Review Article

Understanding the Pattern of Fatalities during Extreme Heat Waves: A Comprehensive Analysis of Hot Summer-Related Deaths

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Abstract

There is widening data gaps in heatwave deaths in India amidst record-breaking temperatures. Heat related morbidities and mortalities are poorly defined and identified in a developing country that is bearing the onslaught of extreme heat waves that worsen every summer. Discrepancies are highlighted between data reported by various agencies regarding heat-related fatalities, raising concerns about the accuracy and consistency of information. The guidelines and policies that are in place to deal with this emergency are not adequate in comparison to the severity of the issue at hand.

Clinicians and medical officers who declare death and perform postmortem examination are not fully sensitized as to the importance of certifying an illness or death to be consequent to effects of heat waves.

Further, the lack of research into the corelation between crime and temperature in an Indian context tend to severely handicap the implementation of administrative and governing policies due to lack of knowledge. Such policies can abate the crime sprees that tend to increase during heat waves.

This article comprehensively aims to describe and elucidate the pattern of mortalities and morbidities that occur during extreme heat waves and hopes to inspire further research into the same to better understand and combat the effects of such avoidable fatalities.

Keywords: Heat- related deaths, Heat wave effects, Patterns of heat wave effects.

Introduction

India is facing one of the hottest summers this year in comparison to the last few years According to the Indian Meteorological Department, in the plains, a heat wave is characterised by maximum temperatures reaching up to 40°C or more, while in coastal areas, it is when maximum temperatures reach 37°C or higher. In hilly regions, the threshold is set at 30°C or higher.

Deaths during these harsh conditions are worrisome as they are usually under reported or

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misdiagnosed. In 2022, total of 8,060 deaths in the country were reported due to causes attributable to forces of nature by the National Crime Records Bureau, India. 9.1% deaths were due to 'Heat/ Sun Stroke. They account for 730 deaths.[1] India registered 2,227 deaths due to the impact of extreme weather events in 2022 which was the fifth warmest year on record in the country since 1901 according to the 'Climate of India During 2022' report released by the Indian Meteorological Department. Thirty of those deaths were attributed to deaths due to heat wave.[2]A Swedish study conducted on the all-cause mortality and heat waves in 10 cities of India during 2018 -2019observed stronger associations between heatwaves and mortality with higher heatwave intensity. Further estimation was made by the researchers that around 1116 deaths annually (95 %CI, 861; 1361) were attributed to heatwaves.[3]

The discrepancies in reporting by these two Government agencies are shocking to say the least. How are the Government authorities determining these deaths? The deaths in India are registered in India under the rules of the Registration of Birth and death Act1969 which states that every birth and death must be reported. If a death has occurred at a medical institution, then the medical practitioner attending to the illness must issue a certificate or if the death has occurred anywhere else apart from a medical institution, then the medical practitioner who recently dealt with the illness must issue a medical certification of cause of death as per section 10.2 and 10.3 of the Act. These deaths as certified are statistical data that serve as information to the stakeholders concerned as to the public health issues prevalent at that period and place.

Ironically, many medical professionals do not attest to cause of death as a heat related death despite history furnished.

Discussion

Heat stroke is associated with high ambient temperatures and high humidity. Thermoregulatory mechanisms fail, sweating ceases and core body temperature rises. Rhythm abnormalities in the heart, disseminated intravascular coagulation, necrosis of the skeletal muscles and heart muscles may occur. [4] Hyperthermia or dysregulated temperature balance of the body is more often seen in the summer months in particularly hot environments, and is more common in those with less medical reserve such as the young, elderly, and those with severe medical conditions such as significant heart disease. In fact, a considerable number of heat-related deaths occurring during a heat wave will not be solely from hyperthermia but will result from heat stress fatally exacerbating underlying significant medical disease.[4]

Heatstroke is defined by a body temperature above 40.6 degrees Celsius, associated with mental abnormalities like delirium, convulsions, or coma, caused by overexposure to environmental heat, excessive ethanol intake[6-8], and is characterized pathophysiologically by a systemic inflammatory response determined by the heat, with subsequent multi organ failure. A less severe form of heatstroke is heat exhaustion, characterized by cardiovascular manifestations[9]. Heat-derived lung damage, such as pulmonary oedema, and acute respiratory distress syndrome, combined with the high rates of people with pre-existing respiratory conditions, and increased pulmonary stress due to heat-related hyperventilation and elevated air pollution during heatwaves, is accountable for the second highest source of mortality and morbidity during heatwaves, following cardiovascular disease. Exposure to extreme heat is also associated with acute kidney injury, adverse pregnancy outcomes, mental health impacts, and increase in non-accidental and injury-related deaths.[10]

Physio-pathologically heatstroke has four main types of effects: acute physiological changes, cytotoxic effects, generalized inflammatory response, and oxidative damage. In an elevated temperature environment circulatory flow is redirected towards the skeletal muscle and skin, to dissipate heat; if concomitant conditions affecting the cardiocirculatory system or insufficient hydration are present, acute cardiogenic shock may occur leading to complications in brain functions from structural damage resulting in stroke, arterial hypotension, multi organ ischemia. Etc, with subsequent increased levels of neurotransmitters in the body. [11-19].

Main cause of death in heatstroke is multi-organ dysfunction, with cerebropathy, acute respiratory

distress syndrome (ARDS), dissolution of skeletal muscle, acute renal failure, cardiac insufficiency, hepatic injury, or hematopenia, (especially thrombocytopenia- decrease in blood cells such as platelets) pancreatic damage, or haemorrhagic diseases [20]

In summary, the signs and symptoms associated with heat related morbidity such as fever, sweating, nausea, dizziness, cramps, excessive thirst, headache, general weakness, lack of energy, mental confusion, purposeless movements, restlessness, staggering gait, hypotension, arrythmia etc. tend to mimic other morbidity states such as cardiovascular diseases, cerebrovascular accidents or acute kidney injury which are, as already mentioned above, complications because of the heat stroke or hyperthermia. The medical professionals attending to those exhibiting these signs and symptoms rarely consider the diagnosis of hyperthermia or heat disorders owing to the lack of awareness or enough diagnostic evidence to come to the conclusion.

The role of extreme heat in causing a death is difficult to determine. While laboratory tests can detect organ damage resulting from heat stroke, and a combination of tests can assess the impact of hyperthermia (high body temperature) on the central nervous system, no single test can definitively identify extreme heat as the cause of death.

The suspected cases of heat related deaths which do undergo postmortem examination are again wrought by uncertainty in terms of diagnosis due to the non-specificity of the findings. The determination of pre-terminal or terminal body temperatures are challenging and at most times unavailable. The diagnosis of hyperthermia typically relies on investigating the scene, understanding the circumstances of death, and reasonably excluding alternative causes of death.

A document issued from the Ministry of Health and Family welfare in collaboration with the National centre for Disease control in 2021 lays down guidelines for identifying and categorizing heat-related deaths. The postmortem findings in heat related deaths based on this document mentionspetechiae or larger haemorrhages in the skin with slippage or petechial haemorrhages over the surface of the lungs, heart, and serosal surfaces. Right-sided cardiac dilatation, subendocardial haemorrhage of the left ventricle, visceral congestion (particularly in the lungs and the brain), and petechial haemorrhages in the thymus, the perifollicular area of the spleen, and lymph nodes are also noted.

The above findings are seen in victims who have survived heat stroke for less than 12 hours. Longer duration of survival i.e.,>12-24 hours exhibitpulmonary oedema of lung with diffuse alveolar damage (ARDS) with other signs of clotting abnormalities in the pulmonary blood vesels. The other finding of importanceis pale and oedematous skeletal muscles. Ancillary investigations such as histopathological examination are necessary in view of the nondescript gross appearance on postmortem.[21]

The specimens that are ideal for collection are skeletal muscles, bowel loops, kidneys, heart, brain and in certain cases liver, pancreas, and spleen. Some of the pathognomicmicroscopic findings are focal necrosis, variation in muscle fiber diameter of skeletal muscles, oedema with or without petechial haemorrhages in the gut, more prominent on the mucosal than on the serosa layer, and on the iliac and colic regions than on the stomach. Rhabdomyolysis resulting in acute tubular injury in the kidneys, focal necrosis of heart muscles and fibrin clot in vessels if there is onset of Disseminated intravascular coagulation (clotting abnormality) in the heart are also visualised. Brain oedema with progressive degeneration of nerve cells are seen in the brain. Significant findings in other organs are congestion and centrilobular necrosis in liver, acute pancreatitis, and microhaemorrhages in adrenal medulla.[21]

Lab diagnosis is also a crucial tool of exclusion to rule out heat related deaths. Increased vitreous sodium and chloride, increased postmortem serum and pericardial fluid creatinine, increased urine myoglobin are seen as a consequence of dehydration and skeletal muscle damage.[21]

It is unfortunate though that not many forensic pathologists or medical professionals in India are open to diagnosing death due to heat stroke or complications of heat disorders as a cause of death. International Classification of Diseases for Mortality

and Morbidity Statistics, 11th Revision, has even codified diseases and deaths that are heat related. Heat stroke (NF01.0), Heat syncope (NF01.1), Heat exhaustion due to fluid depletion (NF01.2), Heat fatigue, transient (NF01.3), Other specified effects of heat (NF01.Y), Effects of heat, unspecified (NF01.Z) are the descriptions and codes given officially to the effects of heat that can be utilised to certify heat-related deaths.[22]The lack of sensitization and misjudgement of the certifying doctors is hiding the true number of Indians dying due to extreme heat. It is extremely challenging for climate scientists, to investigate the connection between heat waves and heat stroke/mortality without access to the data that can emerge from proper reporting of deaths caused due to effects of heat.

Another aspect of fatalities during extreme temperatures is in terms of crime related deaths. During extreme heat, it is no surprise that one tends to feel more irritable and aggressive than in cold weather. The "heat hypothesis" states that hot temperatures increase aggressive motivation and (under some conditions) aggressive behaviour. [23] The expression of violent behaviour is shaped by both individual and societal characteristics, yet the impact of environmental factors remains less comprehended. A 14year old study conducted by the Division of Environmental Health Sciences, University of Minnesota School of Public Health, Minneapolis, USA on the association between temperature and violent behaviour across 436 U.S. countiesestimated that a 10 °C increase in daily temperature or daily departure from long-term normal temperatures were associated with 11.92% (95% PI: 11.57, 12.27) and 10.37% (95% PI: 10.05, 10.69) increase in the risk of violent crime, respectively.[24]

Jinming Hu et al, in a similar study on the corelation between crime and temperature exhaustively applied the box-plot method and linear regression to explore the correlation between temperature residuals and crime residuals. The results showed that more than half of the crime types have similar seasonal cycles (approximately 1 year) to that of temperature. Moreover, the daily residual analyses show that temperature residuals have a positive correlation with assault and robbery residuals in all cities, whose average slopes are more than 0.1.[25]It is overreaching to apply these study results on a global scale as they are limited to developed countries like the United States that are well equipped to deal with the severities of the temperature. Countries like India that are still developing, though acclimated to the tropical temperatures are incompetent to weather the vagaries of global warming and greenhouse effect. In the context of global warming, the world is likely to see an increase in crime in the years to come, if effective crime prevention measures and further developments in environmental governance are not implemented.

There is a dearth of Indian literature in terms of correlation between crime and temperature. However, this prompts for urgent future research in this area if the current trends and future predictions based on scientific models of the oncoming environmental temperature rises are to be believed.

Conclusion

The disastrous consequences of the human intervention into the natural order are very apparent in the famine of the natural resources we as a humanity are facing along with the human-caused natural disasters that are reported every other day. The rise in atmospheric temperatures resulting from global warming is one such manufactured disaster. The deaths ensuing as a result of this phenomenon is however, sadly ignored, under reported and poorly dealt with by the authorities especially in a developing country like India. The portentous effects of such ignorance can only mean poorly implemented environmental governance policies causing more damage and loss of life. "Take urgent action to combat climate change and its impacts" is the Sustainable Development Goal 13 set by the Department of Economic and Social Affairs of United Nations to combat climate change. India is a signatory to the Paris Agreement, which aims to limit global warming to well below 2 degrees Celsius above pre-industrial levels, with efforts to limit it to 1.5 degrees Celsius. India ratified the agreement on October 2, 2016.As a signatory, India is obligated to take steps to reduce its greenhouse gas emissions and implement measures to adapt to the impacts of climate change. How can change be implemented if the effects of climate related extreme weather events such as heat related deaths are not adequately identified or reported?

Efforts to address heat-related deaths in India include early warning systems, public health campaigns, provision of cooling centers, and urban planning strategies aimed at reducing heat exposure in cities. However, there is a continued need for coordinated action at the local, national, and international levels to mitigate the impacts of extreme heat on public health in India. Indian Meteorological Department collaborates with governmental agencies, disaster management authorities, healthcare institutions, and other relevant stakeholders to develop strategies for heatwave preparedness, response, and management. Mandatory reporting of suspected heat wave deaths by the primary and tertiary health centres to the concerned public health authorities must by ensured.

Enhanced community engagement and the integration of long-term climate projections into Heat Action Plans (HAPs) are vital components of a comprehensive and adaptive approach to combat and alleviate the impacts of extreme heat. By fostering collaboration with stakeholders for decision making and embracing future climate insights, HAPs can enhance their responsiveness, effectiveness, and sustainability in safeguarding communities against the threats of heat waves in a changing climate landscape.

Adequate budget allocation is undoubtedly crucial for implementing measures such as establishing cooling centers, providing access to clean drinking water, improving urban planning to relieve urban heat island effects, and enhancing healthcare infrastructure to deal with heat-related illnesses. Policymakers must incorporate burdens associated with heat waves into their planning and decision-making processes to ensure effective prioritization of public health interventions addressing present and future health risks linked to heatwaves in India,.

The effectiveness of budgeting also depends on how efficiently the allocated funds are utilized and whether they are directed towards comprehensive heatwave management strategies. Transparency, accountability, and stakeholder collaboration are essential to ensure that budget allocations translate into tangible actions that effectively mitigate the impacts of heatwaves. Legal framework establishment to formulate clear legal guidelines foisting accountability and holding the stakeholders and authorities answerable for their roles in HAP execution is the need of the hour.

Furthermore, research by the Environmental protection agencies and the concerned authorities regarding all aspects of morbidity and mortalities due to extreme heat waves not excluding crime related deaths is the need for the hour. Researchers need to take stock of the vacuum of literature and studies related to this topic in the Indian context and strive to elicit the data that encourages further research and academic enquiry thus compelling the policy makers to enact enhanced lifesaving and environment-improving measures.

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