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The Impact of Global Warming on the Rise in Heat-Related Illnesses in Emergency Medical Services

Korakot Apiratwarakul[1], Lap Woon Cheung[2,3], Chatkhane Pearkao[4], Kamonwon Ienghong[1]

[1]Department of Emergency Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand; [2]Accident & Emergency Department, Princess Margaret Hospital, Kowloon, Hong Kong; [3]Emergency Medicine Unit, Li Ka Shing Faculty of Medicine, The University of Hong Kong, Pokfulam, Hong Kong; [4]Department of Adult Nursing, Faculty of Nursing, Khon Kaen University, Khon Kaen, Thailand

Correspondence: Kamonwon Ienghong, Department of Emergency Medicine, Faculty of Medicine, Khon Kaen University, 123 Mittraphap Road, Mueang Khon Kaen District, Khon Kaen, 40002, Thailand, Tel +66 46 366 869, Fax +66 43 366 870, Email Kamonwan@kku.ac.th

Purpose: Global warming is one of the critical problems affecting health, society, and the economy. High temperatures are linked to an increase in heat-related illnesses, which have significantly impacted the public health system, particularly emergency medical services (EMS). Analyzing the pattern of heat-related illness cases in EMS can improve resource utilization and preparedness within the public health system.

Patients and Methods: A retrospective study was conducted on EMS data from Srinagarind Hospital, Thailand, covering the summer months (February to May) from 2020 to 2024. Patients with heat-related illnesses were identified in the EMS database using the 10th revision of the International Classification of Diseases (ICD-10) version 2019, specifically codes under "T67 Effects of Heat and Light", which include heat stroke, heat syncope, heat cramps, heat exhaustion, and heat fatigue.

Results: A total of 136 EMS operations from the hospital's database were analyzed. In the summer 2024 group, 95.7% (N=44) of the patients were male. The majority of EMS triage cases required resuscitation (P = 0.020). Outdoor activity was identified as a significant factor related to heat illness, with rates of 83.3%, 92.9%, 93.3%, 97.1%, and 93.5% over the five years of the study. The activation time was 1.30 minutes for the summer of 2024 and 1.24 minutes for the summer of 2023. Notably, the average scene time in the summer 2024 group was significantly longer at 25.2 minutes, compared to 12.0 minutes in the summer 2020 group (P<0.001).

Conclusion: Outdoor activity was the most significant risk factor associated with increased heat-related illnesses. Other contributing factors included male gender, age between 20–40 years, scene temperatures above 35°C, and prolonged scene times exceeding 15 minutes.

Keywords: global warming, healthcare policy, heat illness, prehospital emergency care

Introduction

An increase in the average temperature of the air near the earth's surface and the oceans is commonly referred to as global warming.[1–3] Since the second decade of the 20th century, average temperatures have been rising, and these changes are expected to impact health, society, and the economy.[4–6] The United Nations (UN) has identified global warming as one of the urgent issues that must be addressed sustainably by member countries. In certain regions, surface temperatures have risen by more than ten degrees Celsius above average, which is particularly disruptive to health, especially for those working outdoors.[7] Previous studies have shown that the fatality rate is increasing, with heat being a major contributing factor.[8,9] In the economic sphere, agricultural output has significantly decreased, affecting both household and national income.[7] The long-term effects will be felt throughout the nation's public health system. In terms of public health, food shortages driven by global warming increase the risk of nutritional problems. Additionally, increased rainfall raises the risk of disasters such as floods, mudslides, and infectious diseases, which have particularly affected the public health system, including emergency medical services (EMS).[10–12]

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In Thailand, patients can access EMS by calling 1669, which provides round-The-clock assistance. The operator gathers basic information to assess the severity of the patient's symptoms, categorizes the case based on the national telephone triage level, and dispatches the nearest ambulance unit to provide care and assistance.[13–15] According to statistics from the country's meteorological department, average temperatures are rising in all regions of Thailand, and rainfall patterns have shifted significantly. These changes will impact EMS operations. Therefore, analyzing the patterns of heat-related illness cases in EMS can improve resource utilization, preparedness in the public health system, and inform future policy development.

Material and Methods

This study used data from patients transported to Srinagarind Hospital in Thailand via EMS. As the medical school and advanced tertiary care facility for northeast Thailand, the hospital handles around two thousand EMS operations annually. It operates with two motorcycles and six van ambulances to provide emergency services.

Data Collection

Thailand has three distinct seasons: summer, the rainy season, and winter. This study included patients who received EMS during the summer months (February to May) from 2020 to 2024. Patients who could not be located or had incomplete information were excluded from the study.

Temperature data were provided by the Thai Meteorological Department (Khon Kaen, Thailand), with daily averages recorded at 1:00 PM used for analysis.

Heat-related illnesses range in severity from mild to life-threatening. Heat stroke is the most severe heat-related illness, characterized by a core temperature above 40°C and central nervous system abnormalities. Heat exhaustion occurs when there is a lack of salt or water, leading to fatigue and decreased physical activity. Heat syncope is the symptom of dizziness or fainting in a hot environment, and heat cramps is the symptom of painful muscle spasms during exercise in the heat.[16] However, heat-related illnesses in this study were defined according to diagnoses in the EMS database using the 10th revision of the International Classification of Diseases (ICD-10) version 2019, specifically under "T67 Effects of Heat and Light", which includes heat stroke, heat syncope, heat cramps, heat exhaustion, and heat fatigue.

Activation time was defined as the period from dispatch to the vehicle being en route. Response time was measured from when the 1669-center (Thailand's command and control center) received the call to when the EMS team arrived at the scene. Scene time was defined as the duration between the ambulance's arrival at the patient's location and its departure. One synchronized clock at the dispatch center was used to track time for the study, and EMS activities were monitored via telemedicine. The duration of each operational process was recorded in the EMS database.

Data collected included demographic information such as diagnosis, EMS operation times, gender, age, type of illness, and EMS triage level. Two independent investigators with over ten years of EMS experience organized and documented the information, ensuring no duplicate entries. In cases of data discrepancies, a senior emergency physician was consulted to obtain the correct data.

Sample Size

A formula was used to determine the sample size for the study.[17] Using information from a previous study,[13] an estimate for the proportion (P) was calculated. Based on this, the authors determined that the required sample size would be 83.

Statistical Analysis

The participants' characteristics and demographics were the focus of a descriptive analysis. IBM SPSS for Windows, version 27.0 (IBM Corp., Armonk, New York, USA), licensed from Khon Kaen University, was used for statistical analysis. Means and standard deviations were reported for continuous data, while percentages were used for categorical data. For univariate analysis, the Chi-squared test was used to compare groups, and the two-sample *t*-test was applied to numerical data.

Results

In this study, a total of 136 EMS operations from the hospital's database were analyzed over a five-year period, with the characteristics shown in Table 1. A total of 95.7% (N=44) of participants were male in the summer 2024 group. The

Table 1 Demographics of the Study Population in Summer Months (N=136)

	2020 (N=12)	2021 (N=14)	2022 (N=30)	2023 (N=34)	2024 (N=46)	*p*-value
Gender, Male (%)	10 (83.3)	12 (85.7)	27 (90.0)	32 (94.1)	44 (95.7)	0.863
Age, mean (SD), years	20.2 (2.3)	19.3 (2.5)	20.1 (3.2)	20.3 (2.3)	24.3 (3.1)	0.910
EMS triage (%)						0.020
Resuscitation	6 (50.0)	8 (57.1)	18 (60.0)	20 (58.8)	35 (76.1)	
Urgent	6 (50.0)	6 (42.9)	12 (40.0)	14 (41.2)	11 (23.9)	
Activity of patients (%)						0.780
Outdoor	10 (83.3)	13 (92.9)	28 (93.3)	33 (97.1)	43 (93.5)	
Indoor	2 (16.7)	1 (7.1)	2 (6.7)	1 (2.9)	3 (6.5)	
EMS diagnosis (%)						0.015
Heat stroke	0 (0.0)	1 (7.1)	4 (13.3)	7 (20.6)	10 (21.7)	
Heat syncope	1 (8.3)	2 (14.3)	10 (33.3)	12 (35.3)	15 (32.6)	
Heat cramp	3 (25.0)	3 (21.4)	8 (26.7)	10 (29.4)	11 (23.9)	
Heat exhaustion	8 (66.7)	8 (57.2)	8 (26.7)	5 (14.7)	10 (21.8)	
EMS operation, mean (SD), Min						<0.001
Activation time	1.20 (0.2)	1.25 (0.3)	1.30 (0.2)	1.24 (0.3)	1.30 (0.2)	
Response time	9.02 (3.5)	9.20 (3.2)	10.01 (4.2)	10.25 (4.5)	10.30 (4.1)	
Scene time	12.0 (2.3)	14.2 (3.2)	14.5 (2.8)	22.0 (7.4)	25.2 (10.1)	
Scene temperature (SD), Celsius	33.2 (1.2)	35.4 (1.1)	38.5 (1.5)	41.2 (1.1)	43.5 (1.2)	0.852
CPR on EMS (%)	0 (0.0)	0 (0.0)	1 (3.3)	3 (8.8)	5 (10.9)	0.022

Abbreviations: SD, standard deviation; EMS, emergency medical services; Min, minute; CPR, cardiopulmonary resuscitation.

majority of EMS triage cases were at the resuscitation level (P=0.020). Outdoor activity was the primary factor related to heat illness, accounting for 83.3%, 92.9%, 93.3%, 97.1%, and 93.5% of cases across the five years of the study. The activation time, representing the interval between dispatch and ambulance departure, was 1.30 minutes for summer 2024 and 1.24 minutes for summer 2023. Notably, the average scene time in the summer 2024 group was significantly longer at 25.2 minutes, compared to 12.0 minutes in the summer 2020 group (P<0.001).

After adjusting for confounding factors, the risk factors associated with heat illness in EMS patients are shown in Table 2. Outdoor activity was the most significant risk factor for increased heat illness (adjusted odds ratio [OR] 4.22,

Table 2 Multivariable Analysis of Heat-Illness Patients on EMS (N=136)

	Adjusted OR (95% CI)	*p*-value
Outdoor activity	4.22 (3.99–4.53)	<0.001
Male	3.02 (2.84–3.27)	0.020
Age 20–40 years	2.20 (1.85–2.51)	0.035
Scene temperature > 35 Celsius	2.06 (1.92–2.30)	0.038
Scene time > 15 minute	1.85 (1.60–2.10)	0.042

Abbreviation: OR, odd ratio.

95% CI: 3.99–4.53, P<0.001). Additional factors associated with heat illness in this study included male gender (OR 3.02), age 20–40 years (OR 2.20), scene temperature above 35°C (OR 2.06), and prolonged scene time of more than 15 minutes (OR 1.85).

Discussion

This study aimed to illustrate the characteristics of patients with heat-related illnesses transported by EMS, which have increased over the last five years. Due to significant temperature changes, the study focuses on the summer months (February to May). Consequently, there has been a rise in the number of patients utilizing EMS for heat-related illnesses. The EMS database indicates that no patients in Thailand used EMS for heat-related illnesses during the winter or rainy season. Thailand's proximity to the equator, which results in year-round heat and humidity, may explain this trend, as the nation's citizens are able to adapt to the effects of global warming.[18]

In terms of gender, almost all patients with heat-related illnesses who use EMS are male. This aligns with earlier research showing that men are more likely than women to engage in outdoor activities, such as exercise and construction work, which increases their risk of heat-related illnesses.[19,20]

The majority of patients in the study were in their 20s, which is consistent with previous research showing that heat-related illnesses are more common among both younger and older age groups.[21–23] In Thailand, this pattern is observed in the legal system and among adolescents. Additionally, new police officers and soldiers undergo training, often outdoors, during the summer. Furthermore, the hospital's location in this study plays a key role in receiving patients from military field training exercises.

Regarding the severity of the patients' conditions, it was found that over the course of the five-year study, there was a tendency toward more severe illness. Various factors could contribute to this. For instance, the high temperatures make it more difficult for the police to practice outside of buildings than in the past. As a result, patients' conditions worsen, requiring more resources for treatment during ambulance transport.[24,25]

It was found that most patients participated in outdoor activities, which exposed them to higher temperatures. The heat from the sun overwhelms the body's cooling system, making it difficult to cope with environmental demands. According to this study, outdoor activities carried the highest risk of heat illness (adjusted OR 4.22). A key outdoor event, particularly during Thailand's summer months, is the Songkran Festival, where people splash water on each other-an important part of Thai culture. Because people spend a lot of time doing this outdoor activity in high temperatures during the summer, it can contribute to heat illness.

In terms of diagnosis, there has been an increasing trend of patients with heat stroke, particularly in the current year, significantly impacting the severity of cases and requiring advanced management in ambulances.[24,26,27] As a result, the treatment of heat stroke patients during transport has intensified. Core body temperature must be measured, and patients require ample fluids and cooling with towels to reduce body temperature.[28,29] Patients may present with seizure and therefore may require airway and breathing management with seizure control. Patients with severe heat stroke often require more time at the scene than usual. It was found that the proportion of patients with severe symptoms increased over the past year, leading to extended on-site time for EMS crews due to the complexity of care required.

This analysis shows that over the last five years, the average temperature at incident sites has increased by more than ten degrees Celsius annually. All of these issues are linked to the effects of global warming. It is crucial for EMS policymakers to prepare for shifts in patient patterns, increased demand for medical resources in ambulances, and the need for more complex procedures to deliver timely care.[30,31] To prevent heat-related illnesses, collaboration between EMS, hospital managers, and the general public is necessary to identify contributing factors and develop effective prevention strategies.

There are some obvious limitations to this study. First, because the study was conducted retrospectively, some data were missing or insufficient. Furthermore, because the study focuses on a single EMS system, its results may be difficult to generalize to other contexts. Our study disregarded the relative humidity and heat index, which may influence the risk of heat illness. Our study focused on the EMS operations time, which did not include the EMS procedure at the scene, or the resources used; additional research should be conducted to investigate the utilization of resources used in heat-related illness patients. Finally, several variables influence EMS operation times, which may not have been completely accounted for in this analysis.

Conclusion

Global warming has contributed to the rise in heat-related illnesses in EMS cases. Outdoor activity was the most significant risk factor associated with increased heat illness. Other factors included male gender, age 20–40 years, scene temperatures above 35°C, and prolonged scene times exceeding 15 minutes.

Abbreviations

UN, United Nations; EMS, emergency medical services; ICD-10, 10th revision of the International Classification of Diseases; SD, standard deviation; Min, minute; CPR, cardiopulmonary resuscitation; OR, odds ratio.

Data Sharing Statement

The data sets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethics Approval and Informed Consent

This study was approved by the Khon Kaen University Ethics Committee for Human Research (HE671413), in accordance with the Declaration of Helsinki and the ICH Good Clinical Practice Guidelines. Informed consent was not required, as patient privacy was protected through the use of a unique study number.

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Author Contributions

All authors made significant contributions to the work reported, whether in conception, study design, execution, data acquisition, analysis, and interpretation, or in all of these areas. They participated in drafting, revising, or critically reviewing the article, gave final approval of the version to be published, agreed on the journal to which the article has been submitted, and agreed to be accountable for all aspects of the work.

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Disclosure

The authors report there are no conflicts of interest in this work.

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