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Hot Weather Exposure and Human Health in Vietnam: Impacts, Risk Distribution, and Adaptation Strategies

Nguyen Thi Thu Thuy[1]*, Dao Nguyen Manh[1], Quach Thi Quynh[1], Pham Thi Phuong Lien[1], Tran Thanh Tuan[1], Chu Duc Thanh[1], Do Thi Thuy Trang[1], Trinh Quang Minh[1], Vu Thi Loan[1], Nguyen Van Thanh[2]

[1]Institute of Tropical Biomedicine, Joint Vietnam-Russia Tropical Science and Technology Research Center, Nguyen Van Huyen Street, Ha Noi, Vietnam
[2]Institute of Science and Technology for Energy and Environment, Vietnam Academy of Science and Technology, Hanoi 10000, Vietnam

*Correspondence: thuyntvietnga@gmail.com

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ABSTRACT: In the context of climate change, extreme heat in Vietnam has been increasing markedly in frequency, intensity, and duration, becoming one of the leading environmental threats to public health. This study aims to synthesize scientific evidence on the impacts of heat on human health, analyze the current situation and risk distribution in Vietnam, and propose appropriate response measures. Heat not only directly affects health but also has far-reaching impacts on labor productivity and socio-economic development. Evidence from Vietnam indicates that heat is associated with an increase in physiological and pathological disorders such as dehydration, electrolyte imbalance, cardiovascular and respiratory diseases, kidney injury, and mental health disorders. Prolonged heatwaves increase the risk of hospitalization and mortality, particularly among vulnerable groups such as the elderly, children, pregnant women, individuals with chronic diseases, and outdoor workers. The distribution of risk is uneven, with higher concentrations in major urban areas and the southern region due to prolonged high temperatures combined with high humidity and the urban heat island effect; the North Central and Central Coastal regions are also severely affected due to hot, dry winds. Notably, heat exposure has resulted in the loss of 16 billion working hours annually, leading to economic losses of approximately USD 23 billion (as of 2022). In response to this situation, priority should be given to adaptation measures suited to Vietnam's context, including raising public awareness, protecting vulnerable populations, adjusting working conditions, improving living environments, and promoting effective cooling solutions. These directions are crucial for mitigating the health impacts of heat in the future.

KEYWORDS: Heat exposure; human health; climate change; Vietnam; heat stress.

1. Introduction

High temperature is one of the environmental factors that most directly affects human health. Heat stress is a leading cause of weather-related mortality and can exacerbate cardiovascular diseases, respiratory diseases, asthma, diabetes, kidney disease, and mental health disorders [1–4]. In recent years, heatwaves have increased in frequency, duration, and intensity in the context of climate change [5]. Globally, the World Health Organization (WHO) estimates that there were approximately 489,000 heat-related deaths annually during the period 2000–2019, with Asia accounting for about 45% [6].

Vietnam is located in Southeast Asia and has a tropical monsoon climate characterized by considerable regional variation. The country can be broadly divided into northern, central, and southern climatic regions, with differences in temperature, humidity, rainfall patterns, and seasonal characteristics. These climatic variations influence population exposure and vulnerability to heat-related health risks across different regions. In Vietnam, climate change is increasing exposure to extreme heat. According to the Climate Change Department, the country's average annual temperature rose by approximately 0.89°C during the period 1958–2018, equivalent to about 0.15°C per decade; the number of hot days and drought events has also increased [7]. During the period 2018–2022, summer temperatures experienced by the Vietnamese population were about 0.8°C higher than the baseline period of 1986–2005 [8]. In 2022 alone, Vietnam lost approximately 16 billion potential working hours due to heat exposure, resulting in estimated income losses of about USD 23 billion, equivalent to 5.6% of GDP (2005) [8].

According to the national climate change scenarios, the average temperature in Vietnam could increase by approximately 1.3–1.7°C by mid-century and 2–4°C by the end of the century, depending on emission levels [9]. This trend poses serious challenges to public health, particularly in the context of rapid urbanization, population aging, and a large proportion of outdoor workers. Heat not only increases the risk of mortality and hospitalization due to acute and chronic conditions, but also significantly affects labor productivity, social welfare, and sustainable economic development [10, 11].

Although the impacts of heat have been increasingly well documented, community awareness and preventive behaviors remain limited, especially among vulnerable groups such as the elderly, children, pregnant women, and outdoor workers. Therefore, enhancing awareness, providing scientific evidence, and guiding individual preventive measures are essential. This paper aims to clarify the mechanisms by which heat affects human health, analyze the current situation and risk distribution in Vietnam, and propose intervention recommendations to mitigate the adverse impacts of heat on public health.

2. Mechanisms of the Impact of Hot Weather on Human Health

The human body maintains its core temperature within a narrow range through a balance between heat production and heat dissipation. When ambient temperatures are high—especially when combined with high humidity—thermoregulatory mechanisms (such as peripheral vasodilation and increased sweating) may become insufficient, leading to heat stress and disruption of homeostasis. The consequences can range from heat fatigue and heat exhaustion to heat stroke, a medical emergency that can result in multi-organ damage [11, 12]. As illustrated in Figure 1, exposure to excessive heat triggers a cascade of physiological responses and pathological outcomes affecting multiple body systems.

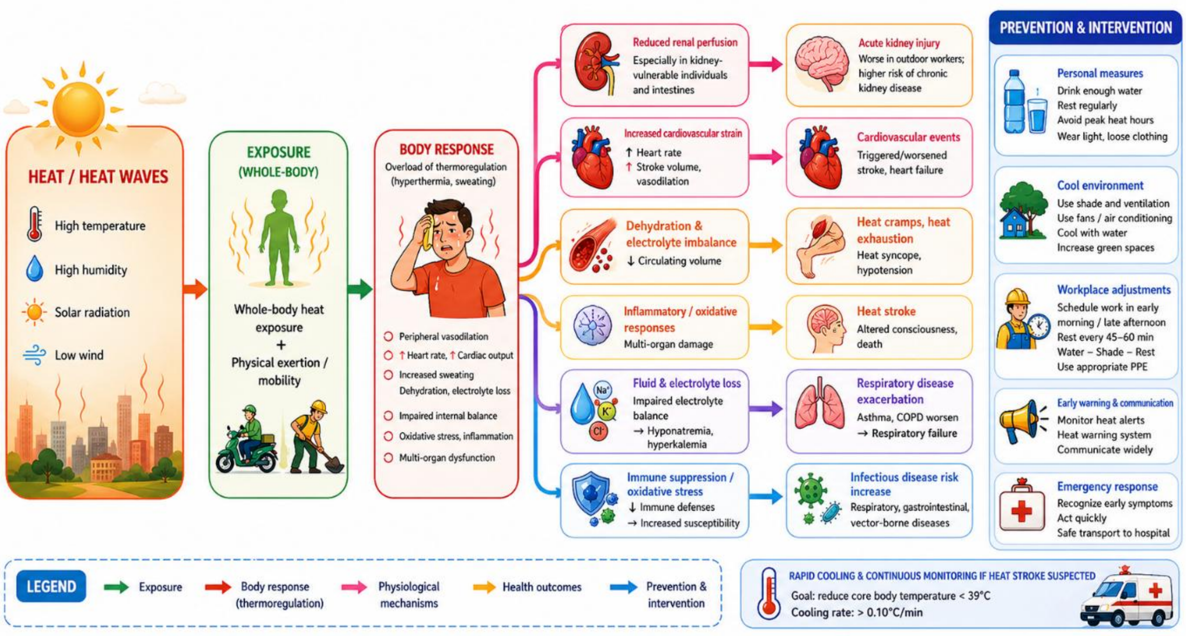

Figure 1. Mechanisms of the effects of heat on the human body and related health outcomes

Medical guidelines emphasize the risk of mortality if timely emergency care is not provided, particularly among children and older adults. Heat exposure can lead to dehydration and hemoconcentration, electrolyte imbalances; increased cardiac workload (elevated heart rate and reduced effective circulating volume); increased risk of thrombosis and impaired blood pressure regulation; and increased ventilation in patients with chronic lung diseases, thereby exacerbating respiratory symptoms [10, 11]. High-risk groups include individuals living in hot and humid environments; those with non-modifiable characteristics such as the elderly, children, pregnant women, individuals with diabetes or impaired sweating; those with modifiable risk factors such as alcohol use, excessive physical activity, or infections; individuals with obesity; those working in hot conditions (outdoor workers, athletes, military personnel); and individuals using certain medications such as beta-blockers, anticholinergics, or diuretics [11]. As summarized in Table 1, heat exposure is associated with a wide spectrum of heat-related illnesses and systemic health impacts, ranging from mild conditions such as heat cramps and heat syncope to severe and life-threatening conditions such as heat stroke, cardiovascular collapse, and multi-organ failure. The table also highlights vulnerable population groups, clinical symptoms, and potential complications associated with each condition.

Table 1. Heat-related illnesses and health impacts in humans.

Condition / Disease	Symptoms	Vulnerable groups	Risks / Complications	Ref
Heat cramps	Muscle spasms, muscle pain (commonly in legs and arms), excessive sweating	Heavy laborers, athletes, outdoor workers	Electrolyte imbalance; may progress to heat exhaustion if untreated	[2–4]
Heat exhaustion	Fatigue, dizziness, nausea, rapid heart rate, moist skin, hypotension	Elderly, outdoor workers, dehydrated individuals	May progress to heat stroke (life-threatening)	[10, 11]
Heat stroke	Body temperature >40°C, altered consciousness, seizures, hot dry or moist skin	Elderly, young children, individuals with underlying conditions, outdoor workers	High mortality, multi-organ failure (brain, liver, kidneys)	[11, 12]
Dehydration	Thirst, dry mouth, reduced urination, dark urine, fatigue	Children, elderly, outdoor workers	Acute kidney injury, electrolyte imbalance	[10, 11, 13]

Condition / Disease	Symptoms	Vulnerable groups	Risks / Complications	Ref
Heat syncope	Dizziness, fainting when standing in the sun for prolonged periods	Elderly, non-acclimatized individuals	Falls, secondary injuries	[2, 11, 14]
Heat-related cardiovascular disease	Chest pain, shortness of breath, increased heart rate, hypertension or hypotension	Individuals with cardiovascular disease, elderly	Myocardial infarction, stroke, death	[11, 15]
Respiratory diseases (asthma, COPD)	Shortness of breath, cough, wheezing, worsened symptoms in hot weather	Children, individuals with chronic respiratory diseases	Acute asthma attacks, respiratory failure	[10, 11]
Heat-related kidney injury	Fatigue, edema, reduced urine output	Outdoor workers, farmers, laborers	Acute or chronic kidney failure	[10, 11, 16]
Heat-related skin diseases (rash, dermatitis)	Rash, itching, redness, blisters	Children, individuals in hot and humid environments	Secondary skin infections	[11, 13]
Heat-sensitive infectious diseases	Fever, diarrhea, dengue fever (increases during hot seasons)	Children, individuals in densely populated urban areas	Disease outbreaks	[11, 15]
Mental health disorders	Insomnia, irritability, anxiety, depression	Individuals with mental illness, those in difficult living conditions	Reduced quality of life, increased suicide risk	[11, 15]
Heat-related pregnancy complications	Preterm birth, low birth weight, stillbirth (based on studies)	Pregnant women	Long-term impacts on newborns	[17]
Heat-related occupational injuries	Reduced concentration, dizziness while working	Outdoor workers, construction, agriculture	Occupational accidents, injuries	[11, 13]
Reduced labor productivity	Fatigue, reduced concentration, exhaustion	All workers, especially outdoor workers	Income loss, economic impacts	[11, 14]

2. Current Situation and Risk Warnings of Heat Impacts on Human Health in Vietnam

2.1. Current situation.

Hot weather in Vietnam typically occurs during the summer months (approximately May to August), with temperatures in many areas exceeding 35–40°C. Prolonged heatwaves create oppressive conditions with high humidity, leading to dehydration, heat-related illnesses, and adverse health effects. Regions such as Northern and Central Vietnam often experience the most intense heatwaves. Vietnam's tropical monsoon climate, rapid urbanization, and a substantial proportion of outdoor workers increase its vulnerability to extreme heat. A study conducted in eight provinces of Vietnam reported that for every 1°C increase above a threshold, the risk of hospitalization rises [18]. In Hanoi, research has shown that hospital admissions for mental disorders may be triggered or exacerbated under hot weather and heatwave conditions [19]. In Ho Chi Minh City, hospitalizations due to mental and behavioral disorders during 2017–2019 were also found to be associated with heatwaves [20]. Heat exposure may further increase the risk of accidents (due to reduced concentration, fatigue, mild heat illness, and harsh working conditions) among residents in Hanoi [21]. In 2022, Vietnam was estimated to have lost 16 billion potential working hours due to heat exposure, resulting in an estimated income loss of USD 23 billion [8]. These figures indicate that heat is not only a health issue but also a livelihood risk, potentially leading to indirect health consequences such as poor nutrition, stress, and reduced access to healthcare [22]. In addition, heat in Vietnam increases the risk of infectious diseases by creating favorable conditions for vectors (e.g., Aedes mosquitoes causing dengue fever, extended malaria seasons) and coastal bacteria such as *Vibrio*, in the context of climate change and urbanization [8].

2.2. Warning levels of heat impact.

A semi-quantitative risk stratification approach has been used to assess heat warning levels across provinces and cities in Vietnam. The warning levels are constructed based on a combination of indicators, including summer climate characteristics, heat exposure levels, urbanization factors, and related health risks. Specifically, input variables include average summer temperature, likelihood of prolonged heatwaves, air humidity, topographic features, population density, degree of urbanization, and the urban heat island effect. The data used for risk classification were synthesized from the Department of Climate Change report on climate change impacts in Vietnam [7], the Vietnam Data Sheet 2023 of the Lancet Countdown [8], and the Climate Change and Sea Level Rise Scenarios for Vietnam (MONRE, 2020) [9]. A semi-quantitative Heat Risk Index (HRI) was used to support the classification of warning levels. The index was calculated as:

$$HRI = (T + HW + H + PD + UHI)/5$$

where T is the summer temperature score, HW is the heatwave frequency score, H is the relative humidity score, PD is the population density score, and UHI is the urban heat island score.

Areas with higher temperatures, high humidity, dense populations, and extensive built-up (concrete) surfaces are classified as higher risk. Each province or city is categorized using a five-level warning scale, ranging from Level 1 (very low risk) to Level 5 (very high risk). Mountainous and highland regions, which generally have lower baseline temperatures and are less affected by urban heat island effects, are classified at lower levels. In contrast, major urban centers, industrial zones, densely populated plains, and southern regions are assigned higher warning levels due to prolonged heat exposure, high humidity, and the capacity for nighttime heat retention. The final classification is derived by combining climate zone assessments with adjustments for urbanization factors, providing a more accurate reflection of actual health risks associated with heat exposure.

As shown in Figure 2, extreme heat in Vietnam is affecting multiple provinces with varying intensity levels. The highest risk level (Level 5) is concentrated in major urban areas and the southern region, including Ho Chi Minh City, Dong Nai, Tay Ninh, Can Tho, An Giang, Dong Thap, Vinh Long, and Ca Mau. In these areas, prolonged high temperatures combined with high humidity and the urban heat island effect significantly increase the risk of heat stroke and cardiovascular diseases. High-risk areas (Level 4) are observed in the North Central and Central Coastal regions (Thanh Hoa, Nghe An, Ha Tinh, Quang Tri, Hue, Da Nang, Quang Ngai, Khanh Hoa), largely due to the influence of hot, dry winds (Lao winds) and intense solar radiation. Northern plains and urban areas such as Hanoi, Hai Phong, Bac Ninh, and Hung Yen fall into the moderate–high risk category (Level 3–4), where dense construction contributes to heat retention. Meanwhile, midland and highland provinces (Level 2–3), and northern mountainous areas such as Lai Chau, Dien Bien, Lao Cai, and Son La (Level 1–2), face lower risks but are still affected in the context of rising temperatures.

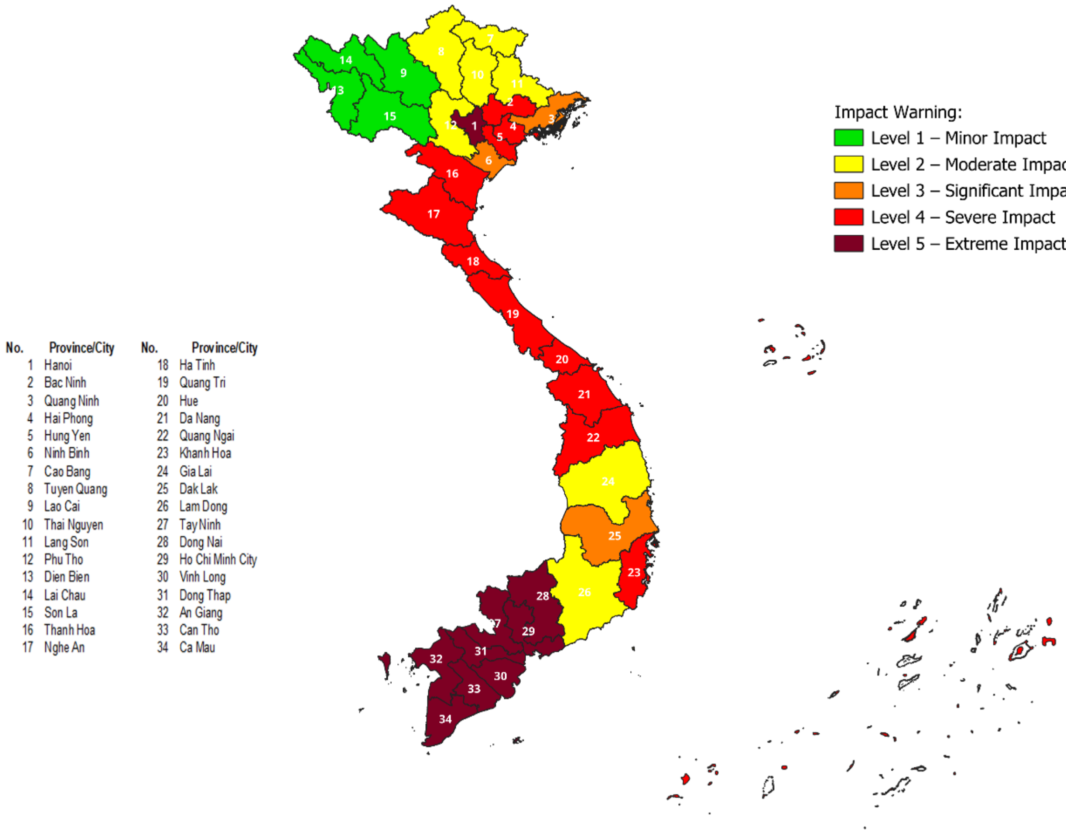

Figure 2. Map of heat risk warning levels across provinces and cities in Vietnam.

3. Recommended Solutions

3.1. For vulnerable groups.

Population groups vulnerable to heat exposure face varying levels of risk due to differences in physiological characteristics, living conditions, and exposure levels, thus requiring tailored intervention recommendations. Elderly individuals, young children, people with chronic diseases, and outdoor workers are considered the highest-priority groups due to impaired thermoregulation, increased risk of dehydration, cardiovascular and renal events, and prolonged heat exposure. Recommended measures for these groups include ensuring a cool living environment, maintaining adequate hydration, limiting outdoor activities during peak heat hours, and monitoring early symptoms. Pregnant women, individuals with mental health disorders, and low-income households living in heat-prone housing conditions are also at high risk due to physiological changes, limited self-care capacity, or restricted access to cooling resources. For these groups, it is important to promote rest, minimize heat exposure, provide support for monitoring, and utilize low-cost cooling solutions. Overall, this stratification highlights the need to prioritize the protection of the most vulnerable populations in order to minimize the health impacts of extreme heat. As summarized in Table 2, vulnerable populations can be categorized based on risk level, physiological sensitivity, and exposure intensity, along with corresponding preventive measures tailored to each group.

Table 2. Vulnerable groups to heat exposure and recommended preventive measures.

Vulnerable Group	Recommendations	Impact Level
Elderly	Stay in cool places; drink water regularly; avoid going out during peak heat hours; monitor for dizziness/heat exhaustion; have family members check 2–3 times per day during heatwaves	Very high
Children/infants	Do not leave children in hot enclosed spaces; increase fluid intake (age-appropriate); wear light clothing; reduce outdoor activities; watch for fever and lethargy	Very high
Pregnant women	Avoid extreme heat; rest frequently; maintain hydration; limit heavy labor; seek medical care immediately if experiencing dizziness, fainting, or severe headache	High
People with chronic diseases (cardiovascular, renal, respiratory, etc.)	Prioritize cool environments; maintain hydration as advised; avoid exertion; do not self-adjust medications; seek medical care if experiencing shortness of breath, chest pain, or confusion	Very high
Outdoor/heavy labor workers	Schedule work in early morning or late afternoon; take breaks every 45–60 minutes; follow the “water–shade–rest” principle; use appropriate protective gear; replenish electrolytes when sweating heavily	Very high
People with mental disorders/under treatment	Avoid prolonged heat exposure; ensure adequate sleep and hydration; remind to drink water; monitor agitation/insomnia; contact healthcare facilities if symptoms worsen	High
Low-income households / heat-prone housing	Improve ventilation, use curtains/shading, apply water-based cooling methods; prioritize access to cooler public spaces when possible; monitor elderly and children	High

3.2. General recommendations.

High-priority measures such as adequate hydration, periodic rest following the “water–rest–shade” principle, and water-based cooling not only have strong evidence but are also supported by clear and practical guidance, including drinking 1.5–2 liters of water per day, resting after 45–60 minutes of labor, and cooling areas such as the neck, armpits, and groin. These measures demonstrate high feasibility at both individual and community levels. Measures with moderate evidence but still strongly recommended—such as avoiding outdoor exposure during peak heat hours, wearing light and breathable clothing, and monitoring meteorological warnings—are also accompanied by specific guidance, including limiting outdoor activities from 10 a.m. to 4 p.m., using appropriate clothing, and tracking “feels-like” temperature, thereby enhancing preventive effectiveness when properly implemented. Meanwhile, conditional measures such as electrolyte replacement or avoiding sudden temperature changes should be applied depending on specific circumstances such as heavy labor conditions or air-conditioned environments.

As illustrated in Figure 3, heat adaptation strategies can be categorized into different priority levels based on their effectiveness, feasibility, and evidence strength, ranging from high-priority core interventions to conditional supportive measures. In the emergency management of heat stroke, international medical organizations emphasize the critical importance of rapid and continuous cooling initiated at the scene. According to the European Resuscitation Council, the “Cool and Run” approach is recommended, in which the patient should be actively cooled immediately until the core body temperature drops below 39°C, with a safe and effective cooling rate of greater than 0.10°C per minute. Monitoring vital signs following the ABC sequence (Airway, Breathing, Circulation) is essential to promptly address life-threatening dysfunctions [23]. Similarly, the National Athletic Trainers’ Association (NATA) in the United States emphasizes that cooling must begin on-site, be maintained throughout transport, and continue at the hospital until the core body temperature is reduced to 38.3–38.9°C [24].

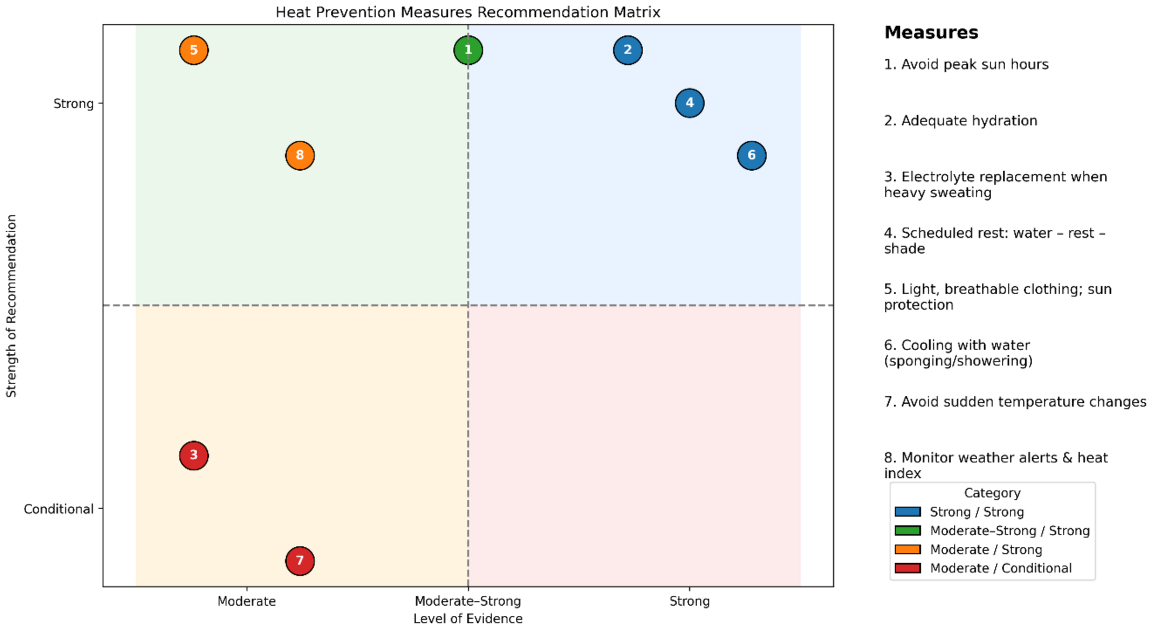

Figure 3. Priority levels of heat adaptation solutions.

In line with this, Singapore's medical practice guidelines highlight three key principles: rapid cooling, stabilization of the patient's condition, and continuous cooling even during transport to healthcare facilities [25]. Several studies have proposed microclimate cooling systems as an innovative approach. These systems are based on active cooling principles and are designed for both prevention and supportive treatment of heat-related conditions. They typically create a localized cool microenvironment around the body or directly act on the skin, enabling rapid and effective thermoregulation in harsh conditions such as outdoor heat exposure, military operations, or industrial settings. Heatstroke emergency tents are a typical example of microclimate applications. These tents combine continuous mist spraying with forced-air ventilation, generating airflow near the skin that enhances sweat evaporation and rapidly reduces body temperature. This method has been shown to be as effective as, or nearly comparable to, cold-water immersion in lowering core temperature in heat stroke patients [26]. Personal liquid cooling garments are another solution, designed with tubing systems that circulate cold fluid in close contact with the skin via a mini pump. Studies have demonstrated that such liquid cooling systems significantly improve heat tolerance and extend safe working time in high-temperature environments [27, 28]. Fan-assisted cooling garments offer a lighter and more portable alternative. These garments use small fans mounted on the sides to draw in outside air and circulate it through the clothing. The airflow promotes sweat evaporation from the skin, enabling natural cooling without the need for cooling fluids. The fabric is typically designed to retain cool air and enhance evaporative efficiency. Research shows that these fan-integrated garments effectively reduce skin temperature and improve thermal comfort under harsh working conditions [29]. In Australia, instant cold packs such as Qwik Ice have been used as a convenient, on-demand cooling solution. These products consist of a dual-compartment package: an outer polyethylene bag containing 120 g of urea and an inner pouch containing 60 ml of water. When activated by striking the center of the pack, the inner pouch breaks, allowing water to react with urea and produce rapid cooling. The pack can then be applied to the body for first aid in heat exposure, pain relief, fever reduction, or support for sports injuries such as sprains and muscle strains. The simple composition of urea and water, without ammonium nitrate, ensures safety during use.

Microclimate-based personal and localized cooling solutions demonstrate significant potential as complementary measures to traditional heat prevention strategies, particularly for outdoor workers, military personnel, and emergency responders exposed to extreme heat. Compared with conventional approaches, these systems provide active and rapid cooling, enhance heat dissipation, improve thermal comfort, help maintain work performance, and reduce the risk of heat-related illnesses. These technologies share a common principle of enhancing heat dissipation through forced convection, evaporation, or conductive heat transfer, thereby enabling rapid cooling and maintaining thermal balance in the body. Compared to passive measures, microclimate systems offer advantages in rapid response, flexibility, and applicability in extreme environments such as outdoor labor, military operations, or emergency rescue. However, large-scale implementation requires consideration of cost, availability, accessibility, and proper user training, especially in low-income settings. Therefore, these solutions should be regarded as effective complementary tools, combined with fundamental measures such as adequate hydration, appropriate rest, and avoidance of excessive heat exposure, in order to optimize strategies for protecting human health against heat.

4. Conclusion

Extreme heat is becoming an increasingly serious challenge to public health in Vietnam in the context of climate change and rapid urbanization. Evidence indicates that heat exposure not only causes acute conditions such as heat exhaustion and heat stroke but also exacerbates many chronic diseases, contributing to increased risks of hospitalization and mortality. These impacts are particularly pronounced among vulnerable groups such as the elderly, children, pregnant women, and outdoor workers. Heat-related risks vary significantly across regions, with the highest levels concentrated in major urban areas, the southern region, and the Central Coastal region, where prolonged high temperatures, high humidity, and the urban heat island effect intensify exposure. In addition to health impacts, extreme heat also leads to substantial losses in labor productivity and economic output, increasing the burden on healthcare systems and social welfare. In response to this situation, strengthening adaptation measures is essential. Priority should be given to raising public awareness, protecting vulnerable populations, adjusting working conditions and schedules, improving living environments, and enhancing early warning systems. At the same time, the application of appropriate cooling solutions tailored to Vietnam's context can help improve prevention effectiveness and mitigate the impacts of extreme heat. In the short term, priority should be given to strengthening heat-health warning systems, raising public awareness, and protecting vulnerable populations. In the long term, integrating heat adaptation into urban planning, occupational health policies, and public health strategies will be essential to enhance resilience to increasing heat exposure in Vietnam. This review is subject to several limitations, including regional heterogeneity in available data and the limited availability of nationwide heat-related health surveillance data in Vietnam. Future studies should strengthen national monitoring systems and generate more comprehensive evidence on the health impacts of heat exposure across different regions and population groups.

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Author Contribution

Nguyen Thi Thu Thuy: Conceptualization, Methodology, Writing; Đao Nguyen Manh, Quach Thi Quynh: Methodology, Data Collection; Pham Thi Phuong Lien, Tran Thanh Tuan, Chu Duc Thanh: Data Collection, Supervision; Do Thi Thuy Trang, Trinh Quang Minh, Vu Thi Loan: Data Collection, Review and editing; Nguyen Van Thanh: Review and editing, Data Analysis.

Competing Interest

The authors declare no competing interests.

References

[1] Li, M. (2024). Research on the effects of extreme heat exposure on human health. *Theoretical and Natural Science, 29,* 194−199. https://doi.org/10.54254/2753-8818/29/20240777.

[2] Ryu, J.H.; Min, M.K. (2021). Diagnosis and treatment of patients with heat-related illnesses. *Journal of the Korean Medical Association*, *64*, 296–302. https://doi.org/10.5124/jkma.2021.64.4.296.

[3] Boonruksa, P.; Maturachon, T.; Kongtip, P.; Woskie, S. (2020). Heat stress, physiological response, and heat-related symptoms among Thai sugarcane workers. *International Journal of Environmental Research and Public Health*, *17*, 6363. https://doi.org/10.3390/ijerph17176363.

[4] Tripp, B.L.; Winkelmann, Z.K.; Eberman, L.E.; Smith, M.S. (2021). Factors affecting incidence rate of exertional heat illnesses: Analysis of 6 years of high school football practices in North Central Florida. *Orthopaedic Journal of Sports Medicine*, *9*, 23259671211026627. https://doi.org/10.1177/23259671211026627.

[5] McCloskey, B.; Memish, Z.; Sharma, A.; Traore, T.; Parker, S.; Zumla, A. (2024). Confronting heat-related illnesses and deaths at mass gathering religious and sporting events. *The Lancet Planetary Health, 8,* e522−e523. https://doi.org/10.1016/s2542-5196(24)00161-x.

[6] Heat and health. (accessed on 4 March 2026) Available online: https://www.who.int/news-room/fact-sheets/detail/climate-change-heat-and-health.

[7] Impacts of climate change in Vietnam. (accessed on 4 March 2026) Available online: https://dcc.gov.vn/en/Impacts-of-climate-change-in-Vietnam.

[8] Vietnam Data Sheet 2023. (accessed on 4 March 2026) Available online: https://lancetcountdown.org/resource/data-sheet-for-vietnam/

[9] Climate change and sea level rise scenarios for Vietnam. (accessed on 4 March 2026) Available online: http://www.imh.ac.vn/files/doc/2017/CCS%20final.compressed.pdf.

[10] Crowe, J.; Nilsson, M.; Kjellstrom, T.; Wesseling, C. (2015). Heat-related symptoms in sugarcane harvesters. *American Journal of Industrial Medicine*, *58*, 541–548. https://doi.org/10.1002/ajim.22450.

[11] Savioli, G.; Zanza, C.; Longhitano, Y.; Nardone, A.; Varesi, A.; Ceresa, I.F.; Manetti, A.C.; Volonnino, G.; Maiese, A.; La Russa, R. (2022). Heat-related illness in emergency and critical care: Recommendations for recognition and management with medico-legal considerations. *Biomedicines*, *10*, 2542. https://doi.org/10.3390/biomedicines10102542.

[12] Garcia, C.K.; Renteria, L.I.; Leite-Santos, G.; Leon, L.R.; Laitano, O. (2022). Exertional heat stroke: Pathophysiology and risk factors. *BMJ Medicine*, *1*, e000239. https://doi.org/10.1136/bmjmed-2022-000239.
[13] Taggart, S.M.; Girard, O.; Landers, G.J.; Wallman, K.E. (2024). Heat exposure as a cause of injury and illness in mine industry workers. *Annals of Work Exposures and Health*, *68*, 325–331. https://doi.org/10.1093/annweh/wxae011.
[14] Fortington, L.V.; Goode, N.; Finch, C.F.; Salmon, P.M. (2022). Heat and sun related medical concerns in Australian led outdoor activities: A three-year prospective study. *Journal of Outdoor and Environmental Education, 25,* 145–157. https://doi.org/10.1007/s42322-022-00094-1.
[15] Daniel, D.; Jaladara, V.; Suciningsih, R.; Tan, X.R.; Tan, P.M.S.; Mahendradhata, Y.; Lee, J.K.W. (2026). Urban heat stress and adolescent health: Impacts and adaptation strategies in Indonesia. *Scientific Reports*, *16,* 4960. https://doi.org/10.1038/s41598-025-34800-y.
[16] Hamzah, N.A.; Azli, M.S.; Anua, S.M.; Abdul Samad, N.I.; Mohd Nawi, M.N.; Mamat, M.N. (2022). Evaluation of environmental heat exposure, heat-related symptoms, and acute physiological changes among farmers in Pasir Puteh and Bachok, Kelantan. *Journal of Energy and Safety Technology*, *5*, 21–30. https://doi.org/10.11113/jest.v5n1.103.
[17] Chersich, M.F.; Pham, M.D.; Areal, A.; Haghighi, M.M.; Manyuchi, A.; Swift, C.P.; Wernecke, B.; Robinson, M.; Hetem, R.; Boeckmann, M.; Hajat, S. (2020). Associations between high temperatures in pregnancy and risk of preterm birth, low birth weight, and stillbirths: Systematic review and meta-analysis. *BMJ*, *m3811*. https://doi.org/10.1136/bmj.m3811.
[18] Tran, N.Q.L.; Ngo, H.K.T.; Tuong Vy, N.T.; Dang, T.N.; Nghiem, S.; Nguyen, H.Q.; Phung, D. (2023). The association between high ambient temperature and risk of hospitalization: A time-series study in eight ecological regions in Vietnam. *Environmental Research: Health*, *1*, 045003. https://doi.org/10.1088/2752-5309/ace646.
[19] Trang, P.M.; Rocklöv, J.; Giang, K.B.; Kullgren, G.; Nilsson, M. (2016). Heatwaves and hospital admissions for mental disorders in Northern Vietnam. *PLOS ONE*, *11*, e0155609. https://doi.org/10.1371/journal.pone.0155609.
[20] Dang, T.N.; Vy, N.T.T.; Thuong, D.T.H.; Phung, D.; Van Dung, D.; Le An, P. (2022). Main and added effects of heatwaves on hospitalizations for mental and behavioral disorders in a tropical megacity of Vietnam. *Environmental Science and Pollution Research*, *29*, 59094–59103. https://doi.org/10.1007/s11356-022-19898-1.
[21] Le, V.T.H.; Berman, J.D.; Wattenberg, E.V.; Ngo, T.V.; Tran, Q.A.; Alexander, B.H. (2024). Temperature-related emergency injury visits in Hanoi, Vietnam. *Injury Prevention*, *30*, 33–38.
[22] Climate Change 2022: Impacts, Adaptation and Vulnerability – Fact Sheet: Health; IPCC. (accessed on 4 March 2026) Available online: https://www.ipcc.ch/report/ar6/wg2/downloads/outreach/IPCC_AR6_WGII_FactSheet_Health.pdf.
[23] Zideman, D.A.; Singletary, E.M.; De Buck, E. (2021). European Resuscitation Council Guidelines 2021: First Aid – Treatment of exertional heat stroke. *Resuscitation*, *161*, 265–283.
[24] Casa, D.J.; Demartini, J.K.; Bergeron, M.F.; Csillan, D.; Eichner, E.R.; Lopez, R.M.; Ferrara, M.S.; Miller, K.C.; O'Connor, F.; Sawka, M.N.; Yeargin, S.W. (2015). National Athletic Trainers' Association position statement: Exertional heat illnesses. *Journal of Athletic Training*, *50*, 986–1000. https://doi.org/10.4085/1062-6050-50.9.07.
[25] Sim, J.D.W.; Lee, J.K.W. (2023). A History of Heat Health Management Policies in the Singapore Military. *Healthcare*, *11*, 211. https://doi.org/10.3390/healthcare11020211.
[26] Douma, M.J.; Aves, T.; Allan, K.S.; Bendall, J.C.; Berry, D.C.; Chang, W.-T.; Epstein, J.; Hood, N.; Singletary, E.M.; Zideman, D.; Lin, S.; Borra, V.; Carlson, J.N.; Cassan, P.; Charlton, N.P.; Markenson, D.S.; Meyran, D.; Sakamoto, T.; Swain, J.M.; Woodin, J.A. (2020). First aid cooling

techniques for heat stroke and exertional hyperthermia: A systematic review and meta-analysis. *Resuscitation*, *148*, 173–190. https://doi.org/10.1016/j.resuscitation.2020.01.007.

[27] Selkirk, G.A.; McLellan, T.M.; Wong, J. (2004). Active versus passive cooling during work in warm environments while wearing firefighting protective clothing. *Journal of Occupational and Environmental Hygiene*, *1*, 521–531. https://doi.org/10.1080/15459620490475216.

[28] Pomares-Hernández, C.; Zuluaga-García, E.A.; Escorcia Salas, G.E.; Robles-Algarín, C.; Sierra Ortega, J. (2021). Computational modeling of passive and active cooling methods to improve PV panels efficiency. *Applied Sciences*, *11*, 11370. https://doi.org/10.3390/app112311370.

[29] Geetha, N.B.; Velraj, R. (2013). Novel concept of PCM-based thermal storage integration in active and passive cooling systems for energy management in buildings. *Energy Engineering*, *110*, 41–66. https://doi.org/10.1080/01998595.2013.10594635.