3. HOW HOT IS TOO HOT?

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Source: David Trilling

Extreme heat is an increasingly regular feature of India's climate, catalyzing governments, public health agencies, and civil society to develop heat action plans (HAPs), policies, and emergency response measures to safeguard the public (Pillai and Dalal, 2023; Singh et al., 2024). Yet key questions remain unanswered about the thresholds that define dangerous heat and the evidence supporting interventions to mitigate its health impacts.

Identifying thresholds for triggering action: How hot is too hot?

A central challenge in crafting any action plan or emergency response is deciding on its trigger point—the conditions above which exposure becomes hazardous and protective measures must be enacted. Perhaps the most intuitive answer to the question "how hot is too hot?" is when conditions exceed the capabilities of human physiology. The goal of the body's thermoregulatory mechanism is to ensure a balance between the heat gain and loss to maintain its temperature within narrow limits for normal function (Meade et al., 2024). Beyond a certain point, heat gain from the environment outstrips the body's ability to cool itself through sweating, especially when high humidity prevents sweat from evaporating. A wet bulb temperature (Twb) of 35°C (95°F) is frequently cited as the physically bound survivability threshold. Above this limit, even a young, healthy person resting in the shade with access to ample drinking water and skin fully coated in sweat would experience a continual rise in core temperature, leading to death from heatstroke within hours (Sherwood and Huber, 2010; Meade et al., 2025).

Such notion of a hard physiological limit has become a popular anchor in discussions among scientists and policymakers of the current and future dangers of extreme heat. However, this framing overlooks several important complexities. For one, recent laboratory studies and physiological models suggest that the true physiological limit for human thermoregulation is lower than 35°C Twb and that how much lower depends on the prevailing air temperature (Wolf et al., 2022; Vanos et al., 2023). For example, Wolf et al. observed minimally active young adults can withstand up to 31°C Twb (88°F) without thermoregulatory failure in hot humid environments but only 26°C Twb (79°F) when conditions were very hot and dry[1]. Updated empirical limits from these studies have been used to argue that exposures to non-survivable heat in already hot countries like India will expand dramatically with further global warming (Vecellio et al., 2023; Powis et al., 2023). However, it has not been considered that this research was conducted on participants in temperate, continental climates of the Global North and is therefore unlikely to be generalizable to India, where inhabitants are both physiologically and socially acclimatized to heat (Taylor, 2014).

While defining India-specific thermoregulatory limits is not itself an intractable problem, heat stroke is not the only—and is not even the predominant—cause of death during heat waves. Most heat-related fatalities result from major adverse cardiovascular events likely due to the elevated strain thermoregulation places on the heart (Meade et al., 2025). Heat exposure is also known to precipitate kidney injury, reduce sleep quality, and exacerbate numerous chronic conditions including diabetes, respiratory illnesses, and mental health conditions (Minor et al., 2022; Vaidyanathan et al., 2019). Epidemiological data clearly show that mortality due to these "indirect" causes begins to occur in temperatures well below physiological limits for thermoregulation (Vaidyanathan et al., 2019; Gasparrini et al., 2015; Tobias et al., 2021). Accordingly, HAPs and emergency responses are often triggered at the point where epidemiological data show a rise in all-cause mortality. While this approach is intuitive and allows for more organic incorporation of local adaptation (e.g., by using country-, region-, or city-level data), it overlooks the myriad ways in which heat undermines health and well-being without necessarily killing.

For example, fieldwork suggests that work productivity begins to decline at much lower air temperatures (Ioannou et al., 2025), which can have cascading consequences for individuals paid at piece- or day-rates, reducing the ability to afford foods or medications (Meade et al., 2025). There is also considerable heterogeneity in how individuals experience heat and in their capacity to cope with it. People living in poorly insulated and ill-ventilated housing are exposed to higher heat stress than those in well-constructed homes with adequate cooling (García et al., 2024; Reckford and Aki-Sawyerr, 2023). Many of the same individuals in overheated homes, whether in low-income housing projects or informal settlements, must also perform heavy physical labor outdoors or in hot factories to earn a living wage (Meade et al., 2025). Their risk of heat-related health impacts is heightened because they cannot limit their exposure.

Heat-health risks are also elevated in groups less able to tolerate heat physiologically, such as those with reduced sweat rates or other vulnerabilities (Meade et al., 2024). These include very young children, older adults, and individuals with certain pre-existing health conditions or taking medications interfering with physiological responses to heat stress. The impact of high heat and humidity is further amplified when sustained for days, weeks and even months. When heat persists for weeks or months, its compounding effects on health, livelihoods, energy, and infrastructure can drive morbidity and mortality that extend well beyond the heat season: these delayed impacts remain difficult to attribute.

Thus, the seemingly straightforward question of "how hot is too hot?" cannot be answered without first

1 High humidity impairs thermoregulation at any given air temperature by preventing sweat from evaporating, which is precisely why wet bulb temperature (Twb) is used as a more comprehensive metric. However, at a given Twb, thermoregulatory failure occurs more rapidly in hot, dry conditions than in humid ones—a counterintuitive finding that reflects the limitations of Twb as an indicator of heat stress across different climate types.

asking: "too hot for what?" and also, "too hot for whom?" Even from a physiological perspective, these are difficult questions—and they become even more complex when translated into explicit triggers for HAPs, emergency responses, and other interventions.

Weighing the evidence on effective solutions: How cool is cool enough?

Once prevailing heat and humidity are deemed sufficiently dangerous to warrant action, interventions should be implemented to remove exposed individuals from the hazard or, at minimum, to mitigate its effects. The suite of available interventions has expanded alongside the growing threat of extreme heat and now spans multiple domains, actors, and time scales. Examples include technological interventions at the household level like air-conditioning and lower-cost alternatives such as cool roofs. HAPs integrate both behavioral elements (e.g., public messaging to promote health-protective actions) and technological components (e.g., systems for disseminating heat alerts) and are driven primarily by the public sector but often co-designed with input from civil society. As interventions extend over longer time-horizons, implementation increasingly requires blending of domains as seen, for example, in efforts to establish workplace heat regulations or integrate heat-resilience into building codes and new housing developments.

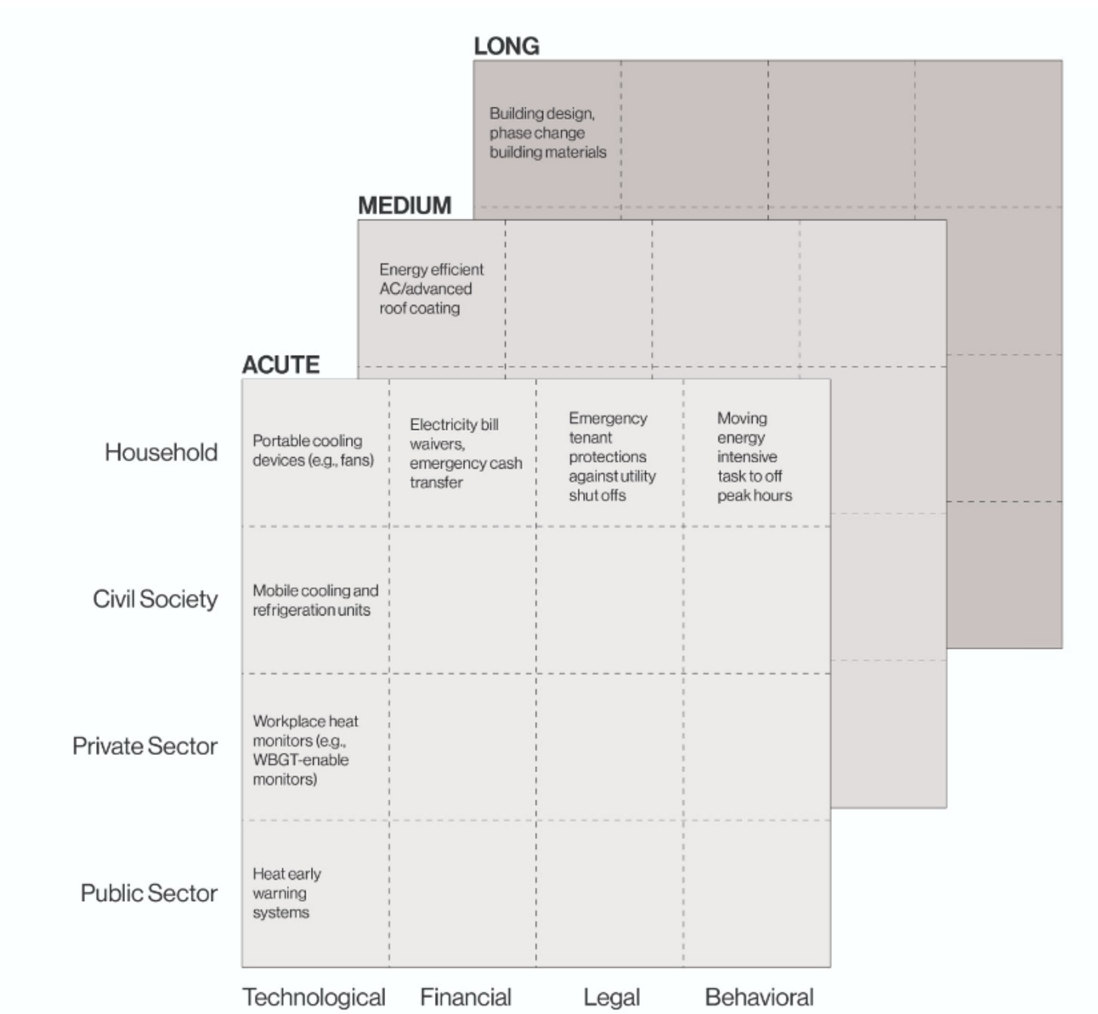

Fig. 2: Conceptual framework mapping emerging heat adaptations. Graphic by: Karthik Girish

A key barrier to deciding which interventions should be prioritized is a lack of data on their effectiveness, particularly in the Indian context. For example, it is well established that air conditioning is highly effective in preventing heat-related morbidity and mortality (Bouchama et al., 2007). However, this strategy is energy intensive and expensive, and therefore remains inaccessible to many of the most vulnerable. At least 80 million working poor in India can't afford even the most basic necessities; additional hundreds of millions more live just above the poverty line, all of whom have limited access to adequate protections from heat (e.g., cooling, shelter, healthcare) (ILO, 2024). Regularly promoted alternatives such as cool roofs typically deliver only a fraction of the cooling power (Das et al., 2025), and it remains unclear whether the provided reduction in indoor temperature, which can amount to only a few °C, is truly sufficient to protect health (Meade et al., 2025). Similarly, although emerging evidence from India suggests that HAPs may reduce heat-related mortality (Hess et al., 2018), it remains unclear whether they effectively reach—and protect—the most vulnerable members of society (Pillai and Dalal, 2023).

Even the establishment of robust evidence supporting the efficacy of an intervention does not guarantee that lives will be saved in the real world, as effectiveness can be compromised if the intervention comes with large economic costs. For instance, oft-discussed strategies like mandatory work breaks, occupational safety equipment and cooling centers, changes to school timings and transport schedules all affect the revenues of businesses and the wages of the vulnerable. There are incentives for employers and employees to circumvent heat-specific costs and effectively sacrifice health to protect business and livelihoods. Despite health risks, low-wage earners around the world advocated for work restoration during the COVID-19 pandemic.

Identification and evaluation of solutions must therefore be heavily grounded in local context, to ensure feasibility and scalability in the long term.

Answering tough questions

The considerable hurdles in identifying physiological upper limits and developing effective, scalable solutions for limiting heat's growing burden do not mean these efforts should be abandoned altogether. Rather, the opposite is true—the challenges underscore that much work is needed to build evidence-based and contextually grounded protections for India and the rest of the world. Doing so will require expanding our understanding beyond laboratory studies and models to include community-informed research linking physiological and epidemiological data with the lived realities of those at greatest risk. Such an approach is the surest way toward the creation of thresholds and interventions that are not only scientifically robust but also socially legitimate and responsive to the diverse ways heat affects health, work, and daily life.