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FAMILY WELFARE

सत्यमेव जयते



# AUTOPSY FINDINGS IN HEAT RELATED DEATHS



National Programme  
on Climate Change  
and Human Health



National Centre for  
Disease Control  
Government of India



## **Acknowledgement**

This guideline for Autopsy Findings in Heat Related Deaths is prepared under National Programme on Climate Change and Human Health (NPCCHH), National Centre for Disease Control (NCDC), MoHFW. It addresses the demand for guidance in identifying and categorizing heat-related deaths and supplements earlier publications, i.e., National Action Plan on Heat Related Illnesses (2021), which outlines National Heat-Related Illness and Death Surveillance. Concentrating on autopsy findings, these guidelines attempt to standardize the approach to confirming heatstroke and heat-related deaths through evidence-based medical decision-making processes.

This guideline was conceptualized under the vision and leadership of Prof (Dr) Atul Goel, DGHS and Director, NCDC. We express gratitude to the expert committee members from pathology departments of various renowned institutes who contributed to its development.

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## 1. Introduction

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Climate change is increasing risks to human health by increasing exposure and vulnerability to extreme heat events like heatwaves, humid heat, heat domes. In 2013–22, compared with 1991–2000, the estimated average annual heat-related mortality increased by 85%, driven by both warming and changing demographics, globally. If global mean temperature continues to increase toward 2°C of pre-industrial levels, annual heat-related deaths are projected to increase by 370% by mid-century, assuming no substantial progress on adaptation.<sup>1</sup>

Although the magnitude and pattern of future heat-related morbidity and mortality will depend on climate change and civilizational dynamics like population growth and aging, urbanization, effective adaptation, and development choices, its current impacts are a warrant urgent health-centric climate adaptation and mitigation. Strengthening our understanding and surveillance of heat-health is crucial in view of this emerging condition which remained largely limited to occupational settings earlier.

Rapid, severe decompression of body's heat dissipation mechanisms following short-term or sustained heat exposure leads to heat stroke. Physiological responses to heat gain, through ambient heat exposure or exertion, also require the heart to pump harder and faster. For people with pre-existing heart conditions, this can lead to a mismatch between a high oxygen demand of the cardiac muscles and reduced oxygen supply. If sustained, it can lead to cardiovascular collapse. Therefore, cardiovascular events are a primary pathway leading to high mortality among older adults. High existing burden of cardiovascular diseases in the population and elevated cardiovascular strain from heat stress, translates to cardiovascular mortality being the leading cause of death during extreme heat.<sup>2</sup> According to study in Western USA, each 4.7°C (10°F) increase in mean daily apparent temperature in summer led to a ~2.6% increase in cardiovascular mortality.<sup>3</sup> Heat-derived lung damage, 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.<sup>2</sup> 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.

Recognition and confirmation of heat-related mortality has emerged as a challenge as different sectors use different case definitions, assessment mechanisms and linked response measures often lead to various estimates. This highlights the importance of understanding characteristics of exposure, physiological factors affecting heat strain,

illnesses, and death and adaptation measures (behavioural, institutional) utilized. Heat-related deaths, an overarching term for deaths where ambient heat has directly or indirectly contributed to the deaths, may be categorized in two types. First, where environmental heat was directly involved in the sequence of conditions causing deaths e.g. heat stroke. Second type of deaths are those in which environmental heat contributed to the deaths but was not in the sequence of conditions causing these deaths. These kinds of deaths are mainly due to exacerbation of pre-existing health conditions.

#### Salient public health aspects of heat-related mortality

1. Heat-related deaths may occur even when there are no active heat wave warnings.
2. Heat stroke deaths represent a small fraction of all heat-related deaths.
3. Extreme ambient temperature is not the only factor that can affect trends in heat-related deaths. Factors like humidity, wind speed, vulnerability of the population in terms of pre-existing medical conditions, their acclimatization status, access to hydration and cooling, timely early warning communication and the steps people have taken to prevent and manage heat emergencies effectively also play key roles in preventing mortality. Institutional adaptation measures like early warning, risk communication measures, surveillance systems, provision of shades/cooling areas, health care preparedness and build environments are important.<sup>7</sup>

National Heat-Related Illness (HRI) and Death Surveillance, under National Programme on Climate Change and Human Health, NCDC, MoHFW tracks health impacts of extreme heat.<sup>8</sup> The digital surveillance collects daily data of heat stroke cases and deaths, emergency attendance, and all-cause deaths from health facilities PHC and above. The integrated surveillance tracks suspected heat stroke cases with daily temperature and relative humidity for near-real time understanding of health impacts of heat and immediate actions. Reporting of confirmation of suspected heat stroke deaths (through clinical assessment or autopsy or detailed Suspected HRI Death investigation (refer National Action Plan on Heat Related Illnesses)<sup>9</sup> allows the opportunity to correlate clinical and autopsy findings with circumstances of death and understand behavioural, institutional and environmental risk factors.

These guidelines on Autopsy Findings in Heat Related Deaths are envisioned to provide medical understanding in recognition of heat-related deaths based on autopsy findings.

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## 2. Autopsy Findings in Heat-Related Deaths

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### Introduction

- The postmortem diagnosis of heat related deaths poses many challenges. Preterminal or terminal body temperatures are frequently unavailable. The autopsy findings are nonspecific and depend upon the duration of survival after exposure.
- The diagnosis of hyperthermia is mostly dependent on the scene investigation, the circumstances of death, and the reasonable exclusion of alternative causes of death.
- Autopsy is not mandatory in heat related deaths.

### 1. When victims of heat stroke survive <12 hr

- a) The only abnormalities noted may be petechiae or larger hemorrhages in the skin with slippage or petechial hemorrhages over the surface of the lungs, heart, and serosal surfaces.
- b) Right-sided cardiac dilatation, subendocardial hemorrhage of the left ventricle, visceral congestion (particularly in the lungs and the brain), and petechial hemorrhages in the thymus, the perifollicular area of the spleen, and lymph nodes have also been described in people who died shortly after the onset of heat stress.

### 2. Longer duration of survival (>12-24 hours)

- a) **Tissue necrosis** occurs due to ischaemia as massive amount of blood is shunted to skin to cause cooling.
- b) The **most affected organs** are lungs, skeletal muscle, gut, kidneys, and brain.
  - **Lungs**- Pulmonary oedema, Diffuse alveolar damage (ARDS), alveolar hemorrhages and clots containing myoglobin in small lung vessels. Pulmonary fat embolization has also been described.
  - **Skeletal muscle**- Gross: pale and edematous skeletal muscles. Microscopy: Hypercontraction bands, fiber degeneration, focal necrosis, variation in muscle fiber diameter.
  - **Gut**- Gut edema with or without petechial hemorrhages, more prominent on the mucosal than on the serosa layer, and on the iliac and colic regions than on the stomach. Subsequent anoxic villi injuries, leading to massive hemorrhages progressing to hemoperitoneum.
  - **Kidneys**-Rhabdomyolysis resulting in acute tubular injury characterised by loss of brush borders, attenuation and sloughing of epithelium, Granular or pigmented casts in tubules.
  - **Brain**- Cerebral edema, Neuronal necrosis, and hyperemia, meningeal edema, progressive degeneration of neurons and replacement with glia.

These changes are prominent in the cerebellum, cerebral cortex and basal ganglia.

**c) Findings in other organs**

- **Liver**-Congestion and centrilobular necrosis in liver, midzonal vacuolar changes.
- **Spleen** –Red pulp congestion, Splenic Haemorrhage
- **Pancreas**: Tissue damage-Acute pancreatitis
- **Heart**-Focal necrosis of myocardium
- **Fibrin thrombi** in vessels if there is onset of DIC
- Fat Embolism
- **Adrenal Medulla** : Microhaemorrhages in adrenal medulla
- **Bone marrow**: Hyperemia, edema, hemorrhages

**d) Microscopic Changes**

- Centrilobular necrosis and midzonal vacuolar changes in the liver
- Neuronal degeneration of the brain
- Acute pancreatitis.
- Rhabdomyolysis may result in acute tubular necrosis of the kidneys.
- Fibrin thrombi in small vessels in cases of disseminated intravascular coagulation.
- Pulmonary fat embolism has also been described.

**e) Biochemical Findings**

These are due to dehydration and skeletal muscle damage, which are distinctive features of heat stroke.

- Increased vitreous sodium and chloride,
- Increased postmortem serum and pericardial fluid creatinine
- Increased urine myoglobin

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### 3. Criteria to Label Heat Stroke or Heat-Related Death

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#### Definition

"Heat-related death" is defined as a death in which exposure to high ambient temperature either caused the death or significantly contributed to it.

a) The diagnosis of heat-related death be based on a history of exposure to high ambient temperature and the reasonable exclusion of other causes of hyperthermia.

b) The diagnosis may be established from the circumstances surrounding the death, investigative reports concerning environmental temperature, and/or measured antemortem body temperature at the time of collapse. Suspected HRI Death investigation form may be used. (refer National Action Plan on Heat Related Illnesses)

#### 1. In case clinical diagnosis is available <sup>1</sup>

a) In cases where the measured antemortem body temperature at the time of collapse was  $\geq 105^{\circ}\text{F}$  ( $\geq 40.6^{\circ}\text{C}$ ), the cause of death should be certified as heat stroke or hyperthermia.

b) Deaths may also be certified as heat stroke or hyperthermia with lower body temperatures when cooling has been attempted prior to arrival at the hospital and/or when there is a clinical history of mental status changes and elevated liver and muscle enzymes.

c) In cases where the antemortem body temperature cannot be established but the environmental temperature at the time of collapse was high, an appropriate heat-related diagnosis should be listed as the cause of death or as a significant contributing condition.

#### 2. In case clinical diagnosis is not available

a) If the investigation provides compelling evidence of continuous exposure to a hot environment and fails to identify an independent cause of death.

b) A significant number of these deaths will occur in persons having some preexisting disease known to be exacerbated by heat stress. These deaths can be certified as heat-related, with the disease being considered a significant contributing condition, or vice versa.

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<sup>1</sup>Donoghue, Edmund et al National Association of Medical Examiners Ad Hoc Committee on the Definition of Heat-Related Fatalities. Criteria for the Diagnosis of Heat-Related Deaths: National Association of Medical Examiners: Position Paper. The American Journal of Forensic Medicine and Pathology 18(1):p 11-14, March 1997.

3. The diagnosis of heat-related death is based principally on investigative information; autopsy findings are nonspecific. The decision to autopsy should be based on the circumstances of the death, the age of the deceased, and the available resources.

4. The collection of blood, urine, and vitreous humor for toxicologic examination is highly desirable if the condition of the body allows it. When these specimens are collected and preserved, toxicologic analyses can be performed as resources become available.

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## 4. Recommendations

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1. Autopsy findings are **nonspecific**, and **autopsy is not mandatory** in all cases of heat related illnesses.
2. Hospitals with the forensic medicine departments may be collaborated to perform the autopsies and send the relevant samples to pathology departments for histopathological evaluation.
3. All pathologists/ forensic pathologists to be aware of the criteria to label a death as Heat-related/ Heat stroke. Necessary Training/ sensitization are required for pathologist/forensic pathologist.

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