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Review article

Drowning Risks and Public Health Vulnerabilities during Urban Floods: Lessons from the Hat Yai Deluge: A Narrative Review

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Abstract

Flooding is among the most prevalent and destructive natural disasters worldwide, and its most catastrophic consequence is the immediate threat to human life through fatal and non-fatal drowning. Urban centers in developing nations face heightened vulnerability because of rapid unregulated urbanization, complex topography, and climate-driven shifts in precipitation. This review examines the November 2025 Hat Yai flood disaster in Songkhla Province, Southern Thailand, as a case study to understand the dynamics, public health burden, and clinical management of flood-induced drowning. Drowning accounted for the majority of immediate flood-related fatalities, driven by flash flooding, delayed evacuation, submerged infrastructure hazards, and vehicle-related submersion. Beyond mortality, non-fatal drowning imposes a substantial public health burden through neurological and pulmonary complications, psychological trauma, and disruption of emergency medical services. Effective clinical management requires a continuum of care spanning pre-hospital airway management, lung-protective mechanical ventilation, empirical antimicrobial therapy for contaminated water aspiration, and targeted temperature management for neuroprotection. Multidisciplinary prevention frameworks that combine early warning systems, community education, the targeted supervision of high-risk populations, and resilient urban infrastructure are essential to reducing future mortality. The Hat Yai deluge underscores the need for a paradigm shift that places drowning prevention and clinical preparedness at the center of urban disaster planning.

Keywords: disaster preparedness, drowning, flood, public health, urban flooding

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Introduction

This narrative review synthesized evidence from multiple sources to provide a comprehensive overview of flooding, flood-related mortality, health impacts, and flood vulnerability in Hat Yai Municipality and the surrounding areas of Southern Thailand. Information was collected from official reports and databases of Thailand's Ministry of Public Health (MOPH), publications and technical resources from the World Health Organization (WHO), systematic reviews, peer-reviewed studies, and other relevant scientific and institutional sources.

Flooding stands as the most prominent natural disaster globally, posing severe risks to critical infrastructure, regional economies, and human lives[1]. While monetary loss and architectural destruction dominate headline narratives, the most catastrophic and irreversible consequence of severe inundation is the immediate threat to public health—specifically, fatal and non-fatal drowning[2]. Urban centers in developing nations face a significantly heightened vulnerability to these threats due to a combination of rapid, unregulated urbanization, complex geography, and changing precipitation patterns driven by global climate shifts[2].

A stark, tragic example of this vulnerability occurred during the historic November 2025 flood in the Hat Yai District of Songkhla Province, located in Southern Thailand[3]. Triggered by an unprecedented monsoon cyclone that dropped over 1,000 millimeters of rain in just five days, the disaster submerged vast commercial and residential areas up to 5 meters deep[4]. This extreme event directly impacted millions of residents, paralyzed the regional economy, and underscored the lethal, fast-moving nature of urban floodwaters[3]. Thailand's Ministry of Public Health (MOPH) reported 145 deaths in the Hat Yai flood disaster by 4 December 2025. Because the death count included cases undergoing forensic investigation and hospital deaths whose relationship to the flood required determination, the figure should be described as the officially reported death toll rather than assuming that all 145 deaths were directly caused by drowning or floodwater. Age- and sex-specific demographic data for all Hat Yai flood deaths were not reported in the publicly available MOPH summaries reviewed. Available hospital information indicates that some hospital deaths involved predominantly elderly and critically ill patients, but this cannot be generalized to the entire flood death toll.

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By analyzing the Hat Yai deluge, public health officials and disaster managers can better understand the complex dynamics of flood-induced drowning and formulate robust prevention frameworks for flood-prone urban environments.

The Dynamics of Flood-Induced Drowning in Urban Centers

During extreme meteorological events like the Hat Yai deluge, drowning risks scale drastically because several interlocking factors transform a modern city into a hazardous aquatic environment.

Topographical Vulnerabilities and Flash Floods

The geographical layout of Hat Yai functions as a natural "bowl-like" topography, surrounded by hills that rapidly funnel runoff into the urban center. When the 2025 cyclone struck, the local drainage infrastructure was instantly overwhelmed[4]. This accelerated water accumulation caught residents off-guard, converting standard asphalt roadways into high-velocity torrents within hours. Flash floods of this nature give individuals very little time to react, significantly increasing the likelihood of sudden submersion.

Delayed Evacuation and Trapped Populations

Conflicting early warnings, combined with a general underestimation of the deluge's severity based on past experiences, led many residents to stay in their homes[5]. As water levels abruptly breached ground floors and reached second-story levels, individuals became trapped. In these scenarios, vulnerable groups (the elderly, young children, and persons with disabilities) face extreme risks of drowning inside their own residences[6]. Alternatively, last-minute attempts to wade through deep, murky waters outside often end in tragedy due to invisible hazards.

Submerged Infrastructure Hazards

Urban floodwaters are vastly different from calm pool waters. In Hat Yai, the floodwaters were highly turbid, concealing open drainage culverts, displaced manhole covers, severed electrical lines, and heavy floating debris[3]. A person wading through just knee-deep water can easily be tripped by hidden debris or sucked into a submerged drainage network by powerful undercurrents, leading to rapid drowning[7].

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Vehicle-Related Submersion

A significant portion of urban flood drownings occurs when individuals attempt to drive through flooded streets[1]. Drivers routinely underestimate the force of moving water; less than two feet of rushing water can easily sweep away a large passenger vehicle. When cars are carried into deeper drainage canals, occupants often become trapped inside due to water pressure preventing the doors from opening, leading to vehicular drowning.

Public Health and Epidemiological Implications

Epidemiological data from global disaster databases indicate that drowning accounts for the vast majority (often exceeding 70.0% to 80.0%) of direct, immediate flood-related fatalities[1]. In major historical Thai floods, including the massive 2011 central plains disaster and the recent 2025 southern deluge, the primary cause of death was officially recorded as asphyxiation from submersion[3].

Beyond immediate fatalities, non-fatal drowning presents a severe, long-term burden on local public health systems.

Neurological and Pulmonary Complications

Survivors of non-fatal drowning often suffer from severe hypoxia, leading to permanent neurological damage[6]. Additionally, inhaling highly contaminated urban floodwater frequently causes severe aspiration pneumonia, acute respiratory distress syndrome (ARDS), and systemic infections that require prolonged intensive care.

Psychological Trauma

The experience of nearly drowning or witnessing a family member drown during a flood leaves profound psychological scars. Communities affected by the Hat Yai flood reported sharp increases in post-traumatic stress disorder (PTSD), severe anxiety, and depression, complicating the long-term social recovery of the region[8].

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Disruption of Emergency Medical Services

During the peak of the Hat Yai flood, rescue boats and emergency medical technicians could not safely navigate the high-velocity currents[3]. This operational paralysis meant that individuals experiencing near-drowning events could not receive immediate cardiopulmonary resuscitation (CPR) or advanced life support, drastically lowering survival rates[9].

Clinical Management and Treatment of Non-Fatal Drowning

Effective intervention for flood-related non-fatal drowning requires a seamless continuum of care, transitioning from immediate field resuscitation to advanced hospital-based therapies. Urban floodwaters introduce specific pathophysiological challenges that dictate aggressive clinical management.

Pre-Hospital Resuscitation and Airway Management

The primary physiological consequence of drowning is persistent hypoxemia caused by fluid aspiration or reflex laryngospasm. Pre-hospital care must prioritize the immediate reversal of hypoxia. Rescuers should initiate bystander CPR using the traditional Airway-Breathing-Circulation (A-B-C) sequence, emphasizing rescue breaths over compression-only CPR, as the underlying arrest is purely respiratory[6]. Routine abdominal thrusts (Heimlich maneuver) are contraindicated as they increase the risk of gastric regurgitation and further pulmonary aspiration. High-flow supplemental oxygen must be administered as soon as feasible, with early endotracheal intubation performed for patients exhibiting severe respiratory distress or altered consciousness.

In-Hospital Mechanical Ventilation and Lung Protection

Upon arrival at the emergency department, patients with severe respiratory failure or established Acute Respiratory Distress Syndrome (ARDS) require admission to the Intensive Care Unit (ICU). Management guidelines dictate lung-protective mechanical ventilation strategies to minimize ventilator-induced lung injury. This includes utilizing low tidal volumes (6 mL/kg of predicted body weight) and titrating positive end-expiratory pressure (PEEP) to maintain adequate alveolar recruitment and oxygenation while avoiding barotrauma[10].

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Empirical Antimicrobial Therapy

Unlike domestic pool submersions, drowning victims of the Hat Yai deluge aspirated highly contaminated urban runoff containing municipal sewage and agricultural wastes. This microbially rich fluid places survivors at an exceptional risk for multi-bacterial aspiration pneumonia. Empirical broad-spectrum intravenous antibiotics (e.g., third-generation cephalosporins or fluoroquinolones) should be initiated promptly when clinical or radiological evidence of pneumonitis appears, with treatment tailored later based on sputum or bronchoalveolar lavage culture results.

Neurological Protection and Targeted Temperature Management

For patients who remain comatose following the restoration of spontaneous circulation (ROSC), neuroprotective protocols are critical to mitigate ischemic-reperfusion injury. The 2025 American Heart Association (AHA) Guidelines for Post-Cardiac Arrest Care recommend maintaining a temperature of 32–37.5 °C and promptly performing EEG to diagnose seizures in adults unresponsive to verbal commands after ROSC.[11]

Multidisciplinary Prevention Frameworks

To mitigate mortality and morbidity rates in future disasters, drowning prevention must evolve from a reactive emergency response into a proactive, multidisciplinary framework. This approach must seamlessly bridge engineering solutions, social behavioral modification, and localized risk communication.

Robust, Transparent Early Warning Systems

The foundational step in preventing flood-related drowning is the eradication of information gaps. During the 2025 crisis, misinformation on social media created confusion regarding which areas would be flooded next[3]. Governments must implement centralized, real-time sensory networks that monitor river levels and rainfall upstream. This data must be translated into clear, definitive evacuation triggers communicated via mobile alerts, community megaphones, and local radio broadcasts, giving citizens ample time to reach high ground before roads become unnavigable[5].

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Community-Level Preparedness and Behavioral Education

Public safety campaigns must actively counter the dangerous misconception that floodwaters are safe to play or wade in[12]. Communities in flood-prone zones like Hat Yai must be taught basic flood physics—specifically, that walking or driving through moving water is inherently lethal. School curricula and local community centers should offer basic swimming literacy, flood survival skills, and bystander CPR training, empowering citizens to rescue others safely without becoming victims themselves[12].

Targeted Supervision and Preemptive Sheltering

Because the elderly and children are disproportionately represented in drowning statistics, disaster management protocols must mandate the preemptive evacuation of these high-risk populations[9]. Safe, elevated community shelters equipped with medical supplies must be established outside the flood-bowl perimeter well before the heavy rainfall peaks[8].

Urban Engineering and Infrastructure Resilience

Long-term structural interventions are critical to reducing the physical hazards of urban flooding. Cities must invest in smart drainage designs, such as self-clearing culverts, visible depth markers on all major roadways, and secure grates on all urban drainage infrastructure to prevent suction hazards during floods[7]. Green infrastructure, including urban wetlands and retention basins, can also reduce the peak volume and velocity of floodwaters inside the city[4].

Conclusion

The catastrophic 2025 flood in Hat Yai serves as a severe warning that traditional flood mitigation strategies, which focus purely on economic infrastructure, are no longer sufficient in an era of climate-induced deluges. Prioritizing human life requires a paradigm shift that places drowning prevention and clinical emergency preparedness at the center of urban disaster planning. By combining advanced early warning systems, resilient infrastructure engineering, aggressive community education, and standardized medical protocols for treating non-fatal drowning,

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vulnerable cities can adapt to changing climate realities and ensure that future floods do not result in preventable loss of life.

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