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Investigation of heat-related deaths at a mass gathering event, Maharashtra, India, April 2023

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ABSTRACT

In India, the likelihood of intense heat waves reported in 2022 is projected to increase 30-fold with continued global warming. India's National Programme on Climate Change and Human Health (NPCCHH) aims to strengthen health sector preparedness to reduce morbidity and mortality from impacts of climate change, including extreme heat. Mass gatherings during summer heighten the risk of severe heat-related illnesses (HRI). A coastal district in Maharashtra state reported deaths during a mass-gathering event in April 2023, prompting an investigation and situational analysis. We conducted a cross-sectional study in the district. We defined confirmed heatstroke deaths as suspected HRI deaths among attendees of the April 16th, 2023, mass gathering, confirmed through post-mortem examination. Medical records were reviewed, and epidemiological data were collected using NPCCHH's suspected HRI death investigation form from relatives and first responders. Data were analysed in proportions. The district reported 12 confirmed heatstroke deaths at a mass gathering of one million attendees on April 16th, 2023. Of these, 11 were found dead within two hours of crowd dispersal. There was no active heatwave warning. Disaster preparedness, although extensive, focused on managing generic scenarios. No information on identifying and preventing HRI was publicised. The heatstroke deaths highlighted policy and implementation gaps in organizing mass gatherings during summer. Recommendations include developing mass gathering-specific preparedness guidelines considering ambient heat exposure.

Background

Global climate change has spurred a concerning trend of rising temperatures worldwide, primarily driven by human activities. Since the 1960s, surface temperatures have exhibited a marked increase, with an average rise of approximately 0.7°C observed between 1901 and 2018[1]. India experiences scorching summers from March to June, with maximum temperatures often exceeding 40°C. Heatwaves, primarily affecting the Northwestern, Central, and Southeastern coastal regions, have increased in frequency, intensity, and duration in recent years[2]. In 2023, Maharashtra's mean land surface air temperature was 25.8°C, at least 0.16°C warmer than the 1981–2010 average. This coastal district of the state where the gathering took place experienced a similar temperature increase of 0.5°C to 1°C compared to the 1981–2010 average.[3]

The effects of escalating temperatures are multifaceted, encompassing severe health risks, diminished agricultural productivity, heightened energy demands, and strain on natural resources[4]. Particularly vulnerable are segments of the population, such as the elderly, children, and economically disadvantaged individuals, exacerbating existing social disparities[4–7].

Recognising the imperative need to address the growing health threats posed by climate change, India's National Programme on Climate Change and Human Health (NPCCHH) has been established to reduce climate-related morbidity and mortality. The programme employs a multi-pronged approach, encompassing awareness campaigns,

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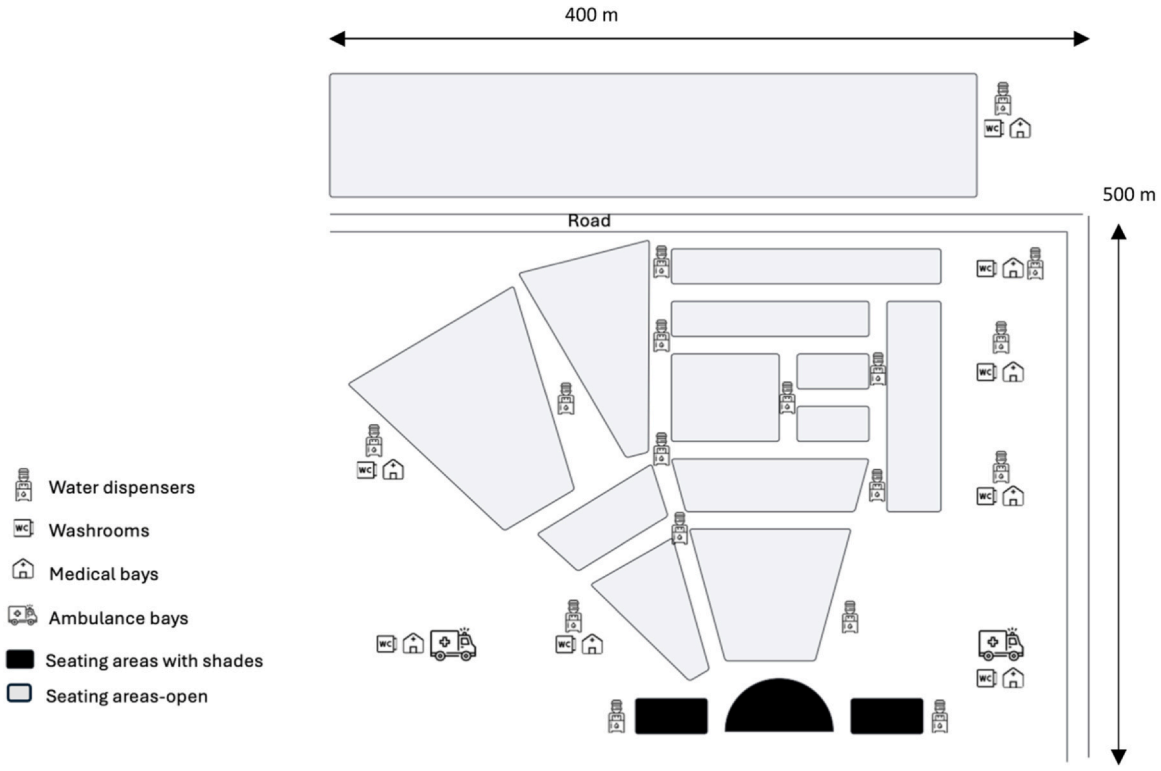

Fig. 1. Overall view of the event (bays and dispensers are not actual numbers).

capacity-building initiatives, strengthened surveillance and early warning systems for climate-sensitive diseases, development of resilient healthcare infrastructure, research promotion, and enhanced preparedness for climate-related health emergencies. The heat strokes and death cases are reported through the Integrated Health Information Platform under HRI surveillance of NPCCHH.

Organising mass gatherings during the summer poses heightened risks of severe heat-related illnesses (HRI) [8] and an added burden to the healthcare system [9]. Mass gatherings in India are a common occurrence. In Maharashtra, a mass gathering event where people are recognised for their contributions to the state is organised annually in this coastal district during April/May, peak summers. Approximately one million people attend this event. They travel from various parts of the state and belong to all age groups, predominantly adults. The event usually takes place in an open ground with makeshift water dispensers and washrooms. On 16th April 2023, the district reported 12 deaths in the same event, prompting an investigation into the circumstances surrounding these fatalities and describing these heat-related deaths.

Methods

We investigated all reported heat stroke death cases from the district on April 16, 2023. A confirmed heat stroke death was defined as death among the attendees of the mass gathering event, which was declared as a heat-stroke death by the district team. Data was collected through a record review by obtaining the line list of the death cases, their medical records, NPCCHH's death investigation forms, and autopsy records of the death cases.

We then conducted a focused group discussion with the first responders, treating physicians, forensic doctors, and district officials involved in planning health activities regarding the preparedness activities of the events, general environmental conditions of the district, the behaviour of the public at the mass gathering event, conditions of deceased patients when they reached the facility, and autopsy findings.

The discussion was recorded as notes with participant consent. Notes were reviewed and summarised to identify key points and emerging themes.

We analysed the findings using the IPCC disaster risk reduction model's matrix [10] that contains four components, namely, hazard, exposure, vulnerability, and risk reduction. We obtained meteorological data from the Indian Meteorological Department website.

This investigation was a part of the NPCCHH's mandate to understand climate change-related mortality to prevent future events. Hence, appropriate consensus from the state and district was obtained. The data was collected after obtaining informed consent from the individuals interviewed. The information obtained from the records was analysed as collective information. All individual details of the cases and deaths were kept confidential.

Results

We interviewed 14 individuals involved in preventing or responding to health incidents during the event.

We identified 12 confirmed heatstroke deaths at a mass gathering of one million attendees on 16th April from the district. Eleven of these patients were found dead at the event site. The median age of confirmed heat stroke deaths was 55 years (30–64 years). Among the affected individuals, 58 % were aged between 46 and 60 years, 67 % were female. Of the 11/12, were found dead within two hours of crowd dispersal.

Hazard: The ambient temperature in the district during the event was 41°C, with a daytime average of 36°C. There were no reported heat waves on the event day or up to three days prior, and there was no active heat wave warning. Relative humidity stood at 60 %. The heat index reached 67°C during the exposure period.

Exposure: The peak exposure occurred on open ground between 10 a.m. and 3 p.m., but the crowd started arriving at the event venue the night before the event date. The event was conducted on open ground (Fig. 1). The drinking water facility was approximately 50 m from the seating areas. The water dispensers were placed directly under the sun on the open ground.

Vulnerability: Of the 12 confirmed heat stroke deaths, 11 attended the event alone. The event volunteers reported that the restroom

Table 1
Assessment using IPCC disaster risk reduction model.

Component	Findings	Recommendations
Hazard	• High temperature • High humidity	Avoiding mass gathering events during summers
Exposure	• Day time prolonged exposure	Scheduling the event during early morning or late evenings Providing shades and cooling structures for the attendees
Vulnerability	• Alone • Empty stomach • Comorbidities	Provide guidance on proper hydration during the event Targeted IEC towards vulnerable population
Risk reduction	• No planning that was heat specific • No IEC regarding heat	Develop a guideline for mass gatherings in context of heat that includes strategies for cooling centres, dehydration prevention etc. Integrate heat-specific considerations into existing disaster risk reduction plans

facilities were located at least 200 m from the seating area; they also reported that the attendees were hesitant to use washroom facilities, nor did they get up to consume water or food in fear of losing their seats. Individuals travelling from other regions would have limited time for heat acclimatisation.

Risk reduction measures: Disaster management authorities undertook preparatory activities, including mock drills for stampede and mass casualty scenarios, one day before the event. However, these preparations were not tailored to include heat-related incidents. Health departments were involved in the later stages of planning. Oral rehydration sachets (ORS) were distributed to the event attendees. Air cooler facilities were available near the stage area. Medical booths provided cool air facilities. Volunteers encouraged individuals to cover their heads with hats, but there was no specific Information, Education, and Communication (IEC) campaign regarding heat. The findings of the assessment using the IPCC disaster risk reduction model are given in Table 1.

Autopsy findings

The estimated time of onset of illness as per autopsy was around 1–3 pm on the same day (Fig. 2). All the death cases had dry skin, prolonged outdoor exposure under direct sunlight, and attendance in crowded venues. Acute renal failure, hypovolemia, and dehydration were identified as the primary causes of death. Postmortem examinations revealed pale and shrunken lungs and kidneys and an empty stomach with no contents. One patient had a known cardiovascular disease and was undergoing treatment. All other systems examined did not have any abnormality.

Discussion

This was a mass casualty related to heat in the district, with 12 confirmed heat stroke deaths. More than half of the deceased were above 45 years old, and most travelled alone. An autopsy revealed acute renal failure as the cause of death for all cases. There were gaps in all four levels of the hazard matrix that had initiated a cascade of events, resulting in 12 deaths.

Excess metabolic energy, typically dissipated into the environment to maintain a stable body temperature (thermal homeostasis), becomes a liability under prolonged exposure to high ambient temperatures[11]. In such situations, the body's thermoregulatory mechanisms are overwhelmed, leading to a dangerous rise in core body temperature. While sweating is the body's primary defence against overheating, facilitating evaporative cooling, the postmortem observation of dry skin in these individuals suggested that this mechanism failed. Dehydration, evidenced by the absence of stomach contents and shrunken kidneys at autopsy, further compromised their ability to regulate temperature, exacerbating the severity of their hyperthermic state. This cascade of events, combined with their vulnerability due to age and solitary attendance at the event, tragically resulted in a lack of timely medical intervention, which led to their deaths.

The autopsy was limited to the examination of major organs, which did not provide sufficient evidence of heat stroke deaths. There were no specific guidelines available for performing an autopsy for a suspected

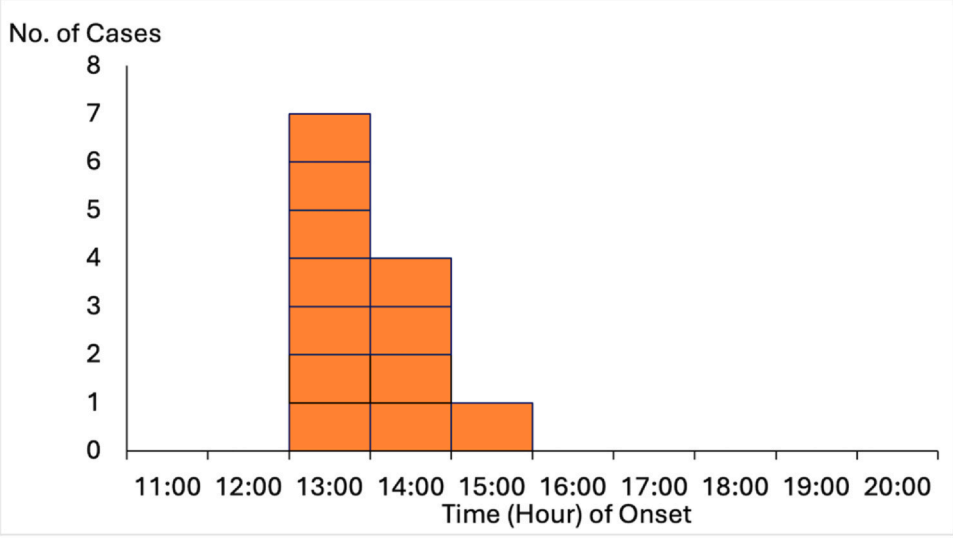

Fig. 2. Time of heat-stroke onset* in confirmed heat-stroke deaths, Maharashtra 2023.

heat stroke death. The availability of heat-specific guidelines might have given a more detailed explanation of the cascade of events preceding the death of these individuals.

Heat stroke is on the severe side of the heat-related illness spectrum, meaning that these individuals should have experienced milder forms of heat-related illness like heat exhaustion or heat stress before developing heat stroke on this day. The medical records available indicate that these individuals did not seek any medical intervention before their death. This shows an apparent lack of awareness among these individuals regarding heat-related illness. The absence of information education communication materials regarding heat-related illness in and around the event site also reiterates the importance of using extensive heat-related IEC during such events.

Organisers involved in such an event must adopt a comprehensive approach to mitigating heat-related illnesses during mass gatherings. This approach should consist of involving the healthcare community early on during the planning of such events. The efforts should also extend beyond heat wave season and summer months, recognising that humidity and crowd density can significantly amplify heat stress, regardless of the season. Elevated humidity, exacerbated by the gathering of large number of people, hinders the body's natural cooling mechanism through perspiration, increasing the risk of heat exhaustion and heat stroke. Therefore, planning and adaptation measures are necessary year-round, particularly concerning crowd size, environmental conditions, and individual risk factors. This may include avoiding such a large-scale event during summers, if conducted then implementing shade structures, hydration stations, cooling areas, and public awareness campaigns. This helps to promote heat safety and encourage early recognition of heat-related illness symptoms.

Lack of direct witness testimony could have led to a potential loss of information about the individual's behaviour before their death, limiting the knowledge about the exact progress of the heat-related illness. The unavailability of medical histories for pre-existing conditions or medications limits our ability to draw a broader conclusion about the vulnerability of the population.

Conclusion

This event underscores the need for integrated planning and preparedness to prevent heat-related deaths during mass gatherings. While creating awareness of heat-related illness is essential, it is equally important to actively involve the healthcare department during the planning of such events. Developing specific guidelines for mass gatherings that include risk assessment, preventive measures, and emergency response protocols is paramount. Furthermore, standardised autopsy guidelines for heat-related deaths would facilitate accurate data collection and analysis, giving a deeper understanding of the contributing factors and, ultimately, more effective prevention strategies.

Moving forward, a multi-pronged approach is necessary that includes pre-event planning considering the meteorological conditions, crowd size, vulnerable population and event timings, targeted campaigns on heat-related illness, and infrastructure to actively treat individuals. Implementing these strategies will make future mass gatherings safer, minimizing the risk of heat-related illnesses and preventing further tragedies.

CRediT authorship contribution statement

Nivethitha N: Writing – review & editing, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Patel Purvi:** Writing – review & editing, Visualization, Supervision, Methodology, Conceptualization. **Kamlapurkar Babita:** Writing – review & editing, Supervision, Data curation. **Kumar Mohan:** Writing – review & editing, Supervision, Data curation, Conceptualization. **Choudhary Sushma:** Writing – review & editing, Supervision, Methodology, Data curation. **Dikid Tanzin:** Writing – review & editing, Supervision, Resources, Data curation. **Shrivastava Aakash:** Writing – review & editing, Supervision, Resources, Conceptualization.

Data Availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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