate fire ground contaminants found at structural fires, wildfires, and WUI fires.

TABLE 6-1: Examples of Chemical Pollutants Related to WUI Fire Events and Human Exposures
(National Academies of Sciences, Engineering, and Medicine, 2022)

GROUP OF POLLUTANTS	COMMON EXAMPLES	ROUTES OF EXPOSURE	POTENTIAL HEALTH OUTCOMES	SELECTED REFERENCES
Asbestos	Fibrous asbestos, chrysotile	Inhalation Ingestion	Cancer; asbestosis; respiratory irritation; pleural disease	EPA, 2021a; ATSDR, 2016
Asphyxiant gases	Carbon monoxide (CO), carbon dioxide (CO2), hydrogen cyanide (HCN)	Inhalation	Depression of central nervous system and hypoxia; acute respiratory effects	NIOSH, 2011; Gold and Perera, 2021
Dioxins and furans (polychlorinated dibenzo-p-dioxins [PCDDs] and polychlorinated dibenzofurans [PCDFs])	2,3,7,8-Tetrachloro-dibenzop-dioxin/furan	Inhalation Ingestion Dermal (low penetration into skin by itself, but can cause skin lesions)	Cancer or predisposition to cancer; reproductive and developmental effects; immune suppression; dermal toxicity; endocrine disruption	CDC, 2017; EPA, 2021b
Flame retardants	Tris(1-chloro-2-propyl) phosphate (TCPP), tris(2-chloroethyl) phosphate (TCEP), tris isobutylated triphenyl phosphate, methyl phenyl phosphate	Inhalation Ingestion	Neurotoxicity or neurodevelopmental damage; reproduction and fetal development effects; endocrine and thyroid disruption	ATSDR, 2015; NIEHS, 2021a
Inorganic acid gases	Hydrogen chloride (HCl), hydrogen fluoride (HF), phosphoric acid, SOx, NOx	Inhalation	Chemical burns; increased risk of laryngeal and lung cancer	ATSDR, 2002; NCI, 2019
Inorganic and organic metals	Lead, lithium, iron, mercury, methylmercury, nickel, cadmium, palladium chloride	Inhalation Ingestion Dermal	Neurotoxicity; reproductive and developmental effects, dermal irritation or allergen; respiratory irritation	Goyer, 2004; NIOSH, 2019a
Isocyanates	Methyl isocyanate, methylene diphenyl diisocyanate, toluene diisocyanate	Inhalation	Irritation and pulmonary sensitivity	ATSDR, 2014a; NIOSH, 2014
Organic and other gases	Phosgene (COCl2), ammonia (NH3)	Inhalation	Acute effects; pulmonary edema and irritation	EPA, 2021c; CDC, 2018
Ozone (O3)		Inhalation	Acute and chronic respiratory symptoms including coughing and exacerbation of chronic diseases such as bronchitis and asthma; increased risk of pulmonary infections	NEPHT, 2020
Particulate matter (PM)	PM is often classified by size, where the size is based on the aerodynamic diameter in micrometers (e.g., PM2.5); smaller particles penetrate deeper into the respiratory system	Inhalation Ingestion Dermal	Cancer; cardiopulmonary toxicant; immunosuppressant; neurotoxicant; reproductive and developmental toxicity	EPA, 2021d; CDC, 2019
Plasticizers	Ortho phthalates including dibutyl phthalate, terephthalates, adipates, benzoates	Inhalation Ingestion	Endocrine disruptors; reproductive and developmental toxicity	EPA, 2022a; CDC, 2021

GROUP OF POLLUTANTS	COMMON EXAMPLES	ROUTES OF EXPOSURE	POTENTIAL HEALTH OUTCOMES	SELECTED REFERENCES
Polycyclic aromatic hydrocarbons (PAHs)	Benzo[a]pyrene, benzo[a] anthracene, benzo[b] fluoranthene, chrysene, pyrene, fluoranthene, naphthalene, anthracene	Inhalation Ingestion Dermal	Cancer; reproductive and developmental (teratogenic) toxicity; kidney and liver damage	CDC, 2022; ATSDR, 2014b
Polychlorinated biphenyls (PCBs)	2-Chlorobiphenyl, 2,2-dichlorobiphenyl, 2,4,5-trichlorobiphenyl; PCBs typically occur as a mixture of PCB congeners (i.e., aroclors)	Inhalation Ingestion Dermal	Cancer; neurotoxicity; immune suppression; endocrine disruption; reproductive and developmental toxicity; respiratory toxicity	ATSDR, 2000; Ahlborg et al., 1992
Volatile organic compounds (VOCs)	Formaldehyde, acetaldehyde, acrolein, benzene, toluene, ethylbenzene, para-xylene, ortho-xylene, meta-xylene, styrene, naphthalene; complex mixtures of VOCs are classified as total VOCs, and some are not toxic	Inhalation Ingestion	Cancer; reproductive and developmental toxicity; neurotoxicity; respiratory irritation; odorants	EPA, 2021c
Other emission and transformation products that are currently unidentified	Per- or polyfluoroalkyl substances (PFASs), including perfluorooctane sulfate and perfluorooctanoic acid Reactive oxygen species, including peroxides (R-OO-R) and superoxides (O2–)	Inhalation Ingestion	Cancer; respiratory and developmental toxicity	NTP, 2016

NOTE: Table 6–1 focuses on groups of chemicals with sound available data. The lists are meant as common examples and not meant to be exhaustive. A wide range of VOCs and SVOCs may be present including amines, amides, nitrosamines, trihalomethanes, glycols, and ethers.

DURATION OF RESPONSE AND FATIGUE

First responders who responded to the Southern California Wildfires may have responded to or were on call for around 24 days straight. Sleep fatigue and exhaustion is often a result of extended shiftwork, affecting both the quality and duration of fire fighters' sleep and ability to rest and recover. Fire fighters frequently report difficulties achieving adequate sleep during 24-hour shifts due to interruptions from emergency calls, stress, and the challenges of resting in environments like the firehouse. When responding to a WUI fire response, shifts may drastically exceed 24 hours and there are few if any opportunities to rest while on call. Compounding the problem is that most of these fire fighters -if not all- had to rest, recover, and sleep near the fires, meaning that they were constantly exposed to the toxic products of combustion 24 hours a day, 7 days a week, during their activation periods.

Sleep fragmentation during shifts can also result in cumulative sleep debt, which impairs cognitive performance and decision-making. Fatigue impairs reaction time and may increase the likelihood of accidents on the job. Eventually, unresolved fatigue oftentimes leads to physical, mental and/or emotional exhaustion

Sleep issues and fatigue do not end when the shift is over. Many fire fighters find it challenging to adapt back to a regular sleep schedule when off-shift, which can contribute to chronic sleep deprivation. Sleep impacts physical, mental, psychological, and emotional aspects for an individual and these are exacerbated when shifts are drastically increased during disaster responses.

CAR AND ELECTIC VEHICLE FIRES

In addition to numerous structures burned in these WUI fires, burning cars are of additional concern, especially electric vehicles (EV). According to Sturm 2022, toxic gases are released during car fires. Conventional car fires release gases such as carbon monoxide (CO), carbon dioxide (CO2), and hydrogen chloride (HCl) from the critical components. For electric vehicles, Strum 2022 found that a lithium-ion battery thermal runaway fire releases highly toxic gases and particles, including hydrogen fluoride (HF), CO, CO2, and many different hydrocarbon compounds (HC) vented. Texas A&M 2024 conducted tests on EVs that also identified high concentrations of heavy metals, including lithium, nickel, cobalt, manganese, and copper in each test, with lithium being the most dominant; citing the concentration of metals ranged from 12 to 760 times their eight-hour permissible OSHA limits.

Additionally, in tests conducted by Texas A&M, 2024, Particulate Matter 2.5 (PM2.5) was extremely high, with levels ranging from 12,000 to 17,000 times higher than the new EPA ambient standard for PM2.5 of 9 $\mu g/m^3$.

SOURCES

1. Ahlborg, U. G., A. Brouwer, M. A. Fingerhut, J. L. Jacobson, S. W. Jacobson, S. W. Kennedy, A. A. F. Kettrup, J. H. Koeman, H. Poiger, C. Rappe, S. H. Safe, R. F. Seegal, T. Jouko, and M. van den Berg. 1992. "Impact of Polychlorinated Dibenzop- dioxins, Dibenzofurans, and Biphenyls on Human and Environmental Health, with Special Emphasis on Application of the Toxic Equivalency Factor Concept." European Journal of Pharmacology: Environmental Toxicology and Pharmacology 228 (4): 179–199. https://doi.org/10.1016/0926-6917(92)90029-C.
2. ATSDR (US Agency for Toxic Substances and Disease Registry). 2000. Public Health Statement Polychlorinated Biphenyls (PCBS): 1–9. https://www.atsdr.cdc.gov/toxprofiles/tp17.pdf.
3. ATSDR. 2002. Hydrogen Chloride. https://www.atsdr.cdc.gov/toxfaqs/tfacts173.pdf.
4. ATSDR. 2014a. Methyl Isocyanate. https://www.atsdr.cdc.gov/toxfaqs/tfacts182.pdf.
5. ATSDR. 2014b. Polycyclic Aromatic Hydrocarbons (PAHs). https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?faqid=121&toxid=25.
6. ATSDR. 2015. Phosphate Ester Flame Retardants. https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?faqid=1164&toxid=239.
7. ATSDR. 2016. Health Effects of Asbestos. https://www.atsdr.cdc.gov/asbestos/health_effects_asbestos.html.
8. CDC (Centers for Disease Control and Prevention). 2017. Dioxins, Furans and Dioxin-Like Polychlorinated Biphenyls Factsheet. https://www.cdc.gov/biomonitoring/DioxinLikeChemicals_FactSheet.html.
9. CDC. 2018. Facts About Phosgene. https://emergency.cdc.gov/agent/phosgene/basics/facts.asp.
10. CDC. 2019. Particle Pollution. https://www.cdc.gov/air/particulate_matter.html.
11. CDC. 2021. Phthalates Factsheet. https://www.cdc.gov/biomonitoring/Phthalates_FactSheet.html.
12. CDC. 2022. Polycyclic Aromatic Hydrocarbons (PAHs) Factsheet. https://www.cdc.gov/biomonitoring/PAHs_FactSheet.html.
13. EPA. 2021a. Learn About Asbestos. https://www.epa.gov/asbestos/learn-about-asbestos#effects.
14. EPA. 2021b. Learn About Dioxin. https://www.epa.gov/dioxin/learn-about-dioxin.
15. EPA. 2021c. Volatile Organic Compounds' Impact on Indoor Air Quality. https://www.epa.gov/indoor-air-quality-iaq/volatileorganic-compounds-impact-indoor-air-quality.
16. EPA. 2021d. Health and Environmental Effects of Particulate Matter (PM). https://www.epa.gov/pm-pollution/health-andenvironmental-effects-particulate-matter-pm.

17. EPA. 2022a. Risk Management for Phthalates. https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/risk-managementphthalates.
18. Gold, A., and T. B. Perera. 2021. EMS Asphyxiation and Other Gas and Fire Hazards. Treasure Island, FL: StatPearls Publishing.
19. Goyer, R. 2004. Issue Paper on the Human Health Effects of Metals. Washington, DC: EPA.
20. National Academies of Sciences, Engineering, and Medicine. 2022. The Chemistry of Fires at the Wildland-Urban Interface. Washington, DC: The National Academies Press. https://doi.org/10.17226/26460.
21. NCI (National Cancer Institute). 2019. Strong Inorganic Acid Mists Containing Sulfuric Acid. https://www.cancer.gov/about-cancer/causes-prevention/risk/substances/inorganic-acid.
22. NEPHT (National Environmental Public Health Tracking). 2020. Air Quality. https://www.cdc.gov/nceh/tracking/topics/AirQuality.htm#ozone.
23. NIEHS (National Institute of Environmental Health Sciences). 2021a. Flame Retardants. https://www.niehs.nih.gov/health/topics/agents/flame_retardants/index.cfm.
24. NIOSH (National Institute for Occupational Safety and Health). 2011. Sodium Cyanide: Systemic Agent. https://www.cdc.gov/niosh/ershdb/emergencyresponsecard_29750036.html.
25. NIOSH. 2014. Isocyanates. https://www.cdc.gov/niosh/topics/isocyanates/default.html.
26. NIOSH. 2019a. Lead & Other Heavy Metals – Reproductive Health. https://www.cdc.gov/niosh/topics/repro/heavymetals.html.
27. NTP (National Toxicology Program). 2016. NTP Monograph: Immunotoxicity Associated with Exposure to Perfluorooctanoic Acid or Perfluorooctane Sulfonate. https://ntp.niehs.nih.gov/ntp/ohat/pfoa_pfos/pfoa_pfosmonograph_508.pdf.
28. Peter Sturm, Patrik Fößleitner, Daniel Fruhwirt, Robert Galler, Robert Wenighofer, Simon Franz Heindl, Stefan Krausbar, Oliver Heger, 2022. "Fire tests with lithium-ion battery electric vehicles in road tunnels." Fire Safety Journal, Volume 134, 103695, ISSN 0379-7112, https://doi.org/10.1016/j.firesaf.2022.103695.
29. Texas A&M Engineering Extension Service (TEEX). 2024. Lithium Ion Battery Fires and Emissions Characterization. https://teex.org/wp-content/uploads/LITHIUM-ION-BATTERY-FIRES-AND-EMISSIONS-CHARACTERIZATION.pdf

PRODUCED IN COLLABORATION WITH

CALIFORNIA PROFESSIONAL FIREFIGHTERS