# 11

# PRIORITISING CLIMATE CHANGE AND HEALTH: THE CURRENT STATUS OF HEAT-HEALTH IN INDIA

*Priya Dutta, Mahaveer Golechha and Dileep Mavalankar*

## Introduction

Climate change is causing an increase in the severity and frequency of extreme weather events and disasters. It is leading to two major changes in weather – an increase in average temperatures and an increase in variability of weather. This leads to the increased possibilities of severe heat and cold waves. In the last twenty years, extreme heat events have become more intense, more frequent and longer-lasting, posing a new global challenge to the health sector worldwide. Extreme heat can lead to dangerous, even deadly, health consequences, including heat stress and heatstroke. As urban populations continue to grow, there is an increasingly urgent need for cities and their residents to adapt to climate change and its impact.

Fortunately, heat-related illnesses are preventable with effective public health interventions. In India, the city of Ahmedabad took the lead in implementing a citywide preparedness plan and developing city-specific heat-health thresholds. The Indian Institute of Public Health, Gandhinagar (IIPHG), in collaboration with other partners, developed and implemented these threshold-based heat action plans. The experience in Ahmedabad provides compelling evidence that heat action plans can meaningfully reduce vulnerability to extreme heat and save lives. This chapter will describe

1. Heat waves and their health impacts from the perspective of public health.
2. Heat Action Plans as public health interventions to reduce heat-related illnesses.

## Heat waves

Extreme temperatures are among the most dangerous natural hazards. Over the past five decades, human activities have released ample greenhouse gases (GHGs), raising the mean global temperature and resulting in an increase in the frequency and intensity of heat waves (Tollefson, 2018). Heat waves are

 DOI: 10.4324/9781003190516-14

anticipated to worsen with climate change, leading to several heat-related health consequences (Gasparrini *et al*., 2017; Nori-Sarma *et al*., 2019).

A heat wave is a prolonged period of abnormal high temperature which causes temporary modifications in lifestyle and adverse health effects in the population (Robinson, 2001). In India, heat waves usually occur during the summer months of April to June. In some rare cases, they may start in March and extend till the first or second week of July. The exact definition of a heatwave varies by location, ambient temperature, humidity and physical, social and cultural adaptations (Robinson, 2001). The Indian Meteorological Department (IMD) declares a heat wave when there is an excess of 5°C or 6°C above a normal maximum temperature less than or equal to 40°C; or an excess of 4°C to 5°C above a normal maximum temperature of more than 40°C (NDMA, 2019). However, if the actual maximum temperature is 45°C or more, a heat wave is declared irrespective of the normal maximum temperature. The normal temperature for that day is derived from a 30-year record of historical temperatures for that area's weather station (NDMA, 2019). The IMD definition does not take into account any health impacts such as morbidity or mortality in determining thresholds for declaring heat waves.

## The impact of heat waves on human health

Several research studies have shown an increased number of deaths during heat waves (D'Ippoliti *et al*., 2010). In 2003, a heat wave in Europe caused excess mortality estimates varying from 25,000 to 70,000 deaths (Maughan, 2012). Very few studies have been conducted in India to assess the effect of ambient temperature on human health. In India, from 1992 to 2015, heat waves have caused 22,653 officially reported deaths; this number includes over 2,500 deaths in India's deadliest heat wave during the summer of 2015 (NDMA, 2019). Heat-related morbidity and mortality can occur due to direct or indirect effects. Direct effects include heat-related illnesses from heat exhaustion to heat stroke. The indirect effects on physiological systems can cause renal insufficiency and exacerbate cardiovascular diseases, respiratory problems and acute cerebrovascular disease.

According to the latest study by the Indian Meteorological Department (IMD) and the Indian Institute of Tropical Meteorology (IITM), the average heat index of India has increased significantly per decade at the rate of 0.56°C and 0.32°C in summer and monsoon respectively, which is statistically significant at 95% level (Jaswal *et al*., 2017). The heat index is a single number which is calculated based upon a combination of different environmental parameters such as temperature and humidity to posit a human-perceived equivalent temperature.

During heat waves, hospital admissions also increased due to people suffering from heat exhaustion, heat syncope, severe dehydration and

vomiting. Depletion of salt and electrolytes in the body can cause heat cramps while working under the direct sun could lead to heat exhaustion. The total impact of heat wave events on mortality in India could be even higher, as these figures probably refer to reported deaths from heatstroke only. Morbidities due to heat waves are not even counted.

## Populations at risk

An increase in ambient temperature contributes directly to an increase in mortality, particularly among those who are vulnerable. Pregnant women, elderly people and young children are more vulnerable to extreme heat.

Elderly age group: Ageing can be characterised by a complex process in which progressive age-specific deteriorations of internal physiological systems inevitably impair the body's capacity to respond to extreme heat. In the elderly population, there is also a deterioration in the ability to dissipate heat, a process pivotal to the maintenance of normal core temperature, especially in extreme heat conditions. Further, heat-related illnesses can also exacerbate existing medical conditions that can make elderly more vulnerable to extreme heat.

Pregnant women: Pregnant and postpartum women and their infants are uniquely vulnerable to the health impacts of heat waves, due to the many physiological changes that occur as a result of pregnancy. Pregnancy increases likelihood for fatigue and dehydration. Dehydration can lead to preterm uterine contractions and even labour.

Infants and children: Due to their anatomical, cognitive, immunological and psychological differences, children and infants are more vulnerable to extreme heat than adults. Because of their small surface-to-body ratio, infants and children are more vulnerable to dehydration and heat stress. During extreme heat events, children are more likely to be affected by respiratory disease, renal disease, electrolyte imbalance and fever.

## The urban heat island effect

Heat waves have a much larger health impact in cities than in surrounding suburban and rural areas. Indian cities are rapidly urbanising with skyrocketing development that converts open space into paved, heat-trapping roofs and roads. These hot surfaces absorb and later re-radiate the sun's thermal energy, worsening city temperatures relative to surrounding rural areas, thereby amplifying the urban heat island effect and increased air pollution (Singh *et al.*, 2020).

There are a number of evidences suggesting that heat-related risks might be reduced through the systemic development of Heat Action Plans which include early warning systems, community awareness strategies and

capacity building of various stakeholders (Hess *et al.*, 2018; Benmarhnia *et al.*, 2019). Therefore, public health intervention is required to deal with the impact of heat waves on human health in India. The heat action plan should be an essential component of city planning for the management and prevention of heat-related illnesses. In India, several efforts have been made to implement public health strategies to combat the negative effect of heat waves (Box 11.1).

### Box 11.1 Case study

### The development and implementation of South Asia's first heat action plan in Ahmedabad, Gujarat, India

In May 2010, the city of Ahmedabad in Gujarat witnessed a major heat wave with a peak temperature of 47°C on 21 May, resulting in over 300 deaths in one day and in excess of 800 deaths in one week (Azhar *et al.*, 2014) (Figure 11.1). Following this, the Indian Institute of Public Health, Gandhinagar (IIPHG), supported by national and international partners, developed and implemented a Heat Action Plan (HAP) in Ahmedabad in 2013. Heat wave early warning systems and adaptation plans have reduced heat wave related mortalities and morbidities in various parts of the world (Knowlton *et al.*, 2014). The Heat Action Plan implemented in Ahmedabad was the first innovative early warning system and preparedness plan for extreme heat

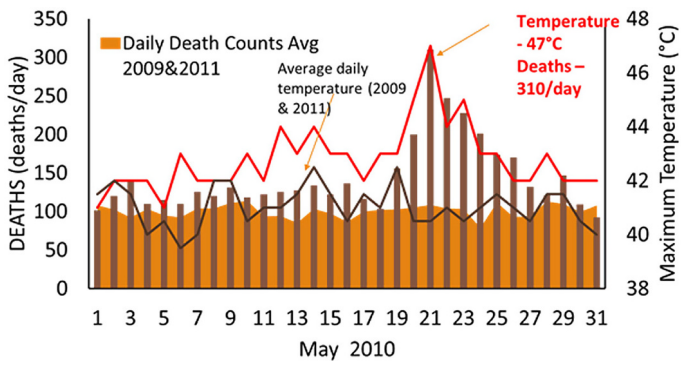


*Figure 11.1* Daily temperatures and all-cause mortality correlation graph of Ahmedabad, Gujarat.

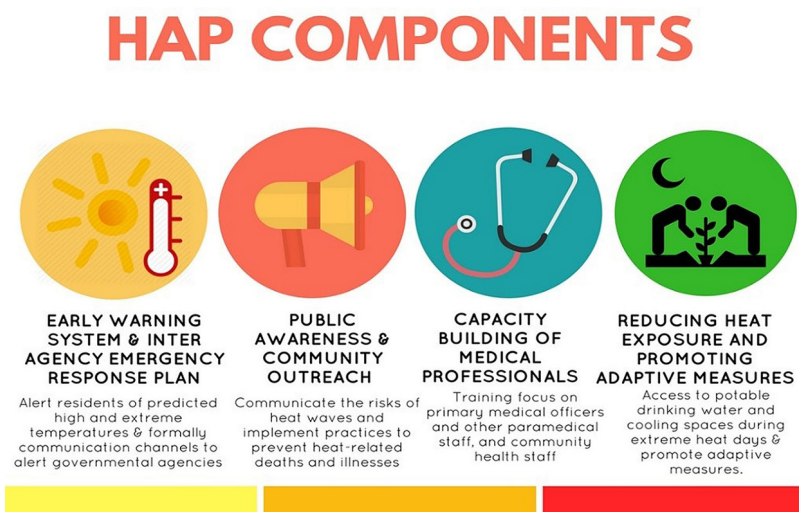


*Figure 11.2* Ahmedabad heat action plan strategies.

events in South Asia, based on learnings from Europe and America (Knowlton *et al.*, 2014).

Heat action plans include early warning systems that alert citizens and organizations in advance of extreme heat, and enable them to respond effectively to save lives. The important strategies of the Ahmedabad Heat Action Plan involved the following components: firstly, building public awareness and community outreach; secondly, an early warning system and inter-agency coordination; thirdly, capacity building of healthcare professionals; and finally, reducing heat exposure and promoting adaptive measures (Figure 11.2). One of the most important components of a Heat Action Plan is the inter-agency emergency response framework for effective coordination between various departments of municipal administration (Figure 11.3). The administration issues a heat alert based on thresholds determined by the IMD, and uses a colour signal system as an additional means of communication. Depending on the alert that has been issued, different departments will activate their channel and perform pre-defined activities (Table 11.1).

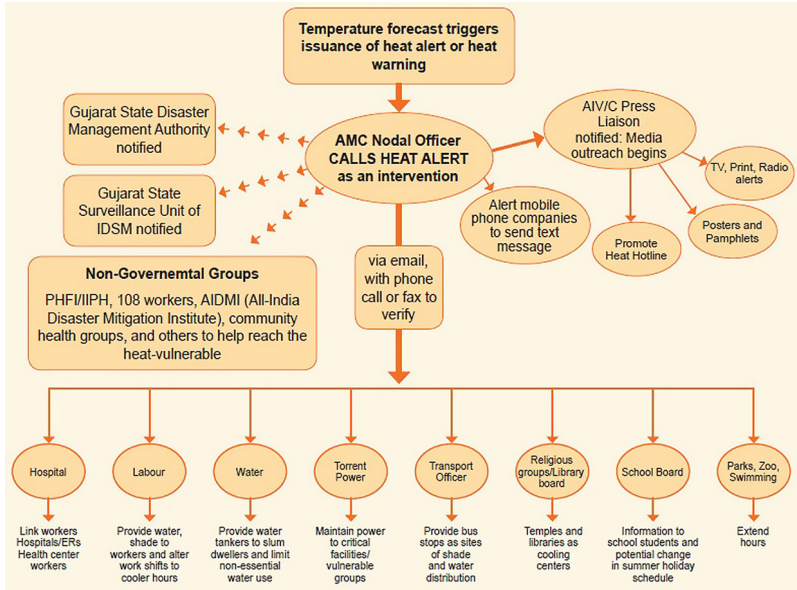


*Figure 11.3* The inter-agency emergency communication plan when the Ahmedabad Municipal Corporation (AMC) nodal officer activates a heat alert.

*Table 11.1* Colour signals for heat alerts

| | | |
|---|---|---|
| Red Alert (Severe Condition) | Extreme Heat Alert Day | An increase of 6°C or more above Normal Maximum Temperature |
| Orange Alert (Moderate Condition) | Heat Alert Day | An increase of 4°C to 5°C above the Normal Maximum Temperature |
| Yellow Alert (Heat-wave Warning) | Hot Day Advisory | Near the Normal Maximum Temperature |
| White (Normal) | Normal Day | Below the Normal Maximum Temperature |

## The impact of the Ahmedabad heat action plan in reducing mortality due to extreme heat events

A preliminary health outcome evaluation analysis suggests that there was at least a 25% decrease from May's excess all-cause mortality in the two years since the HAP was launched (Hess *et al.*, 2018). Hess *et al.* estimated that

the Ahmedabad Heat Action Plan (HAP) saves hundreds of lives every summer, and found a decrease in all-cause mortality in the first two years (2014–2015) after the HAP was implemented. The results of this ecological study indicate that the HAP was associated with reduced mortality during the heat season in 2014–2015, especially at higher temperatures (Hess *et al*., 2018). The Ahmedabad HAP was successful in reducing heat-related illnesses, and the plan has been scaled up in other places across the nation such as Odisha and the Vidarbha region of Maharashtra. The National Disaster Management Authority (NDMA) has developed national guidelines for the prevention and management of heat waves based on the Ahmedabad HAP (Box 11.2).

In subsequent years, cool roof technologies have been added as an additional important strategy under the Heat Action Plan. Cool roofs reflect sunlight and absorb less heat, offering a simple and cost-effective solution to the urban heat island challenge. A study conducted in Ahmedabad slums found that cool roof technologies such as thermocol insulation and solar reflective white paint on the outer surface of the roof can effectively reduce the indoor temperature as compared to non-intervention roofing (Vellingiri *et al*., 2020).

## Limitations to the development and implementation of HAPs

An important limitation to the effective development and implementation of a heat action plan is the unavailability of health-related data on heat-related illnesses on a daily or weekly basis. Without health-related data, it is impossible to work out a city-specific temperature threshold and heat stress index. There are several challenges to conducting heat health research in India. Due to the modest registration of deaths, it is very difficult to obtain all-cause mortality data. Furthermore, it is difficult to understand the effects of heat on cause-specific mortality in sufficiently large sample sizes. Another limitation is the lack of India-specific or region-specific Heat Stress Index data. The present early warning system is largely based on epidemiological studies which links temperature and mortality data, i.e. by correlating the daily temperature-mortality relationship.

Due to the efforts of the National Disaster Management Authority, the Indian Meteorological Department and IIPHG, many cities have developed their heat action plans based on the Ahmedabad HAP. However, effective implementation is lacking, as there is no state-level monitoring.

At the national level, the Ministry of Health, the Ministry of the Environment and other line ministries should work jointly under the National Mission on Climate Change and Human Health to implement climate resilience heat action plans. The government should prioritise integrating climate services for health in public health policy and planning.

**Box 11.2 Case study**

**The development and implementation of India's first climate resilience heat action plan in rural settings under the Rajasthan climate change project**

More than two-thirds of the population of Rajasthan live in rural areas. There has been an increasing trend of heat waves in Rajasthan over the past several years in which several cities in Rajasthan have been severely affected. The Thar Desert area consists of 12 districts covering 60% of the area of Rajasthan and is largely affected by extreme heat events. The IIPHG partnered with UNCIEF Rajasthan and the Government of Rajasthan for the development and implementation of a climate resilience heat action plan in rural settings. The aim of this project was to pilot a model for the prevention and management of heat waves in the rural settings of Rajasthan, based on learnings from Ahmedabad. The project districts in the pilot were Jalore, Udaipur and Jaipur. The important activities of the project were:

- To understand the impact of climate change on health
- To develop a Climate Resilience Heat Action Plan for selected blocks of Rajasthan
- To build capacity and generate awareness among healthcare professionals
- To generate awareness of heat-related illness prevention and management among students and teachers.

Various innovative approaches were used, such as organising a Heat Awareness Day and a Mass Awareness Rally; harnessing the potential of children in community awareness; capacity building of frontline health workers and medical officers; and comprehensive Information, Education and Communication (IEC) material made available in local languages. All these activities helped to mainstream climate change within the public health system. The state government then scaled up activities in districts.

## Key takeaways

- The chapter discusses the role of heat action plans and heat health research in improving the resilience of communities against extreme heat events and for the prevention and management of heat-related illnesses.

- There has been an increasing trend of heat waves in India over the past several years.
- Extreme heat can lead to dangerous, even deadly, health consequences, including heat stress and heatstroke.
- Public health interventions are urgently required to reduce mortality and morbidity due to extreme heat events.
- The city of Ahmedabad implemented South Asia's first Heat Action Plan based on an early warning system.
- The experience in Ahmedabad provides compelling evidence that heat action plans can meaningfully reduce vulnerability to extreme heat and save lives.

## References

Azhar, G. S., Mavalankar, D., Nori-Sarma, A., *et al*., (2014). Heat-related mortality in India: Excess all-cause mortality associated with the 2010 Ahmedabad heat wave. *PLoS One 9*(3), e91831.

Benmarhnia, T., Schwarz, L., Nori-Sarma, A., & Bell, M. L. (2019). Quantifying the impact of changing the threshold of New York City heat emergency plan in reducing heat-related illnesses. *Environmental Research Letters*, *14*(11), 114006.

D'Ippoliti, D., Michelozzi, P., Marino, C., de' Donato, F., Menne, B., Katsouyanni, K., … & Perucci, C. A. (2010). The impact of heat waves on mortality in 9 European cities: Results from the EuroHEAT project. *Environmental Health*, *9*, 37. doi: 10.1186/1476-069X-9-37

Gasparrini, A., Guo, Y., Sera, F., Vicedo-Cabrera, A. M., Huber, V., Tong, S., … & Armstrong, B. (2017). Projections of temperature-related excess mortality under climate change scenarios. *The Lancet Planetary Health*, *1*(9), e360–e367.

Hess, J. J., Lm, S., Knowlton, K., Saha, S., Dutta, P., Ganguly, P., … & Mavalankar, D. (2018). Building resilience to climate change: Pilot evaluation of the impact of India's first heat action plan on all-cause mortality. *Journal of Environmental Public Health*, 7973519. doi: 10.1155/2018/7973519

Jaswal, A., Padmakumari, B., Kumar, N., & Kore, P. A. (2017). Increasing trend in temperature and moisture induced heat index and its effect on human health in climate change scenario over the Indian sub-continent. *Journal of Climate Change*, *3*(1), 11–25.

Knowlton, K., Kulkarni, S. P., Azhar, G. S., Mavalankar, D., Jaiswal, A., Connolly, M., … & Hess, J. J. (2014). Development and implementation of South Asia's first heat-health action plan in Ahmedabad (Gujarat, India). *International Journal of Environment Research and Public Health*, *11*(4), 3473–3492. doi: 10.3390/ijerph110403473

Maughan, R. J. (2012). Hydration, morbidity, and mortality in vulnerable populations. *Nutrition Reviews*, *70* 2, S152–S155. doi: 10.1111/j.1753-4887.2012.00531

National Disaster Management Authority, Ministry of Home Affairs, Government of India. (2019). *National guidelines for preparation of action plan-prevention and management of heat wave*. https://ndma.gov.in/images/guidelines/heatwave-guidelines.pdf

Nori-Sarma, A., Anderson, G. B., Rajiva, A. *et al.* (2019). The impact of heat waves on mortality in Northwest India. *Environmental Research, 176*, 108546.

Robinson, P. J. (2001). On the definition of a heat wave. *Journal of Applied Meteorology*, *40*(4), 762–775. doi: 10.1175/1520-0450(2001)040<0762:OTDOAH>2.0.CO;2

Singh, N., Singh, S., & Mall, R. K. (2020). Urban ecology and human health: Implications of urban heat island, air pollution and climate change nexus. In *Urban Ecology* (317–334). Elsevier.

Tollefson, J. (2018). IPCC says limiting global warming to 1.5°C will require drastic action. *Nature*, *562*(7726), 172–173. doi: 10.1038/d41586-018-06876-2

Vellingiri, S., Dutta, P., Singh, S., Sathish, L. M., Pingle, S., & Brahmbhatt, B. (2020). Combating climate change-induced heat stress: Assessing cool roofs and its impact on the indoor ambient temperature of the households in the Urban Slums of Ahmedabad. *Indian Journal of Occupational and Environmental Medicine*, *24*(1), 25–29. doi: 10.4103/ijoem.IJOEM_120_19