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Editorial

Heatwaves End—Heat Exposure Does Not

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Although heatwaves are typically defined by meteorological thresholds over consecutive days, their health impacts often extend far beyond periods of elevated temperatures [1,2]. There are multiple approaches to defining and quantifying extreme heat and heatwaves, incorporating meteorological, climatological, and epidemiological perspectives [3]. Statistically, most methods rely on fixed thresholds, although human biometeorological factors can be integrated to better reflect physiological relevance. Importantly, the cessation of a heatwave does not mark the end of physiological stress, clinical burden, or infrastructural strain. Instead, heat acts as a cumulative and delayed hazard, with effects that may persist for days or even weeks after ambient temperatures return to normal [3–5]. The purpose of this article is to highlight the relevance of heat exposure following a heat event and to provide selected examples illustrating delayed impacts.

From a clinical perspective, delayed mortality and morbidity are well documented phenomena. Gasparrini et al. demonstrated that heat-related deaths often peak 1–3 days after the highest air temperatures, particularly among older adults and individuals with pre-existing cardiovascular or renal conditions [6]. This lag is attributed to the progressive nature of dehydration, electrolyte imbalance, and thermoregulatory exhaustion, which may initially remain subclinical but subsequently lead to organ failure or fatal arrhythmias.

It is also important to acknowledge so-called harvesting effects, whereby extreme heat advances mortality among highly vulnerable individuals by days or weeks. The 1995 Chicago heatwave is frequently cited in this context, as post-event analyses suggested partial mortality displacement. However, such findings do not diminish the severity of heat impacts. Instead, they underline the extent of pre-existing physiological stress and reduced resilience, reinforcing the need to consider heat exposure as a cumulative process that begins before and extends beyond the formal heatwave period.

Renal stress is particularly relevant in this context. Glaser et al. identified heat exposure as a driver of chronic kidney disease of non-traditional origin (CKDnt), especially among outdoor workers in tropical and subtropical regions [7]. Even short-term heat exposure can trigger subclinical kidney injury, with biomarkers such as NGAL and creatinine rising days after the event. These findings underscore the need for post-heatwave surveillance and follow-up care, particularly for vulnerable populations.

Mental health impacts also extend beyond the meteorological event. Thompson et al. found that psychiatric admissions, sleep disturbances, and cognitive impairments remain elevated for several days after heatwaves [8]. The psychological toll of prolonged discomfort, disrupted routines, and social isolation during extreme heat contributes to delayed mental health deterioration. In addition, sleep deprivation caused by insufficient nocturnal cooling can exacerbate cognitive and emotional strain.

Health systems experience a similar temporal extension of burden. Emergency departments frequently report increased admissions in the days following a heatwave, as patients

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seek care for complications that were initially self-managed or unrecognized. In long-term care facilities, staff observe persistent rehydration needs, fatigue, and worsening of chronic conditions even after temperatures decline. These patterns indicate that heat adaptation strategies must include post-event protocols, not only acute-phase interventions.

Urban infrastructure further amplifies delayed stress. Buildings with poor insulation and low thermal inertia retain heat long after outdoor temperatures fall, prolonging indoor exposure [9]. Asphalt and concrete surfaces release stored heat during the night, maintaining elevated microclimatic temperatures. Vegetation, especially in urban green spaces, may show signs of drought stress days after a heatwave, reducing its cooling capacity and ecological resilience [10]. These delayed biophysical responses contribute to prolonged exposure for urban residents. The importance of monitoring delayed heat stress is further amplified in regions with limited capacity to retrofit or adapt existing urban fabric. Many such locations are characterized by dense, legacy building stocks and climatic typologies already associated with high thermal exposure. In these contexts, structural constraints on adaptation coexist with heightened vulnerability, making post-event monitoring and targeted resilience strategies and/or measures particularly critical.

Across all phases of extreme heat events, tailored community communication plays a critical role in reducing risk. While heat–health action plans have substantially improved pre-event preparedness and during-event response in many regions, post-event communication remains comparatively underdeveloped. Continued guidance after a heatwave is essential to address delayed health effects, reinforce hydration and recovery behaviours, and support vulnerable groups whose functional capacity may remain compromised. Effective communication strategies must therefore extend beyond the meteorological event itself and be adapted to local contexts and population needs. Socially, vulnerable groups such as older adults, people living alone, and individuals with limited mobility require extended recovery time. Reduced mobility during heat events exposes structural inequalities in accessibility, which means that proximity-based planning concepts (such as the "15-min city") cannot assume functional accessibility for vulnerable groups, especially under climate stress. Cumulative fatigue, dehydration, and psychological strain do not resolve immediately, necessitating continued outreach and support. Occupational sectors also report increased accident rates and productivity losses in the post-heatwave period, linked to residual exhaustion and impaired concentration [11]. These effects highlight the importance of workplace policies that consider not only acute heat exposure but also recovery periods.

It should also be noted that heat stress can occur before a heatwave, even when temperatures or meteorological conditions remain just below critical thresholds. Importantly, conditions that do not formally meet extreme event definitions may nevertheless impose significant physiological strain and occur far more frequently than classified heatwaves. Pre-event heat exposure can reduce physiological resilience and increase vulnerability once the heatwave begins. In sum, heat must be understood not only as an acute meteorological event but as a temporally diffuse health hazard. Its impacts persist beyond the visible peak, affecting physiology, psychology, infrastructure, and social systems. Public health frameworks should therefore incorporate post-wave monitoring, clinical follow-up, and infrastructural cooling strategies to mitigate delayed consequences and strengthen resilience.

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