International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Epidemiology and Occupational Health Impact of Heatstroke Among Outdoor Workers: A Narrative Review

Lekha sree. B[1], Kalpana. S[2], Srirajalingham A. S[3], Srinivas. G[4]

[1]PG Student, Department of Epidemiology, The Tamil Nadu Dr. M.G.R. Medical University, Chennai, India
[2]Research Officer, Department of Epidemiology, The Tamil Nadu Dr. M.G.R. Medical University, Chennai, India
[3]PG Student, Department of Epidemiology, The Tamil Nadu Dr. M.G.R. Medical University, Chennai, India
[4]Prof & Head, Department of Epidemiology, The Tamil Nadu Dr. M.G.R. Medical University, Chennai, India

ABSTRACT

Background: Heatstroke is a life-threatening condition characterized by elevated core body temperature and central nervous system dysfunction. Outdoor workers such as those in agriculture and construction are particularly vulnerable due to prolonged heat exposure, intense physical labour, and limited access to cooling measures.

Objective: To review evidence published between 2015 and 2025 on the causes, mechanisms, clinical features, risk factors, complications, and occupational health impacts of heatstroke among outdoor workers.

Methods: A narrative review was conducted by searching PubMed and Google Scholar for literature published between 2015 and 2025. The search strategy combined keywords and Boolean operators including “heatstroke,” “heat stress,” “heat-related illness,” “occupational,” “workers,” and “workplace”. Eligible studies were original research on occupational heat exposure and heat-related illnesses among workers, published in English. A total of 42 articles were selected based on predefined inclusion and exclusion criteria.

Results: Evidence indicates that heatstroke is classified into classic and exertional types. Pathophysiologically, it arises from failure of thermoregulation, systemic inflammation, and multi-organ dysfunction. Clinical features include confusion, seizures, tachycardia, hypotension, and skin changes. Outdoor workers experience increased rates of heat-related illnesses, acute kidney injury, and reduced productivity, with chronic exposure contributing to long-term organ damage. Knowledge gaps persist in early recognition, worker education, and preventive strategies.

Conclusion: Outdoor workers remain disproportionately affected by heatstroke and related complications. Improved awareness, workplace adaptations, and preventive measures are essential for protecting worker health in the context of rising global temperatures.

Keywords: Heatstroke, Occupational Health, Outdoor Workers, workplace heat exposure, Heat-related illness, Exertional heatstroke.

INTRODUCTION

Heatstroke is defined by a markedly elevated core body temperature commonly, but not always, above 40°C together with central nervous system dysfunction such as ataxia, confusion, delirium, or seizures, occurring after exposure to extreme environmental heat or strenuous physical activity. Risk factors include environmental conditions, certain medications, substance use, and pre-existing medical comorbidities**.**[1]
Climate change is driving an increase in global temperatures along with more frequent and severe extreme heat events. While rising heat levels pose a challenge for the general population, they create a particularly serious risk for workers whose occupations require prolonged exposure to hazardous conditions. Occupational illnesses and injuries related to climate change are becoming increasingly evident and may be intensified by socioeconomic disadvantages or unstable working conditions. Higher temperatures are expected to affect more workers across different industries, leading to both direct and indirect health consequences, such as heat-related illnesses, higher injury risks, mental health impacts, and loss of productivity.

The burden of extreme heat will not be shared equally among workers. Certain industries and occupations face greater risks depending on the nature of the tasks and work environments. Jobs that require outdoor labour or involve high physical exertion are especially vulnerable. In addition, personal and social circumstances, such as low income or limited access to protective measures, increase susceptibility to heat-related illnesses. Workers in low- and middle-income countries may be disproportionately affected due to heavier reliance on manual labour, fewer resources for cooling, and higher concentrations of vulnerable populations compared with high-income regions.[2] A recent joint statement by the World Health Organization (WHO) and World Meteorological Organization (WMO) underscores this urgency: over 2.4 billion workers, or roughly 70% of the global workforce, are exposed to harmful heat conditions, resulting in nearly 23 million work-related injuries and almost 19,000 deaths annually. Productivity also declines significantly, with a 2–3% decrease for every degree Celsius increase above 20 °C[3] Extreme heat exposure can disrupt normal biological processes. The human body typically maintains a stable core temperature around 37°C through thermoregulatory mechanisms such as sweating and increased blood flow to the skin. However, when heat stress exceeds the body's ability to cool itself, heat-related illnesses develop. These may begin with milder conditions, such as heat rash or cramps, and progress to more severe outcomes like heat exhaustion and heat stroke. Heat stroke, marked by a dangerously high core temperature and neurological dysfunction, can cause multiple organ failure and death without urgent treatment.

Beyond acute illnesses, prolonged or repeated heat exposure can worsen existing medical conditions or damage organs directly. Cardiovascular, respiratory, and psychiatric conditions may flare up under extreme heat. Kidney function is also at risk; repeated heat stress and dehydration are linked to acute kidney injury and are thought to play a role in the development of chronic kidney disease in some of the world's hottest regions.[2]

Climate change is causing an exponential increase in the number of people exposed to excessive heat in every part of the planet. Approximately 85% more persons over 65 died from heat-related causes between 2000–2004 and 2017–2021. According to studies conducted between 2000 and 2019, there are over 489 000 heat-related deaths annually, with 36% occurring in Europe and 45% in Asia. An estimated 61,672 excess deaths in Europe during the summer of 2022 were attributed to excessive heat. Significant mortality can result from extreme heatwaves, as demonstrated by the 2003 incident, which claimed about 70,000 lives between June and August. A 44-day heatwave in the Russian Federation in 2010 resulted in 56,000 extra deaths. Heat vulnerability is influenced by exposure factors like work and socioeconomic level as well as physiological factors like age and health.[4]. In India, up to 75% of the workforce depend on heat-exposed labour. A worker in the northern Indian state of Rajasthan lost his life in May from the heatwave while carrying stones in a tractor trolley. A few days before him, another worker at a refinery that was still under construction died; before, a 25-year-old labourer in Chennai, southern India, died of heat stroke.[5]

The increasing frequency and severity of heatwaves under climate change are changing the landscape of occupational risk. Inadequate recognition of heat-related hazards in workplace safety frameworks compounds the threat. Therefore, a comprehensive assessment of epidemiology, risk factors, clinical consequences, and preventive strategies is both timely and necessary.

This narrative review aims to synthesize the evidence on heatstroke as an occupational hazard, summarizing its prevalence among vulnerable workers, underlying pathophysiology, clinical impact, and the preventive measures and policy interventions.

METHODOLOGY

SEARCH STRATEGY AND DATABASES

Databases PubMed and Google Scholar were searched for studies published from 2015 to 2025 (10-year window). The electronic search used combinations of the following keywords and Boolean operators: “heatstroke” OR “heat stroke” OR “heat-related illness” OR “heat stress” OR “heat stress disorders “AND “occupational” OR “workers” OR “workplace” OR “work-related” OR “Occupational Exposure” OR “Occupational Diseases” search was “construction workers,” “workplace heat exposure,” “occupational heatstroke,” and “heat prevention.” conducted using the following keywords and Boolean operators.

STUDY CRITERIA

Inclusion criteria.

1. Original research (randomized, quasi-experimental, cohort, case–control, cross-sectional, time-series, case-crossover, or surveillance analyses) assessing occupational heat exposure and HRI (heat cramps, exhaustion, injury, or heatstroke), heat-exacerbated morbidity (e.g., renal/cardiovascular outcomes), injuries, productivity, or mortality;
2. Study population comprised workers (outdoor or indoor; e.g., agriculture, construction).
3. Human studies, English language.

Exclusion criteria.

1. Reviews, editorials, commentaries, or protocols.
2. Animal studies or laboratory human experiments without occupational framing.
3. Case reports or single-case series without workplace relevance.

Literature search and screening

A total of 90 articles were identified from PubMed.8,690 articles were identified from Google Scholar using the keywords and Boolean operators. After removing duplicates based on author names, publication years, journal names, and article titles, records were screened for eligibility. Following abstract and full-text screening, only 42 articles met the inclusion criteria and were included in this review.

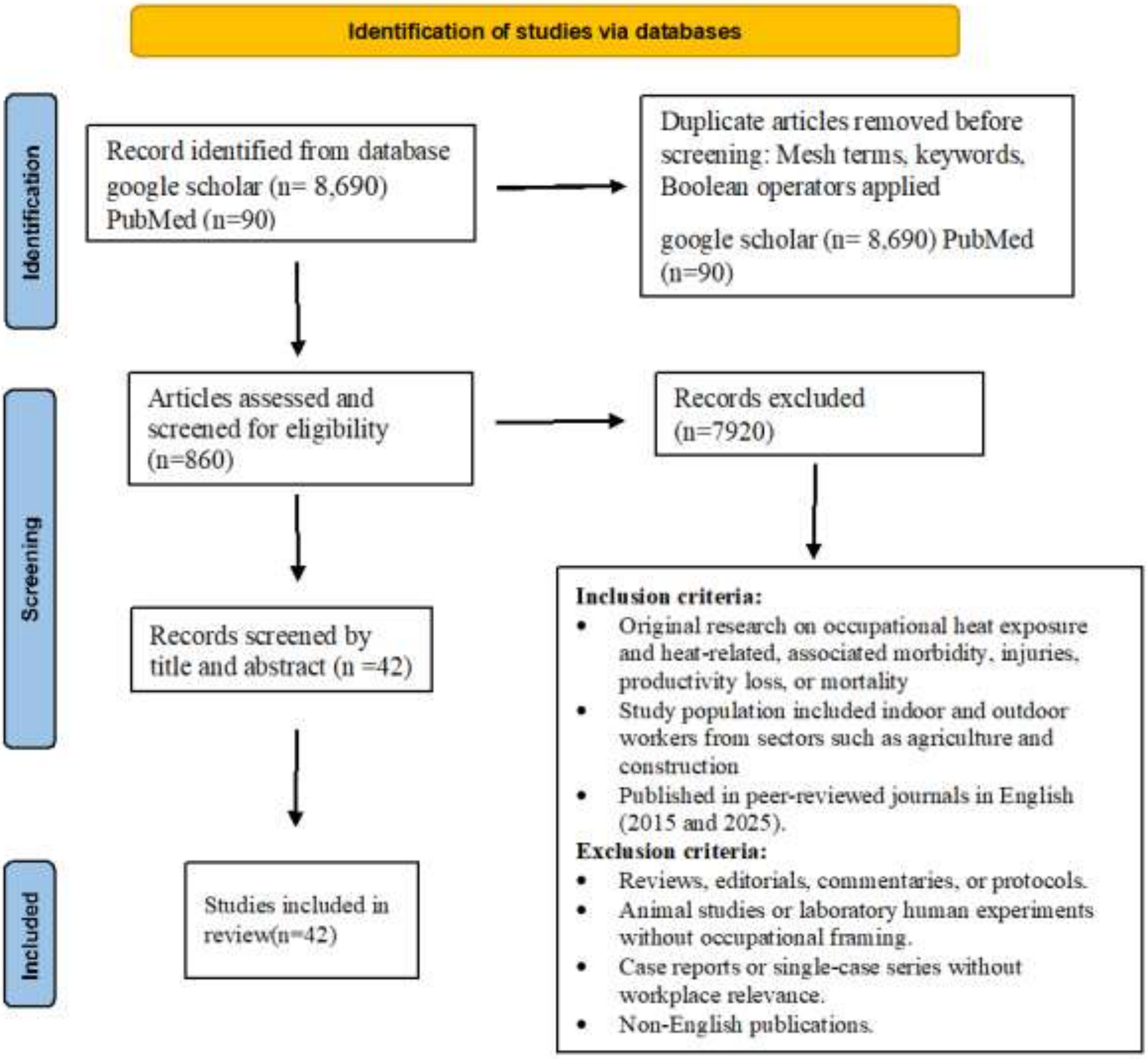


Figure 1. PRISMA-style flow diagram of study selection

ETIOLOGY

It is crucial to determine where a patient lies on the spectrum of heat-related illnesses. The early presentation of heat exhaustion, characterized by symptoms such as muscle cramps, fatigue, dizziness, nausea, vomiting, and headache, may resemble other stages of heat illness. When these symptoms advance and lead to end-organ dysfunction, the condition progresses to heat injury. The defining feature that separates heat stroke from heat injury is the presence of neurological impairment. Heat stroke is further classified into two forms: classic heat stroke, which predominantly affects elderly individuals with pre-existing chronic medical conditions, and exertional heat stroke, which occurs in otherwise healthy individuals who engage in strenuous physical activity under hot or humid conditions.[6]

Classic Heatstroke

Classic heatstroke frequently occurs as an epidemic among elderly persons whose ability to adjust physiologically to heat stress has become compromised, chronically ill persons, and those who cannot care for themselves. Rising global temperatures causing heat waves, as well as urbanization with its attendant inner-city heat islands, are the major extrinsic factors, Children's susceptibility to classic heatstroke.[7] It seen in people who are exposed to a hot environment, especially in young and elderly persons. Those with chronic diseases such as Parkinson disease, heart failure, or diabetes or who take medications can have a decreased response to dehydration.[8]

Exertional heat stroke

Is seen in healthy people who undergo strenuous activity in hot weather, such as marathon runners, military trainees, and outdoor workers.[8] Exertional heatstroke is a medical emergency, sporadic in nature, and directly related to strenuous physical activity. It can strike athletes, labourers (e.g., firefighters and agricultural workers), soldiers, and others engaging in activities that many of them previously performed uneventfully under similar conditions of exercise intensity and duration and environmental exposure.[7]

Figure 2. Features of Classic vs. Exertional Heatstroke:

Table 1. Epidemiologic and Clinical Features of Classic and Exertional Heatstroke.

Feature*	Classic Heatstroke	Exertional Heatstroke
Age group	Prepubertal, elderly	Postpubertal and active
Occurrence	Epidemic (heat waves)	Sporadic (any time of year)
Concurrent activity	Sedentary	Strenuous
Health status	Chronically ill	Generally healthy
Medications	Often being used (prescribed medications)	Usually none being used (sometimes ergogenic aids, illicit drugs)
Mechanism	Absorption of environmental heat and poor heat dissipation	Excessive heat production, which overwhelms heat-loss mechanisms
Sweating	May be absent (dry skin)	Usually present (wet skin)
CNS dysfunction	Common	Common
Acid–base disturbance	Respiratory alkalosis	Metabolic acidosis
Rhabdomyolysis	Unusual	Frequent
Liver dysfunction	Mild	Marked to severe
Renal failure	Uncommon (<5%)	Common (25–30%)
DIC	Mild	Marked to severe
ARDS	Common	Common
Creatine kinase	Mildly elevated	Markedly elevated
Calcium	Normal	Low (hypocalcemia)
Potassium	Normal	Usually high (hyperkalemia)

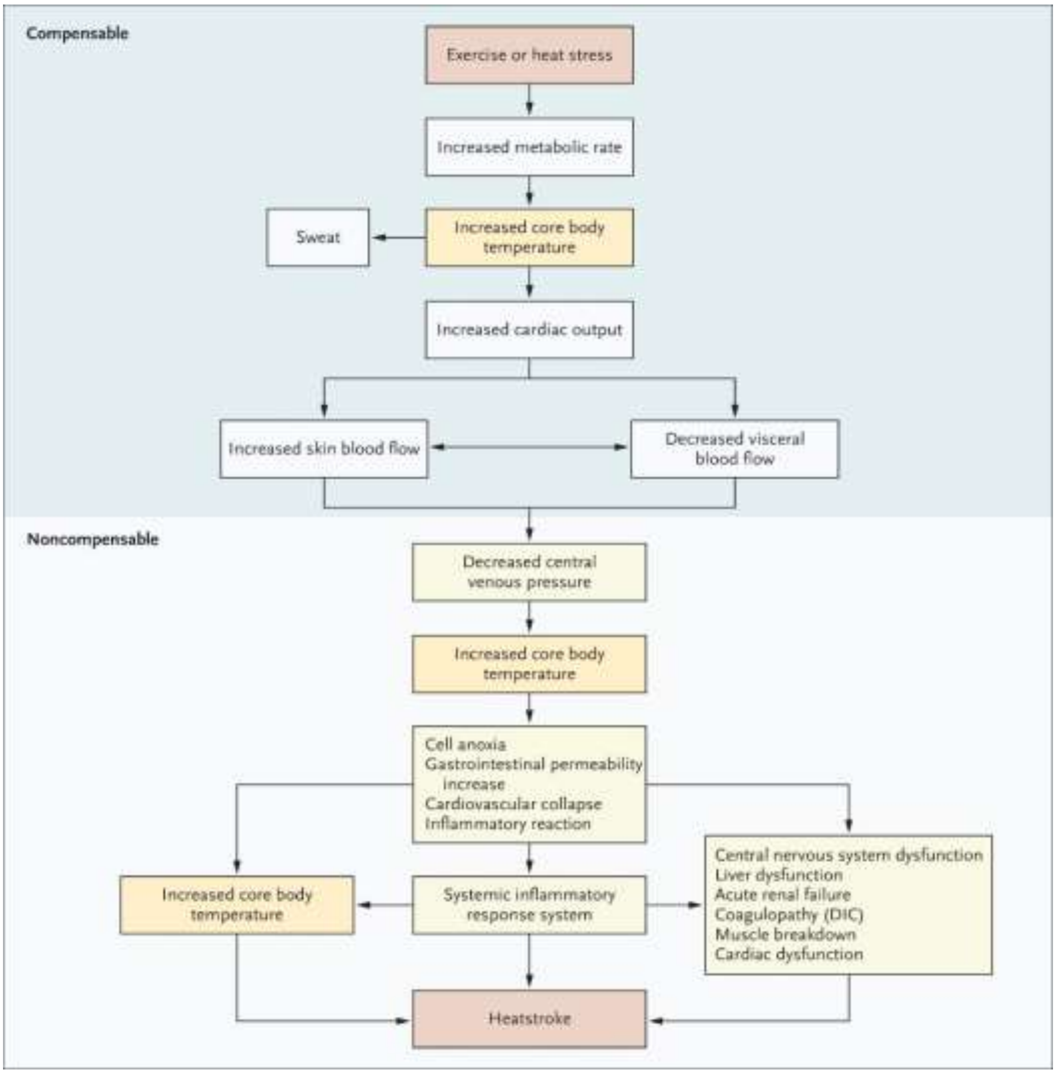
* ARDS denotes acute respiratory distress syndrome, CNS central nervous system, and DIC disseminated intravascular coagulation.

cc: Epstein, Y., Yanovich, R. et al. (2019) [7]

PATHOPHYSIOLOGY

Normally, thermoregulation is a very efficient mechanism, with a core temperature change of only 1°C for every 25°C to 30°C increase in ambient temperature. Under adaptation, heat-shock proteins mitigate cellular injury from hyperthermia. Heat dissipation relies on increased cardiac output, reduced splanchnic blood flow, and sweating. These mechanisms are illustrated in Figure 3. However, when humidity exceeds 75%, evaporative cooling becomes ineffective. If the environmental humidity exceeds 75%, evaporative cooling becomes less effective. Once ambient temperature exceeds that of the skin, pathways such as radiation, conduction, and convection cannot adequately remove body heat. Inadequate water replenishment may result in significant electrolyte imbalances. Dehydration is primarily caused by normal or hypernatraemia, Severe brain injury, brain swelling, and bleeding may result. Hyponatraemia develops rarely as a result of overcompensation with hypotonic fluid replacement, as seen in marathon runners and other exertional heat stroke populations. The breakdown of muscle tissue or acidosis during heatstroke can drive potassium out of cells and into plasma, resulting in elevated serum potassium levels. Potassium is a powerful vasodilator in skeletal and cardiac muscle, and severe deficiency causes circulatory dysfunction and decreased muscle blood flow, predisposing to rhabdomyolysis.[1]

Figure 3. Pathophysiological Pathway Leading to Heat Stroke.



cc: Epstein, Y., Yanovich, R. et al. (2019) [7]

Heat stroke occurs as a result of a transition from a compensable thermoregulatory state to a non-compensable condition. Heat stress causes a thermoregulatory response, resulting in increased cardiac output and blood flow redistribution. When central venous pressure begins to fall significantly, core temperature rapidly rises and becomes non-compensable. In addition to multiorgan failure resulting from the combination of circulatory collapse and elevated body temperature, thermoregulatory failure exacerbates pathophysiological processes at the cellular level, including an inflammatory response, and finally manifests as heatstroke. DIC means disseminated intravascular coagulation.[7]

SYMPTOMS OF HEAT STROKE

Heat stroke develops with a variety of acute clinical symptoms, the most critical being a significantly increased core body temperature, generally reaching 40 °C (104 °F)[9]. Patients may experience neurological abnormalities such anxiety, delirium, confusion, slurred speech, seizures, or even combativeness in addition to heat [10]. Cardiovascular abnormalities are also common, manifesting as tachycardia, tachypnea, and hypotension in around 25% of cases. Other symptoms might include nausea, vomiting, dizziness, weakness, blurred vision, and fainting. The skin appearance differs depending on the kind of heat stroke: in classic (non-exertional) cases, it is often hot and dry, whereas in exertional heat stroke, excessive sweating is common. Prompt recognition of these indicators is critical, whether by afflicted persons or spectators, because seeking prompt medical treatment and commencing speedy intervention can save lives..[6]

Figure 4. Heat stroke signs and symptoms.

RISK FACTOR

Outdoor workers such as those in agriculture, construction, firefighting, and logistics face elevated risk for heatstroke due to the interplay of environmental, occupational, and individual vulnerabilities.

Environmental factors, including high ambient temperatures, intense solar radiation, elevated humidity, and poor airflow, overwhelm the body's capacity for heat dissipation through sweating and vasodilation, Occupational conditions like physically demanding labour and the use of impermeable or insulating protective clothing further constrict heat loss, particularly when shade or cooling breaks are limited[11] Individual susceptibility is heightened among workers with inadequate heat acclimatization, dehydration, obesity, advanced age, chronic diseases (e.g., cardiovascular, renal, or metabolic disorders) [12]

Figure 5. Risks factors of Heatstroke.

Table 2. Risk Factors Underlying Heatstroke.*

Heatstroke Type and Risk Factor	Explanation
Classic	
Weather	Heat waves, with successive hot days and nights
Physiological factors	Cardiovascular insufficiency impeding normal cardiovascular adjustments to heat stress: inability to maintain acceptable stroke volume in the heat, inadequate peripheral vasodilatation due to structural changes and compromised nitric oxide–mediated vasodilatory mechanism, reduced capillary density and quality of cutaneous microcirculation, decreased sweat rate and sweat-gland output in response to heat stress
Social factors	Social isolation, unventilated and non–air-conditioned living space, inability to care for oneself, confinement to bed
Underlying illness	Exacerbation of mental, cardiovascular, cerebrovascular, and pulmonary illnesses and multiple sclerosis by exposure to heat stress
Medications	Beta-blockers, diuretics, calcium-channel blockers, laxatives, anticholinergic drugs, salicylates, thyroid agonists, benztropine, trifluoperazine, butyrophenones, α-agonists, monoamine oxidase inhibitors, sympathomimetic medications, tricyclic antidepressants, SSRIs
Exertional	
Social factors	Overmotivation, peer and coach pressure
Functional factors	Low physical fitness (physical effort unsuited to physical fitness; "killer workouts"), lack of acclimatization (habituation) to heat, low work efficiency, overweight (reduced ratio of skin area to mass and greater heat-storage capacity in fat layers), protective clothing (reduced sweating efficiency)
Acquired factors	Viral or bacterial infection (even if subclinical), dehydration, sleep deprivation, sweat-gland dysfunction (e.g., deep burns, scarred skin on >40% of total body-surface area)
Congenital factors	Chronic idiopathic or familial anhydrosis, ectodermal dysplasia
Drug abuse	Amphetamines and amphetamine-like agents (e.g., ephedra), MDMA, cocaine, PCP and LSD, synthetic stimulants of the cathinone class (e.g., α-PHP), alcohol

cc: Epstein, Y., Yanovich, R. et al. (2019) [7]

COMPLICATION

Heatstroke can lead to a wide range of systemic complications affecting multiple organ systems. In the central nervous system (CNS), patients may develop altered mental status, coma, seizures, cerebral edema, or cerebellar ataxia. Cardiac involvement is common and may present with tachyarrhythmias, acute decompensated heart failure, ST-segment changes, a prolonged QT interval, The respiratory system may be affected by aspiration, acute respiratory distress syndrome (ARDS), bronchospasm, or pulmonary edema. Significant metabolic disturbances such as respiratory alkalosis, metabolic acidosis, hypo- or hyperkalaemia, hyponatremia, hypoglycaemia, and hypocalcaemia can also occur. Haematological complications may include disseminated intravascular coagulation (DIC), thrombocytosis, and leucocytosis. The renal system is at risk of acute kidney injury (AKI) and renal failure, while the liver may develop acute hepatic failure, which is often self-limiting but, in severe cases, can necessitate liver transplantation. Additionally, rhabdomyolysis caused by muscle breakdown and dehydration may contribute to renal injury, and in some cases, compartment syndrome can develop as a serious musculoskeletal complication.[13]

DIAGNOSIS

Heatstroke should be suspected in any patient arriving at the emergency department with altered consciousness, confusion, or seizures during periods of heatwaves or high ambient temperatures, particularly in the summer months. A rectal temperature measurement should be obtained immediately; if it is found to be above 40 °C, a presumptive diagnosis of heatstroke can be made. Rapid cooling measures must be initiated without delay until the core temperature falls below 39 °C. At the same time, other potential causes of hyperpyrexia and altered mental status (such as malaria, encephalitis, urinary tract infection, pneumonia, viral fever, or neuroleptic malignant syndrome) should be carefully ruled out through clinical assessment and appropriate laboratory tests. It is important to recognize that heatstroke may also develop in conjunction with acute infections or alcohol withdrawal states.

Initial investigations include complete blood count, chest radiography, urine microscopy, and malarial parasite screening. If there is suspicion of central nervous system infection or stroke, cerebrospinal fluid examination and neuroimaging may be required. To identify possible complications, key laboratory evaluations consist of serum electrolytes, renal function tests (urea and creatinine), arterial blood gas analysis, liver function tests, prothrombin time, and muscle enzyme markers such as creatine phosphokinase (CPK) and lactate dehydrogenase (LDH)[14].

PROGNOSIS

The prognosis of heatstroke depends critically on early diagnosis and rapid core-temperature reduction. Severe cases marked by high-grade hyperthermia and multi-organ failure have mortality rates approaching 60% (MODS-related)[15] Survivors often face lasting consequences: neurological sequelae, such as cerebellar ataxia, cognitive impairment, dysarthria, and amnesia, afflict 20–30% of cases despite prompt treatment[16] Furthermore, discharge evaluations show that around 15% of heatstroke survivors experience neurological sequelae, while about 58% endure dysfunction in at least one organ system (e.g., renal or hepatic)[17] Thus, even with immediate intervention, heatstroke can result in substantial long-term neurological and systemic impacts underlining the critical importance of prevention, especially among vulnerable occupational groups.

HEAT STROKE ON OUTDOOR WORKERS

Outdoor workers including those in agriculture, construction, mining, and transportation are at high risk for heatstroke due to prolonged exposure to direct sunlight, high ambient temperatures, and heavy physical exertion. Occupational heat exposure is worsened by dehydration, inadequate rest breaks, and lack of cooling facilities[18], [19]

Epidemiological evidence shows that outdoor workers contribute disproportionately to occupational heat-related illnesses. For example, agricultural workers account for nearly 50% of occupational heat-related deaths in the United States[20] In India, construction and agricultural workers report frequent episodes of heat exhaustion, dehydration, and kidney injury during peak summer months[21] Beyond acute illness, chronic occupational heat exposure in outdoor workers has been linked to chronic kidney disease of non-traditional origin (CKDnt) in tropical regions, particularly among agricultural workers in Central America and South Asia[22], [23] Thus, outdoor workers face dual burdens: the immediate risk of life-threatening heatstroke and the long-term consequences of organ damage and reduced work capacity. The key evidence is summarized in Table 1.

Table: 1 Summary of Key Studies on Heatstroke and Occupational Heat Exposure Among Outdoor Workers (2015–2025)

Author & Year	Study Design	Population / Setting	Key Findings	Implications
Li et al., 2015(24)	Quasi-experimental	4,596 residents, Licheng, China	Heatwave intervention reduced HRIs, esp. in rural areas (OR=0.495); cost-effective (US$15.06/participant).	Targeted interventions are effective & affordable in reducing HRIs.
Li et al., 2016[24]	Cross-sectional	2,241 residents, Licheng, China	Higher KAP scores in urban women & educated groups; low knowledge ↑ risk of HRIs.	Awareness programs should target vulnerable groups.
Nguyen et al., 2018[25]	Cross-sectional	1,027 outdoor workers, Hanoi, Vietnam	Construction workers had lower knowledge but fewer symptoms; older females at higher risk; weather forecast use protective.	Occupation-specific awareness & low-cost preventive measures needed.
Zhang et al., 2019[26]	KAP intervention	105 migrant construction workers, Shenzhen	Education & early warnings improved knowledge ($p<0.01$) & habits ($p<0.05$); urine biomarkers showed stress.	Interventions improve awareness but physiological risk remains.
El-Gamal et al., 2021[27]	Cross-sectional	378 residents, Jeddah, Saudi	18.2% had HRIs; 49% never received education; higher KAP linked to age, gender, AC use, education.	Strengthen health education to reduce HRIs.
Venugopal et al., 2021[28]	Cross-sectional	2,104 workers, India	Outdoor workers had more heat symptoms (45.2% vs 39.1%), kidney strain, productivity loss (OR=11.4).	Policies must prioritize outdoor unorganized sectors.
Zhang et al., 2021[29]	Retrospective case-control	117 ICU patients, China	Mortality 11.1%; predictors = cooling delay (HR=4.87), HR, SOFA score.	Early cooling improves survival.

Venugopal et al., 2021[14]	Cross-sectional	~1,500 industrial workers, South India	WBGT > limits in 70%; ↑ core temp in 11.3%; kidney dysfunction in 49% salt-pan workers.	Chronic exposure linked to kidney injury; urgent interventions needed.
Tan et al., 2022[30]	Mixed-method	140 outdoor workers, SE Asia	Awareness present, but job demands & lack of employer support hinder prevention; HAP improved compliance.	Employer-driven HAPs are critical.
Flunker et al., 2022[31]	Case-crossover	12,213 agricultural workers, Washington, USA	Injury risk ↑ at Humidex ≥25; strongest during cherry harvesting.	High heat ↑ injury risk; prevention must cover accidents too.
Calkins et al., 2022[32]	Case-crossover	63,720 construction workers, Washington, USA	Injury risk ↑ with humidex; highest in young/older, inexperienced workers.	Construction-specific prevention programs needed.
Rajendran et al., 2023[33]	Cross-sectional	280 brick kiln workers, Puducherry, India	11.4% reported HRIs; KAP linked to education, income, work experience.	Education & socioeconomic uplift improve resilience.
Li et al., 2023[34]	Cohort	9.6M participants, Shenzhen, China	HRI doubled risk of CVD (HR=2.53); heatwave warnings reduced admissions.	Heat early warnings protect long-term health.
Dardavessis et al., 2023[35]	Cross-sectional	1,055 participants, Greece	Higher KAP in females, educated, urban residents; linked with better health & wealth.	Socio-demographics shape preparedness.
Guin et al., 2025[36]	Regression analysis	India (2001–2019), IMD & NCRB data	19,693 heatstroke deaths; AP, UP, Punjab worst-hit; working-age men highest risk.	Welfare & planning needed to prevent occupational heat deaths.

Although several studies have examined the risk factors, clinical manifestations, and management of heatstroke, there remains a critical gap in the knowledge and preventive practices among outdoor workers. This gap highlights the need for strengthening awareness and occupational health interventions. The table below (Table 2) summarizes key evidence on heatstroke in outdoor workers and the areas where knowledge and preventive practices remain inadequate.

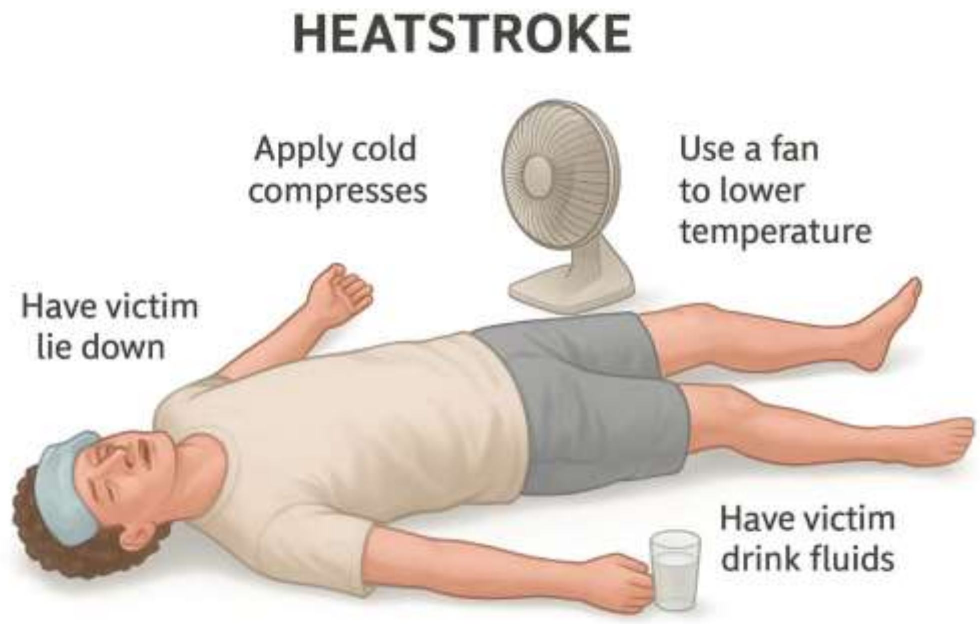
Table: 2 Research Gaps in Knowledge, Preventive Practices, and Intervention Programs Related to Heatstroke among Outdoor Workers

Area of Evidence	Existing Findings	Gap Identified
Knowledge of risk factors and symptoms	Studies from Asia, Middle East, and Africa show limited awareness of heatstroke risk factors (e.g., dehydration, prolonged sun exposure) and early symptoms (dizziness, confusion, cramps) among outdoor workers (Al-Khatib et al., 2020; Tawatsupa et al., 2013).	Inadequate knowledge persists across high-risk groups such as construction and agricultural workers, despite frequent exposure to extreme heat.
Preventive practices	Some workers adopt basic measures (hydration, shaded rest), but adherence is inconsistent and often dependent on employer enforcement (Varghese et al., 2005; Venugopal et al., 2016).	Limited evidence on how knowledge influences preventive behaviour, leaving uncertainty about the effectiveness of awareness-based interventions.
Intervention programs	Training programs and workplace cooling strategies have been introduced in select industries (Xiang et al., 2015; Kjellstrom et al., 2016).	Few interventions are systematically evaluated or scaled up; most remain fragmented and localized.

HEAT STROKE FIRST AID

Heatstroke impairs a person’s awareness, so bystanders play a critical role in providing first aid. The affected individual should be moved to a cooler place, and rapid cooling measures should be started such as pouring water over the skin, fanning, or applying ice-soaked towels over large body surfaces and replacing them frequently. Ice packs can also be placed in the armpits or around the neck to accelerate cooling. Equally important is avoiding harmful interventions: fever-reducing drugs like acetaminophen are ineffective and may worsen complications, and giving fluids by mouth should be avoided due to the risk of aspiration.[37]

Figure 6. First aid treatment for heat stroke



TREATMENT

In suspected heatstroke cases, patients should be moved to a shaded, cool area and transferred to a medical facility promptly. Rapid cooling must begin immediately, even before transport if possible. Blood tests can follow once cooling is initiated. Cooling techniques are external or internal, with external methods most used in the field. The evaporative method spraying cool water on the skin while fanning warm air achieves cooling at about 0.3°C per minute.[38] In clinical environments, additional supportive treatments include intravenous fluids, monitoring of vital signs, and interventions for organ dysfunction as needed (e.g., dialysis for rhabdomyolysis-induced kidney injury)[39] Heatstroke patients need close monitoring and may require IV fluids, airway support, or medications to stabilize organ function, often necessitating hospitalization or ICU care until recovery is ensured.[37]

PREVENTION

- **Early Warning Systems** – The IMD should activate heatwave alerts to the disaster management cell and local administration.
- **Public Awareness** – Information on heatwave risks, prevention, warning signs, and when to seek medical help should be widely disseminated through SMS alerts, radio, TV, newspapers, and community networks.
- **Health System Preparedness** – PHCs, CHCs, district hospitals, and private facilities should ensure readiness for heat-related emergencies.
- **Community and Government Action** – Ensure public access to safe drinking water, temporary shelters, and shaded areas. Schools, colleges, offices, shops, and businesses should remain closed during peak heat hours (11 a.m. to 4 p.m.).
- **Workplace Regulations** – Suspend heavy outdoor labour (e.g., construction, quarrying, canal and road work) when temperatures exceed 44 °C.[14]

Preventing heat-related illness among outdoor workers relies on a combination of engineering controls, administrative strategies, and worker training. Employers should implement workplace measures such as increasing air flow, providing shade, ventilation, and reflective barriers around machinery or sources of radiant heat, climatization programs are also essential.[40]

POLICIES

Heat stroke action plan First launched by NDMA in 2016 and updated in 2019, these plans are active in 23 states and over 130 cities. They centre on early warnings, health preparedness, and public awareness, though they typically lack occupation-specific focus[41] Early Warning Systems, The India Meteorological Department (IMD**)** issues simplified heat alerts via SMS, WhatsApp, posters, and local media, targeting informal and vulnerable workers(42). Occupational Safety Laws, The Factories Act, 1948 and Building and Other Construction Workers (BOCW) Act, 1996 were consolidated into the Occupational Safety, Health and Working Conditions (OSH) Code, 2020. While they provide a legal framework for heat protection, weak enforcement and state-level exemptions reduce impact.[42]

CONCLUSION

Heatstroke represents a critical occupational health concern, especially among outdoor workers exposed to extreme temperatures and intense physical activity. This review highlights that the risk of heat-related illnesses is determined by a complex interplay of environmental, occupational, and individual factors. Environmental conditions, such as high ambient temperature, humidity, and solar radiation, can quickly overwhelm the body's thermoregulatory mechanisms. Occupational demands, including prolonged physical exertion, heavy workloads, and inadequate rest, further increase susceptibility.

Epidemiological evidence indicates that outdoor workers in agriculture, construction, disproportionately high rates of heat-related morbidity and mortality. Acute consequences can range from heat exhaustion and dehydration to severe neurological impairment and multi-organ failure. Chronic exposure may contribute to long-term health effects, including renal, cardiovascular, and metabolic dysfunction, highlighting the cumulative impact of repeated heat stress.

Despite increasing recognition of the health risks, gaps remain in the understanding of heatstroke among outdoor workers, particularly regarding knowledge of early warning signs, clinical recognition, and occupational vulnerability. The reviewed literature demonstrates variability in awareness, physiological risk, and outcomes across different regions and worker populations. Overall, this narrative synthesis emphasizes the urgent need for continued research to better characterize risk profiles, identify high-risk occupational groups, and advance understanding of heat-related morbidity and mortality. Addressing these knowledge gaps is essential to mitigate health impacts and protect the most vulnerable workers from the increasing risk of heat stroke at workplace.

DECLARATIONS SECTION

Funding Declaration:

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Clinical Trial Number:

Clinical trial number: not applicable.

Consent to Participate:
Consent to Participate declaration: not applicable.

Ethics and Consent to Publish:
Ethics and Consent to Publish declarations: not applicable.

Research Data Availability:
No new data were generated or analyzed in this study.

REFERENCE

1. Morris A, Patel G. Heat Stroke. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2025 [cited 2025 Jun 11]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK537135/
2. Gibb K, Beckman S, Vergara XP, Heinzerling A, Harrison R. Extreme Heat and Occupational Health Risks. Annu Rev Public Health. 2024;45:315–35. doi:10.1146/annurev-publhealth-060222-034715
3. Calma J. Workers need better protections from the heat [Internet]. The Verge. 2025 Available from: https://www.theverge.com/news/764463/heat-stress-health-work-protections
4. World Health Organization. Heat and health [Internet]. 2025 [cited 2025 Jul 20]. Available from: https://www.who.int/news-room/fact-sheets/detail/climate-change-heat-and-health
5. Think Global Health. The Toll of Extreme Heat on India's Laborers [Internet]. 2025 [cited 2025 Jun 15]. Available from: https://www.thinkglobalhealth.org/article/toll-extreme-heat-indias-laborers
6. Morris A, Patel G. Heat Stroke. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2025 [cited 2025 Jul 20]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK537135/
7. Epstein Y, Yanovich R. Heatstroke. N Engl J Med. 2019;380(25):2449–59. doi:10.1056/NEJMra1810762
8. Peiris AN, Jaroudi S, Noor R. Heat Stroke. JAMA. 2017;318(24):2503. doi:10.1001/jama.2017.18780
9. ScienceDirect Topics. Heat Stroke - an overview. 2025 [cited 2025 Aug 25]. Available from: https://www.sciencedirect.com/topics/medicine-and-dentistry/heat-stroke
10. Mayo Clinic. Heatstroke - Symptoms and causes https://www.mayoclinic.org/diseases-conditions/heat-stroke/symptoms-causes/syc-20353581
11. Bryan K. UN agencies urge employers to track workers' dehydration risk from heatwaves Financial Times. 2025 Aug 22 [cited 2025 Aug 25]. Available from: https://www.ft.com/content/da8def75-9be5-4840-be8f-e9252437c2f2
12. Wikipedia. Occupational heat stress https://en.wikipedia.org/w/index.php?title=Occupational_heat_stress&oldid=1295373671
13. Burgin R. EM@3AM: Hyperthermia [Internet]. emDocs. 2025 [cited 2025 Aug 25]. Available from: https://www.emdocs.net/em3am-hyperthermia-2/
14. Jain Y, Srivatsan R, Kollannur A, Zachariah A. Heatstroke: Causes, consequences and clinical guidelines. Natl Med J India. 2018;31(4):224. doi:10.4103/0970-258X.258224
15. Ren E, et al. Development and validation of a risk prediction model for multiple organ dysfunction syndrome secondary to severe heat stroke based on immediate assessment indicators on ICU admission. Front Med. 2024;11. doi:10.3389/fmed.2024.1481097

16. Yang M, et al. Outcome and risk factors associated with extent of central nervous system injury due to exertional heat stroke. Medicine (Baltimore). 2017;96(44):e8417. doi:10.1097/MD.0000000000008417
17. Chen L, Xu S, Yang X, Zhao J, Zhang Y, Feng X. Association between cooling temperature and outcomes of patients with heat stroke. Intern Emerg Med. 2023;18(6):1831–42. doi:10.1007/s11739-023-03291-y
18. Zheng H, Hutchins AP, Pan G, Li Y, Pei D, Pei G. Where cell fate conversions meet Chinese philosophy. Cell Res. 2014;24(10):1162–3. doi:10.1038/cr.2014.93
19. Patel H, Kukol A. Evaluation of a novel virtual screening strategy using receptor decoy binding sites. J Negat Results Biomed. 2016;15(1):15. doi:10.1186/s12952-016-0058-8
20. CDC. Page Not Found | CDC https://www.cdc.gov/niosh/topics/heatstress/heatrelillness.html
21. Barros J, et al. Anti-sessile bacterial and cytocompatibility properties of CHX-loaded nanohydroxyapatite. Colloids Surf B Biointerfaces. 2015;130:305–14. doi:10.1016/j.colsurfb.2015.04.034
22. Fiaschi L, Nelson-Piercy C, Tata LJ. Hospital admission for hyperemesis gravidarum: a nationwide study of occurrence, reoccurrence and risk factors among 8.2 million pregnancies. Hum Reprod. 2016;31(8):1675–84. doi:10.1093/humrep/dew128
23. Harolds JA. Quality and Safety in Healthcare, Part LII: Other Lessons From Positive Psychology Regarding Burnout. Clin Nucl Med. 2019;44(10):792–4. doi:10.1097/RLU.0000000000002534
24. MDPI. A Cross-Sectional Study of Heat Wave-Related Knowledge, Attitude, and Practice among the Public in the Licheng District of Jinan City, China: https://www.mdpi.com/1660-4601/13/7/648
25. Xu Y, Chen J, Du J, Jin Y. Knowledge, attitudes, and practices among the general community population toward heatstroke. Front Public Health. 2024;12. doi:10.3389/fpubh.2024.1373025
26. C P. Study of KAP Investigation and Interventions on the Impact of Migrant Workers under Heatwaves. Environ Epidemiol. 2019;3:307. doi:10.1097/01.EE9.0000609344.44320.79
27. Wang X, et al. Knowledge, Attitudes, and Practices of Military Personnel Regarding Heat-Related Illness Risk Factors: Results of a Chinese Cross-Sectional Study. Front Public Health. 2021;9. doi:10.3389/fpubh.2021.707264
28. ADS. Heat-health vulnerabilities in the climate change context-comparing risk profiles between indoor and outdoor workers in developing country settings [Internet]. 2021 [cited 2025 Jul 03]. Available from: https://ui.adsabs.harvard.edu/abs/2021ERL....16h5008V/abstract
29. Zhong L, et al. Risk Factors for the 90-Day Prognosis Of Severe Heat Stroke: a Case-Control Study. Shock. 2021;55(1):61. doi:10.1097/SHK.0000000000001589
30. Ragupathy S. Stakeholder Risk Perception About Heat: An Interview-Based Study Among Outdoor Workers in South India. Hum Factors Ergon Manuf Serv Ind. 2025 [cited 2025 Jul 03]. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1002/hfm.21062
31. Spector JT, et al. A Case-Crossover Study of Heat Exposure and Injury Risk in Outdoor Agricultural Workers. PLoS ONE. 2016;11(10):e0164498. doi:10.1371/journal.pone.0164498
32. Calkins MM, et al. A case-crossover study of heat exposure and injury risk among outdoor construction workers in Washington State. Scand J Work Environ Health. 2019;45(6):588–99.
33. Ramakrishnan I, et al. Risk perceptions of heat-related illnesses, assessing vulnerability, and adaptive capacity of brickkiln workers in a rural Puducherry: A cross-sectional study. Indian J Community Fam Med. 2025;11(1):8. doi:10.4103/ijcfm.ijcfm_99_23

34. Huang Q, et al. Heatwave warnings mitigate long-term cardiovascular diseases risk from heat-related illness: a real-world prospective cohort study. Lancet Reg Health West Pac. 2025;55:101468. doi:10.1016/j.lanwpc.2025.101468
35. Kumar A, Singh DP. Heat stroke-related deaths in India: An analysis of natural causes of deaths, associated with the regional heatwave. J Therm Biol. 2021;95:102792. doi:10.1016/j.jtherbio.2020.102792
36. Guin P, Bhan N, Sethi K. Mortality due to heatstroke and exposure to cold: Evidence from India. Temperature. 2025;12(2):179–99. doi:10.1080/23328940.2025.2475420
37. Cleveland Clinic. Do You Know the Symptoms of Heat Stroke? [Internet]. 2025 [cited 2025 Aug 25]. Available from: https://my.clevelandclinic.org/health/diseases/21812-heatstroke
38. Glazer JL. Management of Heatstroke and Heat Exhaustion. Am Fam Physician. 2005;71(11):2133–40.
39. Wikipedia. Hyperthermia https://en.wikipedia.org/w/index.php?title=Hyperthermia&oldid=1302474984
40. OSHA. OSHA Technical Manual (OTM) - Section III: Chapter 4 [Internet]. 2025 [cited 2025 Aug 26]. Available from: https://www.osha.gov/otm/section-3-health-hazards/chapter-4
41. PreventionWeb. Country heat policy review: https://www.preventionweb.net/resource/case-study/country-heat-policy-review-india
42. Wikipedia. Occupational Safety, Health and Working Conditions Code, https://en.wikipedia.org/w/index.php?title=Occupational_Safety,_Health_and_Working_Conditions_Code,_2020&oldid=1279904685