



Sweat, Smoke, and Regulatory Shortfalls:

# Climate Risks at Work

by A. Michael Ierardi, Taylor Burnham, and Daniel Lauer

As heat waves grow longer and wildfire seasons become more intense, it is time to rethink the safeguarding of frontline workers who experience occupational exposures exacerbated by climate change.

The increasing frequency and severity of heat waves and wildfire events across the globe underscore the critical urgency of addressing climate change-related occupational health risks. Recent studies project significant rises in heat-related mortality and economic burdens over the coming decades that are driven by prolonged heat events and widespread wildfire outbreaks, among other natural disasters.<sup>1</sup> Emergency response workers—including wildland firefighters, emergency medical service (EMS) workers, and search and rescue teams—often encounter prolonged exposure to heat and wildfire smoke while performing fire mitigation activities and suppressing active fires. Communities living near wildfires also experience exposures to wildfire smoke, which is a heterogeneous mixture of gases, particulate matter (PM), and volatile organic compounds (VOCs).<sup>2</sup>

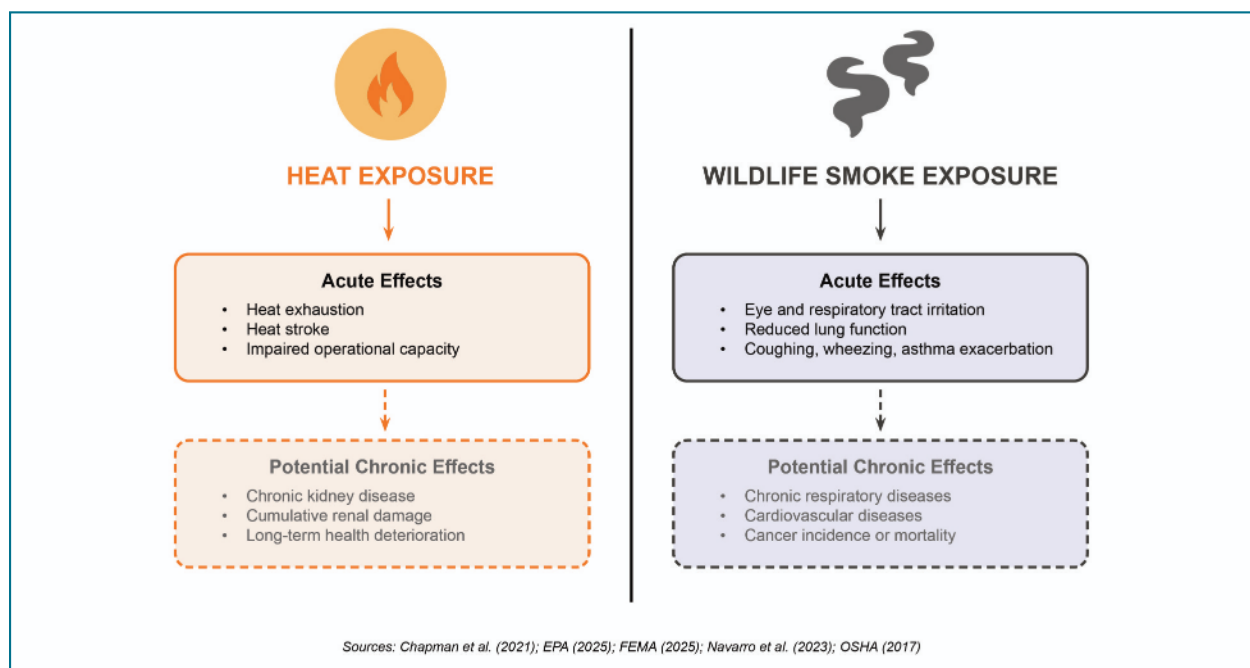
While acute health effects (e.g., coughing, wheezing, asthma exacerbations) associated with exposure to excessive heat and wildfire smoke have been well documented, the potential relationship between these exposures and long-term health outcomes, such as cardiovascular and chronic respiratory diseases, remain uncertain.<sup>2</sup> Although chronic health outcomes associated with complex mixtures such as wildfire smoke remain understudied, long-term health effect data are generally available for some individual constituents of wildfire smoke, including PM.<sup>3,4</sup> The robust body of literature for any individual component, to the extent that it exists, may be relied upon to inform potential chronic health effects associated with wildfire smoke exposure. Further, regulatory frameworks in the United States are inconsistent across jurisdictions, with existing occupational health

standards often lacking specificity or remaining insufficiently protective in the face of escalating climate-driven risks. The Occupational Safety and Health Administration (OSHA) still relies on a broad general duty requirement rather than prescribing explicit heat-stress or wildfire-smoke limits, and only a few states have adopted enforceable heat stress standards. As a result, most workers have no binding protections to guard against the rising threats of extreme heat and hazardous smoke.

A recognition of these gaps is essential to safeguarding the health and safety of emergency response workers, who are increasingly at the forefront of climate change mitigation efforts. In this article, we describe the potential occupational health impacts of climate change-driven exposures among emergency responders, gaps in current U.S. regulations, and recommendations for future research and policy actions.

### Human Health Effects of Heat and Wildfire Smoke

Emergency responders are at an increased risk of acute health impacts from excessive heat and wildfire smoke (see Figure 1). These types of exposures are commonplace for emergency responders based on their job duties and work environments, though they may be rarer in more “traditional” workplaces. Acute effects associated with heat exposure can include heat exhaustion, heat stroke, and other heat-related illnesses, often exacerbated by strenuous physical activity and heavy personal protective equipment (PPE).<sup>4,5</sup> Similarly, acute exposure to wildfire smoke commonly results in temporary eye and respiratory tract irritation



**Figure 1.** Human Health Effects of Heat and Wildfire Smoke Exposures.

These exposures pose serious short- and potential long-term health risks, especially for outdoor and emergency response workers.



and respiratory effects such as reduced lung function and wheezing.<sup>6</sup> These immediate health concerns pose significant operational challenges and can impair a worker's capacity to respond effectively in critical emergency scenarios. Beyond acute effects, prolonged and repeated exposure to excessive heat and wildfire smoke presents potential chronic health risks. Chronic exposure to heat stress has been linked with chronic kidney disease, as repeated episodes of dehydration and thermal stress may cause renal damage.<sup>7</sup> It has been hypothesized that wildfire smoke exposure increases the risk of long-term health effects, such as all-cause mortality and cardiopulmonary morbidity; however, available epidemiological evidence is limited by a lack of quantitative exposure data for specific wildfire smoke constituents and individual-level exposure data (rather, exposure typically is estimated at the zip code level or based on a number of fires in a geographical area).<sup>2,8</sup>

Wildland firefighters and other first responders may also experience detrimental mental health outcomes, although this potential relationship is likely modified by numerous factors. Thus, despite the increasing frequency and intensity of wildfires across the globe, there are still significant gaps in the understanding of potential human health effects associated with direct exposure to wildfire smoke and heat due to limitations in exposure assessment, confounding control, and outcome measurement.<sup>2</sup> Longitudinal studies of emergency response workers with more precise exposure assessment approaches are needed to address this important research gap.

## Regulatory Landscape

Most OSHA standards were adopted long before the recent surge in extreme heat and catastrophic wildfires. The current framework for protecting the emergency response workforce, therefore, remains siloed and reactive, and addresses individual hazards, such as noise or specific chemicals (e.g., benzene, formaldehyde, and metals). Voluntary consensus guidelines from organizations like the National Fire Protection Association (NFPA) offer scenario-specific recommendations, but no federal guidance documents provide insight for comprehensively managing the complex interplay of climate-driven hazards: extreme heat, particulate and gaseous exposures from wildfire smoke, increased ultraviolet radiation, dehydration and heat-related illness, psychosocial stress, and the ergonomic burdens of additional PPE.

Although some states—California, Oregon, and Washington—uniquely have rules in place to protect workers from wildfire smoke (enacted in 2019, 2022, and 2023, respectively; 8 CCR Section 5141.1; OAR 437 002 1081; WSR 25-09-064), there is no federal ruling specific to wildfire smoke. Rather, wildfire smoke exposure can only currently be controlled through the implementation of standalone rules for PPE or the Occupational Safety and Health Act's general duty clause. There are also standards intended to protect single groups of workers—such as fire brigades, industrial fire departments, and private or contractual type fire departments (29 CFR Part 1910.156)—as well as workers conducting hazardous waste operations and emergency response (HAZWOPER) activities (29 CFR Parts 1910.120



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and 1926.65). These rules do not, however, currently cover every worker with potential occupational risk from emergency response activities and wildfires, such as volunteers or others employed at the state and local levels. The absence of an integrated, science-based federal standard largely leaves this workforce without clear, anticipatory safeguards for concurrent hazards.

OSHA also proposed to regulate heat-related hazards at the federal level for the first time in 2024 (89 FR 70698). While this proposed standard is a major advancement for many workers, it excludes workers covered under the new OSHA Emergency Response Standard (e.g., firefighters, hazardous materials crews, and urban search-and-rescue teams) and leaves these workers without mandatory temperature

triggers, rest breaks, shade, or training. As depicted in Figure 2, several states also have existing workplace heat standards, with more states actively pursuing legislation.<sup>11</sup> Any gaps or inconsistencies between proposed federal and state standards could leave these workers without adequate protection.

While these regulatory activities are moving in the right direction for emergency response workers, the patchwork efforts and potential for gaps between standards may still leave some workers inadequately protected during heat waves and wildfire events.

As heat waves grow longer and wildfire seasons become more intense, it is time to rethink the safeguarding of frontline workers who experience occupational exposures exacerbated by climate change. Structured risk assessment frameworks should be employed by federal and state agencies to systematically identify and quantify concurrent exposures to extreme heat and wildfire smoke, prioritize interventions, and design effective controls. These frameworks would set clear requirements for hazard identification, exposure monitoring, risk characterization, and periodic review, so that protections evolve in anticipation of rapidly changing climate threats.

OSHA's proposed Emergency Response Standard and heat and injury prevention rules represent progress, but they do not fully cover all responder groups. Gaps and inconsistencies between state and federal rules could still leave many workers

susceptible to extreme heat and wildfire-related hazards. With wildfires becoming more frequent and severe, even in regions of the United States unaccustomed to extreme heat or wildfire smoke, a coordinated national approach is urgently needed. While the implementation of a federal wildfire smoke standard would be ideal, current political priorities may delay formal rulemaking. State-level efforts may need to take precedence for the time being, which can lay the groundwork for a unified national standard later on.

At the same time, more research is needed to understand the full range of potential long-term impacts these exposures may have on emergency responders. While the short-term risks of heat-related illness and smoke inhalation are well known, less is understood about the chronic effects of repeated exposure, such as kidney disease, respiratory illness, cardiovascular events, and cancer. Longitudinal studies that track responder health over time are essential. A shared national database combining exposure monitoring and health outcomes would support quicker action and better-informed policies.

This challenge cannot be solved by one discipline alone. Collaboration is essential among public health professionals, industrial hygienists, toxicologists, epidemiologists, emergency planners, physicians, government organizations, and climate scientists. These partnerships should also inform any training efforts to ensure that responders have the tools, information, and situational awareness needed to stay safe, whether those responders are managing a structure fire or navigating wildfire smoke during a disaster response.

Equally important is attention to the physical and psychological toll of this work. As climate-related emergencies grow more frequent and severe, responders need better access to hydration, cooling, rest, and mental health support. The goal must go beyond injury and illness prevention; it should include building a resilient and well-supported workforce. Emergency responders are already rising to the demands of the climate era. Now, the systems around them must respond in kind by providing consistent protection, data-driven policies, and real investments in their health, safety, and well-being. **em**

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