

Review Article

Disparities in Heat-Related Emergency Medical Services Activations: A Global Review of Trends

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Abstract: Anthropogenic climate change has unequivocally accelerated the frequency, intensity, and duration of extreme heat events (EHEs) across both temperate and tropical regions, with profound implications for human health and health systems. Heat exposure is now recognized by the World Health Organization as the leading weather-related cause of mortality globally, accounting for hundreds of thousands of excess deaths annually and affecting health across age, physiological, and socio-economic gradients. Emergency Medical Services (EMS) activations for heat-related illness (HRI) serve as a critical 'canary in the coal mine,' providing high-resolution temporal and spatial data on health crises. However, the burden of these activations is profoundly uneven. This review analyzed data from 2020 to 2026, highlighting how structural inequities—ranging from historical redlining to modern energy poverty—concentrate HRI in specific demographic and geographic enclaves. We evaluate the 'Urban Heat Island' effect, the biological nuances of heat susceptibility, and the operational challenges of field-based cooling. Our findings suggest that current mitigation strategies are often reactive and fail to address the root causes of climate vulnerability. We conclude with a call for data-driven, equitable public health interventions that utilize EMS data to target resources toward the most marginalized communities.

Keywords: disparities, heat-related, emergency, medical services, activations, global, trends

1. INTRODUCTION

Anthropogenic climate change has unequivocally accelerated the frequency, intensity, and duration of extreme heat events (EHEs) across both temperate and tropical regions, with profound implications for human health and health systems [1]. Heat exposure is now recognized by the World Health Organization as the leading weather-related cause of mortality globally, accounting for hundreds of thousands of excess deaths annually and affecting health across age, physiological, and socio-economic gradients [2]. The present review synthesizes evidence from 2020 through 2026, foregrounding Emergency Medical Services (EMS) activations for heat-related illness (HRI) as an unusually sensitive epidemiologic indicator of acute community health stress [3]. Unlike aggregated hospital admissions or mortality counts, EMS activations provide high-resolution temporal and spatial data that reveal sub-daily spikes in morbidity attributable to heat exposure and capture events that do not culminate in mortality but reflect severe physiological stress. This makes EMS data a critical sentinel in climate health surveillance [4]. Epidemiological metrics indicate that heat exposure is expanding rapidly in scope and magnitude: global heat-related mortality increased approximately 85% for individuals over 65 between 2000–2004 and 2017–2021, and recent European summers saw tens of thousands of excess deaths linked to heatwaves alone. These increases are not evenly distributed but are shaped by structural determinants of vulnerability [5]. We systematically examine how historical and contemporary

inequities concentrate heat vulnerability in specific demographic and geographic enclaves. Historical residential segregation (e.g., redlining) and contemporary energy poverty reduce access to effective cooling infrastructure, amplifying physiological stress during prolonged heatwaves [6]. Urban heat island (UHI) dynamics — wherein built environments with low albedo and sparse vegetation trap thermal energy — can raise ambient temperatures by 3–10°C relative to surrounding rural areas, disproportionately harming residents in low-income neighborhoods [7]. Social determinants such as poverty, lack of greenspace, limited housing insulation, and fragmented health care access coalesce to increase incidence and severity of HRI and create significant heterogeneity in EMS activation patterns. The physiological underpinnings of HRI risk are multifactorial. Extreme heat exacerbates cardiovascular and respiratory load, impairs thermoregulation, and precipitates electrolyte imbalance, particularly in older adults and individuals with chronic non-communicable diseases (e.g., COPD, heart failure, diabetes) [8]. Recent studies demonstrate that each 1°C increase in ambient temperature is associated with significant elevations in both disease-specific mortality and morbidity, with quantifiable relative risk increases across diverse urban environments [9]. Our analysis also interrogates operational challenges inherent in prehospital care during EHEs. EMS systems face surges in call volumes during prolonged heatwaves, with longer on-scene times and increased resource utilization in 2023–2024 compared to 2020–2022, suggesting escalating clinical complexity of heat presentations [4]. Field-based cooling interventions, while effective for acute cases, are often implemented in a reactive fashion and hampered by limited staffing, inadequate shading and water resources, and uneven community outreach. Despite evidence of rising heat exposure and its health impacts, many current mitigation strategies remain reactive rather than pre-emptive. Public health response systems often rely on threshold temperature warnings and ad hoc cooling stations, leaving underlying vulnerabilities unaddressed [10]. Moreover, urban planning and climate adaptation frameworks frequently underinvest in green infrastructure, energy equity, and community-level education that could ameliorate the compounded risk borne by structurally marginalized populations. We conclude that equitable and data-driven public health interventions must leverage EMS activation data as a foundational surveillance tool to target resources where vulnerability is highest. Interventions that integrate socio-economic, environmental, and health system data — including early warning systems, targeted outreach to high-risk groups, and climate-adaptive infrastructure investments — are critical to curbing the disproportionate burden of heat-related morbidity and mortality in the coming decades. Such approaches must be embedded within broader climate adaptation and social justice frameworks to ensure that the most marginalized communities are prioritized in resilience planning.

2. THE BIOLOGICAL AND ENVIRONMENTAL DRIVERS OF HRI

The human thermoregulatory system is a highly evolved, yet intrinsically vulnerable physiological network designed to maintain core body temperature within a narrow, survivable range. Under conditions of thermal stress, heat dissipation is centrally regulated by the hypothalamus, which initiates cutaneous vasodilation to increase peripheral blood flow and activates eccrine sweat glands to facilitate evaporative cooling [11]. While elegant in principle, this system operates near its functional limits during extreme heat events, particularly when environmental conditions overwhelm the body's capacity to offload metabolic and ambient heat. A critical determinant of thermoregulatory efficiency is the Wet Bulb Globe Temperature (WBGT), an integrative index that incorporates ambient air temperature, relative humidity, wind speed, and radiant solar load. Unlike simpler metrics such as the Heat Index, WBGT more accurately reflects the physiological heat burden experienced by the human body [12]. High humidity is especially deleterious, as it markedly reduces the vapor pressure gradient required for sweat evaporation. Under such conditions, sweating becomes increasingly ineffective, leading to progressive heat storage, rapid elevation of core body temperature, and heightened risk of heat exhaustion and heat stroke [13]. Experimental and occupational health studies demonstrate that

once WBGT thresholds exceed approximately 28–30 °C, even healthy adults experience precipitous declines in physical and cognitive performance, with core temperatures rising despite maximal sweating. Biological susceptibility constitutes the first and most proximal layer of heat-related disparity. Older adults face a well-documented “triple threat” that substantially impairs thermoregulation [14]. First, aging is associated with a diminished sudomotor response, resulting in reduced sweat rate and delayed onset of sweating. Second, the thirst mechanism becomes blunted with age, increasing the likelihood of dehydration even under severe heat stress. Third, geriatric populations carry a disproportionate burden of chronic cardiometabolic and renal disease, often managed with medications such as diuretics, beta-blockers, and anticholinergics that further compromise heat dissipation, plasma volume, and cardiovascular reserve [15]. Together, these factors explain why older adults account for the majority of heat-related mortality and a disproportionate share of emergency medical services (EMS) activations during extreme heat events. However, biological vulnerability does not act in isolation. The Urban Heat Island (UHI) effect functions as a powerful environmental amplifier that magnifies individual susceptibility at the population level [16]. In dense metropolitan areas such as Chicago, New York City, and Phoenix, impervious surfaces, high-rise structures, and limited vegetation trap solar radiation during the day and slowly re-emit it at night. As a result, urban neighborhoods—particularly those with sparse tree canopy and aging infrastructure, experience persistently elevated nocturnal temperatures, often several degrees Celsius higher than surrounding suburban or rural areas [17]. This phenomenon of “nocturnal heat retention” is especially harmful because it eliminates the overnight cooling period that is physiologically essential for recovery from daytime heat exposure. Continuous thermal load prevents normalization of core temperature, increases sympathetic nervous system activity, and exacerbates dehydration and cardiovascular strain [18]. EMS data from multiple U.S. cities reveal a consistent surge in heat-related calls during the early morning hours, most notably between midnight and 4:00 AM, a temporal pattern strongly correlated with elevated nighttime minimum temperatures rather than daytime peaks. This pattern underscores that heat-related illness is not solely a function of daytime exposure but is critically shaped by cumulative and uninterrupted heat stress. Importantly, UHI effects are not randomly distributed. Marginalized urban populations—often residing in historically disinvested neighborhoods with limited access to air conditioning, green space, or energy-efficient housing—are disproportionately exposed to sustained nocturnal heat [7]. For these communities, extreme heat is not an episodic environmental hazard but a chronic physiological stressor, manifesting as repeated EMS activations, exacerbations of chronic disease, and elevated mortality risk. Thus, the interaction between impaired human thermoregulation and structurally intensified urban microclimates provides a mechanistic explanation for the pronounced spatial and demographic clustering of heat-related morbidity observed in contemporary cities [9].

3. ENVIRONMENTAL RACISM: FROM REDLINING TO THERMAL INEQUITY

The disparities we see in 2026 EMS activations are rooted in the policies of 1936. Research connecting historical redlining maps to modern Land Surface Temperature (LST) reveals a chilling correlation [10]. Formerly redlined neighborhoods are, on average, 5–12°F hotter than their 'greenlined' counterparts. These areas were systematically denied the funding for parks, community gardens, and tree canopies. Instead, they were paved over for industrial use and high-density housing. Consequently, EMS units in these 'thermal islands' experience call volumes that are 3–5 times higher during heatwaves than in wealthier, greener districts. This is not just a matter of weather; it is a manifestation of environmental racism that has left Black and Hispanic communities with fewer biological and environmental buffers against a warming planet. The ability to survive a heatwave in 2026 is increasingly tied to the ability to pay a utility bill [11]. 'Energy poverty' describes the condition where a household cannot afford to cool its living space to a safe temperature. EMS data highlights a high frequency of indoor HRI in low-income senior housing and mobile home parks. Often, patients are discovered in rooms reaching 95°F+ because

they feared the cost of running an air conditioner [19]. Housing quality also dictates risk. Modern luxury buildings often feature high-efficiency cooling and reflective glass, whereas low-income multi-family units frequently lack cross-ventilation and 'cool roof' technology. This 'AC Gap' is a primary driver of the disparities observed in EMS clinical records.

4. OCCUPATIONAL DISPARITIES: THE OUTDOOR WORKFORCE

While geriatric and pediatric populations are inveterately physiologically susceptible to heat stress, the working-age cohort (approximately 18–50 years) constitutes a surprisingly substantial proportion of emergency medical services (EMS) activations for heat-related illness, owing principally to occupational exposure to extreme thermal environments [20]. This demographic group, often overlooked in public discourse on heat vulnerability, encompasses manual laborers engaged in construction, agriculture, sanitation, and related sectors where metabolic heat production is superimposed on high environmental heat — a combination that exacerbates thermoregulatory strain and accelerates the trajectory from compensated heat strain to clinical heat exhaustion or heat stroke [6]. Occupational heat stress, defined as a state in which the cumulative metabolic and environmental heat load exceeds the body's capacity for dissipating heat, is a widespread global phenomenon; more than 2.4 billion workers face excessive environmental heat at their place of employment, contributing to an estimated 22.85 million annual work-related injuries linked to heat exposure [16]. In sectors dominated by outdoor manual labor, workers routinely encounter wet bulb globe temperature (WBGT) readings that surpass occupational safety thresholds well before mid-day. WBGT integrates ambient temperature, humidity, radiant heat, and wind speed, and has been shown to strongly correlate with physiological heat strain and productivity loss; even moderate increases above baseline WBGT values (e.g., >24–28°C) are associated with significant declines in work capacity and elevated risk of heat-related symptoms [14]. In practice, agricultural and construction workers often begin their shifts in the early morning only to find that by approximately 10:00 AM, WBGT values in direct sun or poorly ventilated sites exceed levels considered “dangerous” for sustained exertion, with concomitant increases in heart rate, core temperature, and dehydration risk. Institutional and socio-legal factors further compound occupational heat risk among working-age populations. A substantial fraction of manual laborers in agriculture and construction within the U.S. Southwest — particularly in California's Central Valley, a region of extensive crop production and seasonal heat extremes — are immigrant workers, including those without authorized legal status [18]. Fear of legal reprisal, job loss, or retaliation can deter early presentation for medical care, leading to delays in treatment and potentially more severe clinical presentations by the time EMS is engaged. Although precise statewide EMS data stratified by immigration status are limited in publicly available datasets, California occupational health surveillance has documented that a significant proportion of heat-related illness cases occur in working-age adults actively engaged in heavy labor, and that occupational heat illness may be underreported due to barriers in seeking care and reporting [19]. Empirical data from emergency department (ED) and workers' compensation records corroborate that adults in the working age range represent the majority of heat illness presentations linked to occupational exposures. In a recent California analysis covering 2016–2023, nearly 12.5 % of heat-related illness ED visits among persons aged 16–84 was classified as occupational, with outdoor workers in agriculture and construction disproportionately represented among these cases [13]. This pattern is consistent with broader occupational health research showing that outdoor laborers systematically experience heat exposure exceeding recommended threshold limit values, with measurable physiological effects such as elevated core body temperature and increased incidence of heat stress symptoms. Beyond acute injury and illness, occupational heat exposure carries longitudinal health consequences that further degrade resilience and functional capacity in this population. Chronic heat strain has been implicated in renal dysfunction, cardiovascular strain, and other systemic sequelae, risks that are accentuated in the context of repeated exposures

without adequate rest, hydration, or cooling interventions [17]. These findings highlight that working-age adults are not inherently resistant to heat but are thrust into heightened risk by the intersection of climate change, labor practices, and structural insecurity. Interventions to mitigate this burden must therefore extend beyond acute EMS response and encompass comprehensive occupational heat stress management, including enforcement of protective standards, acclimatization protocols, and legal protections that enable workers to seek timely health care without fear of adverse socio-legal consequences.

5. CLINICAL MANAGEMENT AND THE PATH TO MULTI-ORGAN FAILURE

Emergency Medical Services (EMS) management of heatstroke represents a time-critical race against the nonlinear “heat–time” injury curve, in which delays in definitive cooling translate directly into irreversible organ damage and mortality. Heatstroke is clinically defined not solely by extreme hyperthermia—typically a core body temperature exceeding 40 °C—but by the presence of central nervous system (CNS) dysfunction, including altered mental status, seizures, or coma [18]. This distinction is critical, as it reflects the systemic nature of heatstroke: a state of acute thermoregulatory failure accompanied by widespread inflammatory, coagulopathic, and endothelial injury. Once core temperature surpasses critical thresholds, cellular protein denaturation, mitochondrial dysfunction, and disruption of the blood–brain barrier occurs in rapid succession. Heat-induced intestinal ischemia promotes translocation of endotoxins, triggering a systemic inflammatory response that closely resembles septic shock [12]. Without prompt intervention, this cascade progresses toward multiorgan dysfunction, including acute kidney injury, hepatic failure, rhabdomyolysis, disseminated intravascular coagulation, and cardiovascular collapse. Importantly, these processes are time-dependent rather than temperature-dependent alone, underscoring why rapid cooling is the single most decisive intervention in the prehospital setting [13]. Accordingly, contemporary emergency medicine doctrine emphasizes the principle of “cool first, transport second.” Empirical evidence from athletic, military, and civilian cohorts consistently demonstrates that survival rates decline precipitously when effective cooling is delayed beyond approximately 30 minutes from symptom onset [15]. Each additional minute spent above critical core temperatures substantially increases the probability of neurological sequelae and death. Transporting an inadequately cooled patient, even to a nearby emergency department, may therefore paradoxically worsen outcomes if definitive cooling is deferred. Modern prehospital cooling strategies span a continuum of treatment intensity, ranging from low-resource to highly effective but resource-intensive modalities. Evaporative cooling, achieved through misting and forced airflow, is widely used due to its simplicity but is markedly less effective in high-humidity environments where evaporative capacity is constrained [17]. Chemical ice packs, applied to the groin, axillae, and neck, offer modest conductive heat transfer but often fail to achieve the rapid cooling rates necessary for severe heatstroke. Increasingly, progressive EMS systems are adopting cold-water immersion (CWI) bags, which can reduce core temperature at rates exceeding 0.15–0.20 °C per minute and are widely regarded as the gold standard for exertional heatstroke. However, access to high-intensity cooling is not uniform across EMS systems, revealing a critical axis of inequity. The ability to deploy CWI or equivalent aggressive cooling depends on equipment availability, crew size, scene safety, training, and call volume pressure. In high-density, low-income urban zones—where heat exposure is amplified by urban heat island effects and call volumes surge during extreme heat events—EMS units may be chronically overstretched [16]. Under such conditions, crews may lack the time, personnel, or equipment required to initiate prolonged, resource-intensive cooling on scene, defaulting instead to rapid transport with suboptimal interim measures. This disparity in prehospital treatment intensity has measurable consequences. Within the same metropolitan area, survival outcomes for heatstroke can vary substantially by ZIP code, reflecting not differences in ambient temperature but differences in system capacity and response quality. Communities with fewer EMS units per capita, longer response

times, and limited access to advanced cooling modalities experience higher rates of severe morbidity and mortality, even when hospitals are geographically proximate [11]. Thus, heatstroke outcomes are shaped not only by physiology and climate but by the spatial distribution of emergency care resources. These findings underscore that effective heatstroke management is as much a systems-level equity issue as it is a clinical challenge. As extreme heat events become more frequent and intense under climate change, the gap between recommended “cool first” protocols and real-world EMS capabilities is likely to widen unless deliberate investments are made [15]. Expanding access to high-efficiency cooling equipment, enhancing EMS staffing during heat emergencies, and integrating heat-specific surge protocols are essential to prevent geography and socioeconomic status from determining survival along the heat–time curve.

6. MITIGATION STRATEGIES AND POLICY RECOMMENDATIONS

To address these disparities, we must move beyond simple 'Heat Warnings.' Public health policy must involve:

- Predictive Resource Positioning: Using 2026 AI models to stage EMS units in redlined, high-UHI districts during heat spikes.
- Mandatory Labor Protections: Enforcing hydration and shade breaks for all outdoor workers, regardless of legal status.
- Retrofitting the City: Investing in 'cool roofs' and urban forests in the census tracts identified by EMS data as 'HRI hotspots.'
- Universal Cooling Access: Redefining cooling as a human right and providing subsidies to eliminate energy poverty.

7. CONCLUSION

The pronounced disparities observed in heat-related Emergency Medical Services (EMS) activations function as biological readouts of structural inequality, translating abstract social and economic inequities into measurable physiological harm. Heat does not act as a neutral environmental exposure; rather, it operates as a force multiplier, intensifying pre-existing fractures embedded within housing policy, labor systems, energy access, urban design, and health care infrastructure. The spatial and demographic clustering of heat-related illness is therefore neither incidental nor inevitable, but the predictable outcome of decades of uneven investment and systemic marginalization. As this review concludes in 2026, the evidence is unequivocal: the escalating burden of heat-related morbidity and mortality cannot be meaningfully reduced through clinical optimization alone. While advances in prehospital cooling protocols, EMS surge capacity, and hospital-based management are necessary, they are fundamentally downstream interventions—reactive responses to injuries that have already occurred. The persistence of stark inequities in EMS activations across neighborhoods, occupational groups, and demographic strata demonstrates that heat-related illness is not merely a biomedical phenomenon, but a structural pathology rooted in urban governance and social organization. Heat exposure reveals the moral geography of cities. Neighborhoods with limited tree canopy, substandard housing, energy insecurity, and occupational precarity experience disproportionate thermal stress, while simultaneously possessing the least capacity to buffer its effects. In this context, extreme heat becomes a form of environmental violence, silently exacting a toll that accumulates through repeated EMS calls, chronic disease exacerbations, and premature mortality. The body becomes the site where policy failures are rendered visible, with EMS activations serving as the first formal acknowledgment of harm. Emergency Medical Services data occupy a uniquely powerful position in this landscape. Unlike mortality statistics or hospital discharge records, EMS activations capture acute, place-based, and temporally precise manifestations of vulnerability. They illuminate where the system fails earliest and

most often, providing an empirical foundation for anticipatory, equity-focused interventions. When systematically analyzed and operationalized, EMS data can guide the strategic deployment of cooling infrastructure, inform heat-resilient urban planning, and justify targeted protections for high-risk workers and communities. A meaningful response to heat-related illness therefore demands a reimagining of urban justice, one that treats thermal safety as a fundamental public good rather than an individual responsibility. This entails embedding climate adaptation within housing policy, labor regulation, energy systems, and emergency preparedness, while centering those populations historically excluded from resilience planning. The question is no longer whether cities can adapt to rising heat, but for whom that adaptation is designed. As global temperatures continue their upward trajectory, the ethical imperative is clear. EMS data must serve not merely as a record of suffering, but as a guiding instrument for prevention, accountability, and repair. Only by aligning clinical insight with structural reform can societies ensure that, in an increasingly hot world, vulnerability is no longer predetermined by zip code, occupation, or income—and that those most exposed are no longer left to bear the heat alone.

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