

การเฝ้าระวังการเสียชีวิตที่เกี่ยวข้องกับความร้อนในประเทศไทย

ระหว่างปี 2561-2566

Surveillance of heat related deaths in Thailand during 2018-2023

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บทคัดย่อ

การเปลี่ยนแปลงของสภาพภูมิอากาศที่ร้อนขึ้นได้นำมาซึ่งผลกระทบทั่วโลกในแง่ของการเสียชีวิตที่เกี่ยวข้องกับความร้อน ประเทศไทยก็ได้รับผลกระทบในลักษณะ วัตถุประสงค์ของการวิจัยนี้คือเพื่อรายงานอัตราการเสียชีวิตของบุคคลที่เกี่ยวข้องกับสภาพอากาศร้อนในประเทศไทยระหว่างปี พ.ศ. 2561-2566 ข้อมูลถูกรวบรวมจากฐานข้อมูลเฝ้าระวังการเสียชีวิตที่เกี่ยวข้องกับความร้อนของกองระบาดวิทยา กรมควบคุมโรค ตั้งแต่ปี พ.ศ. 2561 ถึง 2566 ข้อมูลได้รับการวิเคราะห์รายปีโดยใช้สถิติเชิงพรรณนา ความแตกต่างของอัตราการเสียชีวิตในแต่ละปีได้รับการวิเคราะห์โดยใช้สถิติโค-สแควร์ และการกระจายตัวของการเสียชีวิตถูกสังเกตโดยใช้ QGIS ผลวิจัยพบว่า มีผู้เสียชีวิตที่เกี่ยวข้องกับความร้อนทั้งหมด 139 ราย โดยมีอัตราส่วนเพศชายต่อเพศหญิงอยู่ที่ 7.2:1 ค่ามัธยฐานของอายุคือ 53 ปี โดยกลุ่มอายุ 51-60 ปี และ 60 ปีขึ้นไปมีอัตราการเสียชีวิตสูงสุด อาชีพที่ต้องทำงานกลางแจ้งพบว่ามีความสัมพันธ์กับสถานที่เสียชีวิต นอกจากนี้ยังพบว่ามีโรคประจำตัว เช่น โรคเบาหวานและโรคหัวใจ และหลอดเลือดในกลุ่มนี้ การเสียชีวิตที่เกี่ยวข้องกับความร้อนในแต่ละปีแสดงความแตกต่างอย่างมีนัยสำคัญทางสถิติ ($p < 0.001$, $\alpha = 0.05$) สรุปว่าแนวโน้มการเสียชีวิตจากภาวะที่เกี่ยวข้องกับความร้อนในประเทศไทยเพิ่มขึ้นทุกปีตามอุณหภูมิที่สูงขึ้น ปัจจัยที่เกี่ยวข้อง ได้แก่ เพศชาย ผู้ที่ทำงานกลางแจ้ง ผู้สูงอายุ และผู้ที่มีประวัติโรคเรื้อรังถูกรายงานในกรณีการเสียชีวิตที่เกี่ยวข้องกับความร้อน

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Abstract

The increasing global warming has led to severe consequences in terms of heat-related deaths. More recently, Thailand has also experienced similar impacts from global warming. The objective of this research

is to report the mortality rates of individuals related to hot weather conditions in Thailand during the period of 2018–2023. The data were collected from the surveillance database of heat-related deaths at the Epidemiology Division, Department of Disease Control from 2018 to 2023. The data were analyzed annually using descriptive statistics. Differences of mortality rates in each year were analyzed by the Chi-square test, and the distribution of deaths was observed using QGIS. There were 139 heat-related deaths, with a male-to-female ratio of 7.2:1. The median age was 53 years, with the age group of 51–60 years and 60 years and older having the highest mortality rates. Occupations involving outdoor work were reported as the location of death. Underlying diseases such as diabetes and cardiovascular diseases were also reported in this group. Deaths related to heat in each year showed a statistically significant difference ($p < 0.001$, $\alpha = 0.05$). In conclusion, the trend of deaths from heat-related conditions in Thailand increased each year with rising temperatures. Males, outdoor workers, the elderly, and those with underlying health conditions were predominantly reported in the heat-related death cases.

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คำสำคัญ

การเฝ้าระวัง, การเสียชีวิตที่เกี่ยวข้องกับความร้อน, สภาพอากาศร้อน

Keywords

surveillance, heat-related deaths, hot weather

Introduction

The term “the death related to heat stroke or heat-related illness” refers to a condition where the core body temperature exceeds 40 degrees Celsius ($^{\circ}\text{C}$) causing abnormal functioning of the nervous system, leading to symptoms such as dizziness, seizures, and loss of consciousness.⁽¹⁾ The term “Heat associated death” as defined by the surveillance definition of heat-related illness from the Centers for Disease Control and Prevention (CDC), refers to deaths occurring during hot weather seasons where the cause of death is unknown, and the deceased persons have history of exposure to high temperatures, either through work or various activities both indoors and outdoors.⁽²⁾

According to a study published in the journal Nature Climate Change, conducted by 70 researchers using data from major epidemiological projects and climate model simulations in 43 countries, it was found that deaths related to heat globally between 1991 and 2018, on average, 37% were attributable to changes in weather conditions or global warming resulting from human activities.⁽³⁾ These activities include the emission of greenhouse gases that degrade the Earth’s atmosphere, leading to broad-ranging health impacts on humans. The global situation of deaths related to heat revealed that between 1998 and 2017, there were over 166,000 fatalities worldwide due to heat-related conditions. In 2003, countries in

the European region accounted for over 70,000 deaths from heat, with notably around 56,000 fatalities reported in the Russian Federation during 44-day period of high temperatures.⁽⁴⁾ Additionally, between 1973 and 2003, the United States had approximately 8,015 deaths attributed to heat-related causes, with the highest number of fatalities occurring in July–August 2006 in the state of California, with 140 deaths reported.⁽⁵⁾

Most International heat-related death surveillance systems have been found to be a passive surveillance systems, reporting from hospitals where patients were admitted or diagnosed in emergency departments based on symptoms and entering ICD-10 codes related to heat-related deaths into relevant agencies in each country.^(6,7) In some countries, like the United States, the state of Florida has been capturing heat-related situation data using Google search technology to assist in monitoring heat-related death reports.⁽⁸⁾

In Thailand, the surveillance system for monitoring deaths related to heat has two main monitoring system: 1) passive surveillance, which does not monitor or report from health facilities, but data reports from various provinces through email, phone calls from relevant epidemiological officers, online media in the form of Web Scraping, managed by the Bureau of Epidemiology, Department of Disease Control. and 2) Event-based surveillance programs of the Department of Disease Control which reports suspected heat-related deaths, both individual and group reported from district/provincial public health offices, Disease Prevention and Control Offices (DPOs), and other agencies Epidemiological officers verify, collect, and compile from these two data sources before analyzing and presenting it in various

formats to networks and the public. In the 2019, according to the surveillance data, there were as many as 57 deaths attributed to heat-related conditions, with a mortality rate of 0.09 per 100,000 population.⁽⁹⁾ The trend of heat-related deaths in Thailand has been increasing, particularly due to the geographical location of the country in the hot tropical region of Southeast Asia, which experiences hot weather. The criteria for assessing hot weather conditions are as follows: "Hot weather" refers to temperatures between 35.0–39.9°C, while "extreme heat" means temperatures of 40.0°C and above.⁽⁷⁾ Such temperature conditions contribute to heat-related fatalities. Deaths related to heat in Thailand continue to be underreported due to similarities with natural cause of deaths or unclear causes of death, often resulting in unspecified or loosely attributed causes such as "unknown" or conditions associated with the victim's health, such as heart disease or stroke. Therefore, there is a need for interdisciplinary studies, including environmental forensics, which utilize chemical and physical tools along with various statistical data gathered through environmental surveys and weather conditions to ascertain causes of death.⁽⁸⁾ This approach is complemented by forensic epidemiology, which applies epidemiological knowledge concerning risk factors and disease distribution in populations, including both communicable (infectious) and non-communicable diseases (environmental factors or various accidents), to clearly identify affected populations and risks, thus facilitating clearer identification of causes of death and their implications for legal proceedings.⁽¹⁰⁾

The objective of this study was to investigate general data and mortality rates of heat-related deaths in Thailand during the years 2018–2023.

Materials and Methods

Study Population and Data Sources

This study was a descriptive research study that analyzed general data such as gender, age, occupation, underlying health conditions, risk behaviors, and the distribution of deceased individuals categorized by provinces. The data retrieved into this study were secondary data. The received data were categorized as follows: 86 (61.9%) deaths from email, phone call with attachment to Hotweather related illness and deaths surveillance report (HWS-1) from relevant epidemiology officers, 44 (31.7%) from online media reports and 9 (6.4%) deaths were identified via the Event-based surveillance program. The data covered the period from March 2018 to June 2023. These data were recorded and initially analyzed from the surveillance system for heat-associated deaths by the Epidemiology Bureau, Department of Disease Control. The definition of heat-associated deaths to report was as follows: “Unspecified causes of death during the summer season, particularly among individuals with history of significant heat exposures from both indoor and outdoor work or activities, are monitored in accordance with the Meteorological Department’s announcements regarding the annual onset of summer in Thailand⁽¹¹⁾ with attached Hot-weather related illness and deaths surveillance report (HWS-1). Therefore, based on the definition, this surveillance system monitored only during the summer season in Thailand did not provide year-round coverage. It operated as an event-based reporting system, not a passive surveillance system that gathered data from hospitals. The ethical considerations of this study had been reviewed and approved by the Human Research Ethics Committee, Department of Disease Control (Certificate Number FWA00013622,

Certified on December 28th, 2023).

Data analysis

Observation of demographic data such as gender, age, occupation, marital status, pre-existing medical conditions, and symptoms processed at the time of death. Descriptive analysis represented the percentages, averages, standard deviations, medians, and maximum–minimum values. Discovering of the mortality rate performed a calculation by using the formula: Mortality rate = (Number of deaths in 4 months in each year × 100,000) //population at risk in 4 months in each year. The categorical variables were analyzed using the Chi-square test. Additionally, the distribution of deaths reportedly varied by provinces in Thailand using QGIS software.

Results

Demographics data:

From the surveillance data of heat-related deaths from the Bureau of Epidemiology, Department of Disease Control, from 2018 to 2023, there were a total of 139 deaths reported, 86 (61.9%) deaths from email with attached Hot-weather related illness and deaths surveillance report (HWS-1) from relevant epidemiology officers, 44 (31.7%) from online media reports and 9 (6.4%) deaths were identified via the Event-based surveillance program.

In all, 122 were male (87.8%) and 17 were female (12.2%), with a male-to-female ratio of 7.2:1.0. The median age was 53 years. The lowest age was 3 years old and the oldest age was 83 years old. When classified by age groups, the highest number of deaths was found in the 51–60 years and 60 years and above groups, with 38 deaths per group. These were followed by the 41–50 years group, which accounted for 35 deaths, and the 31–40 years group

for 18 deaths. The highest number of deaths by occupation was among those not specified for 57 deaths, followed by laborers 33 deaths , farmers 17 deaths , and homeless 12 deaths (Table 1).

Risk behaviors of the deceased were found to include regular alcohol consumption 28 cases, alcohol consumption and smoking 10 cases, activities or outdoor working 9 cases, regularly smoking 5 cases, and smoking and drug use 1 case. When classifying risk behaviors by demographics data, it was found that males had more risk behavior than that of females, 87.8%. The age groups with the highest prevalence of risk behaviors were 51-60 years and 60 years and above, having more risky than other age groups, 27.33% (Table 2).

Data of conditions showed that 46 of the deceased had underlying health conditions, 25 had no conditions, and 68 were unknown or not specified. The most common were hypertension 21 cases, followed by diabetes 10 cases, coronary artery disease 6 cases, and asthma 5 cases. When categorizing the conditions by risk behaviors, regular alcohol consumption, outdoor work, and smoking were the most prevalent risk behaviors with conditions, more

than other risk behaviors (Table 3).

The top 10 provinces with the highest number of deaths were Chonburi 11 cases, followed by Chiang Mai and Buriram 8 cases, Lopburi and Udon Thani 7 cases, Phrae 6 cases, Lampang and Samut Prakan 5 cases, and Prachinburi and Suphanburi 4 cases. In the year 2019, the highest number of deaths was 57 cases, and the highest number of patients in Chiang Mai 6 cases (Figure 3).

The locations of death were found to be outdoors or outside, such as in fields, on roadsides, under trees, totally 82 cases (59.0%). Indoor, such as bathrooms, garages, accounted for 57 cases (41.0%) (Table 1).

The causes of death among the 139 deceased individuals were unspecified or unknown causes 26 cases, deaths from cardiovascular diseases (heart and blood vessel diseases) 19 cases, deaths to Heat Stroke 7 cases, Heat cramp effects 1 case, and effects of heat and light 1 case.

The position of the deceased was mostly lying down, such as lying on their back, face down, or on their side, tally 104 cases (74.8%) and the other 6 cases (4.3%) were found in a sitting position.

Table 1. Demographic data of heat-related deaths during 2018-2023.

Characteristic	Year						Total
	2018 N=18 (%)	2019 N=57 (%)	2020 N=12 (%)	2021 N=7 (%)	2022 N=8 (%)	2023 N=37 (%)	
Gender							
Male	17 (94.4)	47 (82.5)	9 (75.0)	7 (100.0)	8 (100.0)	34 (91.9)	122 (87.8)
Female	1 (5.6)	10 (17.5)	3 (25.0)	0 (0.0)	0 (0.0)	3 (8.1)	17 (12.2)
Age (yrs.)							
≤30	0 (0.0)	1 (1.8)	0 (0.0)	0 (0.0)	0 (0.0)	2 (5.4)	3 (2.1)
31-40	2 (11.1)	13 (22.8)	1 (8.3)	1 (14.3)	0 (0.0)	1 (2.7)	18 (12.9)
41-50	6 (33.3)	11 (19.3)	0 (0.0)	3 (42.9)	4 (50.0)	11 (29.7)	35 (25.2)
51-60	1 (5.6)	17 (29.8)	4 (33.3)	1 (14.3)	1 (12.5)	14 (37.8)	38 (27.3)
>60	8 (44.4)	13 (22.8)	6 (50.0)	2 (28.6)	3 (37.5)	6 (16.2)	38 (27.3)
Unspecified	1 (5.6)	2 (3.5)	1 (8.3)	0 (0.0)	0 (0.0)	3 (8.1)	7 (5.0)

Table 1. Demographic data of heat-related deaths during 2018–2023. (Continue)

Characteristic	Year						Total N=139(%)
	2018 N=18 (%)	2019 N=57 (%)	2020 N=12 (%)	2021 N=7 (%)	2022 N=8 (%)	2023 N=37 (%)	
Occupation							
General employee	6 (33.3)	13 (22.8)	0 (0.0)	3 (42.9)	1 (12.5)	10 (27.0)	33 (23.7)
Agriculture	3 (16.7)	4 (7.0)	4 (33.3)	0 (0.0)	2 (25.0)	4 (10.8)	17 (12.2)
Private sector workers	1 (5.6)	2 (3.5)	1 (8.3)	0 (0.0)	1 (12.5)	0 (0.0)	5 (3.6)
Salesman	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (5.4)	2 (5.4)
Private business	1 (5.6)	2 (3.5)	1 (8.3)	0 (0.0)	0 (0.0)	0 (0.0)	4 (2.9)
Selling old things	0 (0.0)	2 (3.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (5.4)
Businessperson	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.7)	1 (0.7)
Student	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.7)	1 (0.7)
Monk	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.7)	1 (0.7)
Unemployed	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.7)	1 (0.7)
Security guard	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.7)	1 (0.7)
Civil servant	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (5.4)	2 (5.4)
Homeless	6 (33.3)	5 (8.8)	0 (0.0)	1 (14.3)	0 (0.0)	5 (13.5)	17 (12.2)
Unspecified	1 (5.6)	29 (50.9)	6 (50.0)	3 (42.9)	4 (50.0)	9 (24.3)	52 (37.4)
Underling health condition							
Absence	2 (11.1)	8 (14.0)	5 (41.7)	0 (0.0)	1 (12.5)	9 (24.3)	25 (18.0)
Presence	5 (27.8)	22 (38.6)	4 (33.3)	1 (14.3)	2 (25.0)	12 (32.4)	46 (33.1)
Unspecified	11 (61.1)	27 (47.4)	3 (25.0)	6 (85.7)	5 (62.5)	16 (43.2)	68 (48.9)
Location							
Outdoor	9 (50.0)	31 (54.4)	7 (58.3)	5 (71.4)	7 (87.5)	23 (62.2)	82 (59.0)
Indoor	9 (50.0)	26 (45.6)	5 (41.7)	2 (28.6)	1 (12.5)	14 (37.8)	57 (41.0)
Table 2. Risk behaviors of heat-related deaths during 2018–2023.							
	Risk behaviors N=139,(%)						Unspecified N=85 (%)
	Alcohol drinking N=28 (%)	Alcohol drinking with Smoking N=10 (%)	Outdoor activity N=2 (%)	Outdoor working N=8 (%)	smoking N=5 (%)	Smoking with drug abuse N=1 (%)	
Gender							
Male	27 (96.4)	10 (100.0)	1 (50.0)	7 (87.5)	5 (100.0)	1 (100.0)	71 (83.5)
Female	1 (3.6)	0 (0.0)	1 (50.0)	1 (12.5)	0 (0.0)	0 (0.0)	14 (16.5)
Age group (yr.)							
≤30	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (3.6)
31–40	6 (21.4)	2 (20.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	10 (11.8)
41–50	9 (32.1)	3 (30.0)	0 (0.0)	2 (25.0)	3 (60.0)	1 (100.0)	17 (20.0)
51–60	8 (28.6)	2 (20.0)	1 (50.0)	2 (25.0)	2 (40.0)	0 (0.0)	23 (27.1)
>60	4 (14.3)	3 (30.0)	1 (50.0)	4 (50.0)	0 (0.0)	0 (0.0)	26 (30.6)

Table 2. Risk behaviors of heat-related deaths during 2018–2023. (Continue)

	Risk behaviors N=139,(%)						
	Alcohol drinking N=28 (%)	Alcohol drinking with Smoking N=10 (%)	Outdoor activity N=2 (%)	Outdoor working N=8 (%)	smoking N=5 (%)	Smoking with drug abuse N=1 (%)	Unspecified N=85 (%)
Underline health condition							
Absence	10 (17.9)	6 (60.0)	0 (0.0)	0 (0.0)	1 (20.0)	0 (0.0)	7 (8.2)
Presence	5 (17.9)	3 (30.0)	0 (0.0)	4 (50.0)	4 (80.0)	1 (100.0)	29 (34.1)
Unspecified	13 (46.4)	1 (10.0)	1 (50.0)	4 (50.0)	0 (0.0)	0 (0.0)	49 (57.6)

Table 3. The underling health conditions crossed with risk behaviors of heat-related deaths during 2018–2023.

Underling health Condition	Risk behaviors (N=139,(%))						
	Alcohol Drinking N=28 (%)	Alcohol Drinking with smoke N=10 (%)	Outdoor activity N=2 (%)	Outdoor working N=8 (%)	Smoking N=5 (%)	Smoking with drug abuse N=1 (%)	Unknow/ Unspecified N=85 (%)
Hypertension							
Absence	24	10 (100.0)	2 (100.0)	6 (75.0)	2 (40.0)	1 (100.0)	73 (85.9)
Presence	4	0 (0.0)	0 (0.0)	2 (25.0)	3 (60.0)	0 (0.0)	12 (14.1)
Diabetes							
Absence	28	10 (100.0)	2 (100.0)	7 (87.5)	2 (40.0)	1 (100.0)	79 (92.9)
Presence	0 (0.0)	0 (0.0)	0 (0.0)	1 (12.5)	3 (60.0)	0 (0.0)	6 (7.1)
Coronary artery disease							
Absence	27 (96.4)	10 (100.0)	2 (100.0)	7 (87.5)	3 (60.0)	1 (100.0)	83 (97.6)
Presence	1 (3.6)	0 (0.0)	0 (0.0)	1 (12.5)	2 (40.0)	0 (0.0)	2 (2.4)
Asthma							
Absence	27	10 (100.0)	2 (100.0)	8 (100.0)	5 (100.0)	1 (100.0)	81 (95.3)
Presence	1 (3.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (4.7)

Data analysis of the proportion of heat-related deaths each year

From the data analysis of the proportion of heat-related deaths each year from 2018 to 2023 showed that the number of deaths varied annually.

The highest number of deaths occurred in the year 2019 was 57 cases (41%). The lowest was in the year 2021 having 7 cases, (5.1%). The number of deaths in each year, had significantly different with a *p*-value of less than 0.001 ($\alpha=0.05$) (Table 4).

Table 4. Data analysis of the proportion of heat-related deaths between years.

Year	N (%)	χ^2	p-value
2018	18 (12.9)	85.417	<0.001*
2019	57 (41.0)		
2020	12 (8.6)		
2021	7 (5.1)		
2022	8 (5.8)		
2023	37 (26.6)		

*Chi-square test (Goodness of fit), significant at $\alpha=0.05$

The Mortality Rate

Based on surveillance data collected during the summer seasons of 2018 to 2023 (March–June), in accordance with the Thai Meteorological Department’s announcements, the data analyses of heat-related deaths and mortality rates discovered unstable trend. The highest was observed in the year 2019, the number of deaths decreased in the years 2020 to 2022, and then increased again in 2023 (Figure 1). When analyzing the number of deaths compared to the maximum temperatures each year, an increasing

trend in deaths with rising temperatures was found, especially in April 2019, where the highest temperature was 44.2 degrees Celsius and found with the highest number of deaths in 27 cases. Similarly, in April 2023 found the highest temperature at 44.6 degrees Celsius where the number of deaths was 17 cases (Figure 2). Regional distribution data indicated that heat-related deaths were found in all regions of Thailand, where the lowest death tolls were in the southern region (Figure 3).

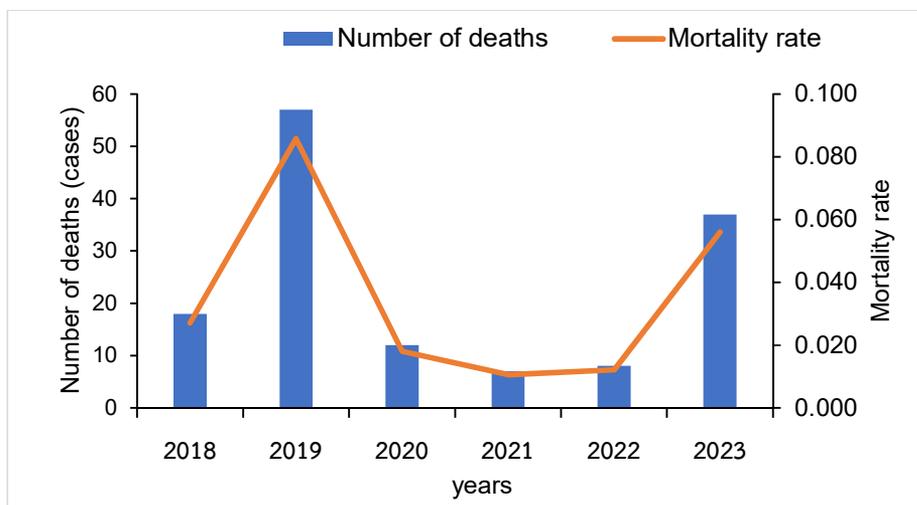


Figure 1. Number of deaths and Mortality rate of heat-related deaths during in 2018–2023.

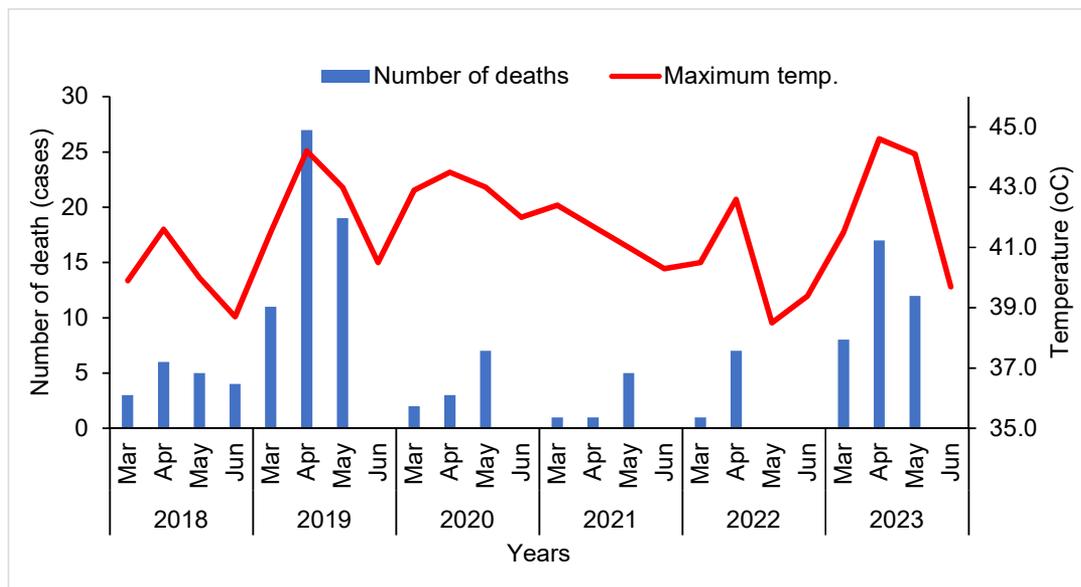


Figure 2. Number of deaths with heat-related deaths compared to temperature in each month during 2018–2023.

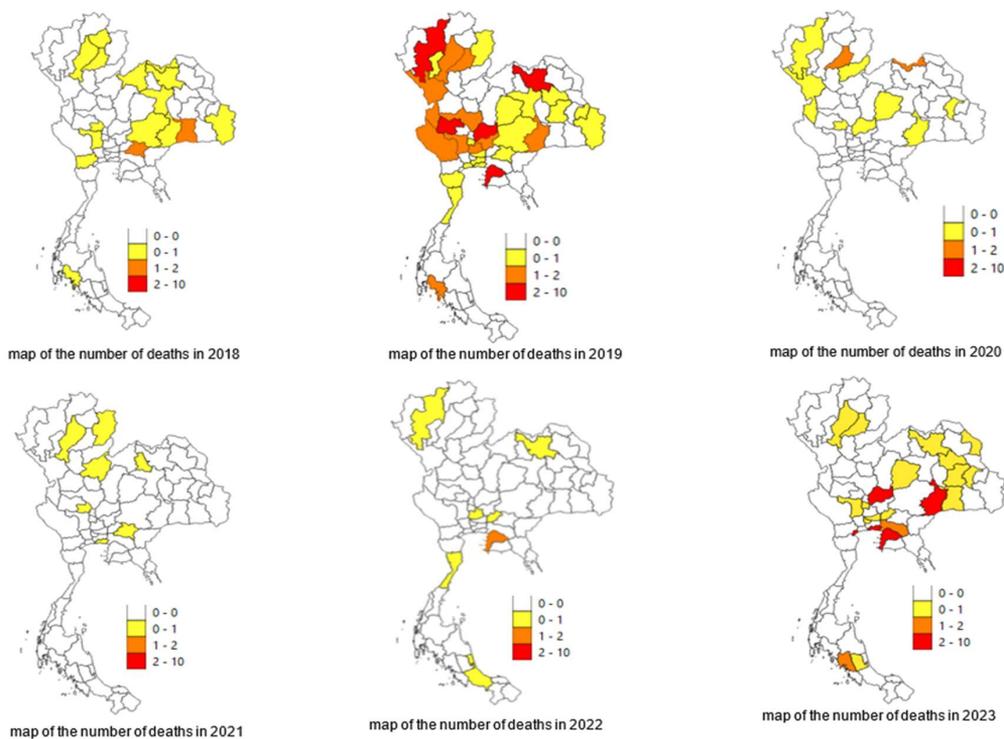


Figure 3. Thailand’s map of heat-related deaths during 2018–2023.

Discussion

A study of the surveillance system for heat-related deaths in Thailand from 2018 to 2023 found that the majority of deaths were among males, similar study of Shaohua Gu et al.⁽¹²⁾ The elderly group affected mostly is in the age group 51–60 years and 60 years and above, more than other age groups, similar finding of Masafumi KUZUYA.⁽¹³⁾ It has been noted that the elderly are more prone to illness or death from heatstroke compared to other groups due to their decreased physiological response to temperature changes. Their sweat exudate or heat dissipation may be more or less than other age groups. Additionally, dehydration in the elderly is a concern because some have irregular excretion, frequent urination at night, which can lead to excessive water loss during the day when exposed to high temperatures. If the lost water is not adequately replenished, this can lead to serious health issues. Part of occupation, the majority found are unspecified occupation, followed by laborers and agricultural workers, consistent with the findings of other studies by Supharerk Thawillarp.⁽¹⁴⁾ It is anticipated that the majority of these occupations involve outdoor work, with average working hours predominantly during the daytime when temperatures are highest. Additionally, the fact that most of the deceased had conditions such as hypertension, diabetes, cardiovascular diseases, and asthma might be a contributing factor to their higher risk of death, similar to the study of Kongkiat Kulkantrakorn,⁽¹⁵⁾ which indicates that physiological responses to extreme heat can lead to death when body temperature exceeds the limit, causing an increased heart rate and blood viscosity, which reduces blood flow to the brain. This is particularly critical for those with pre-existing conditions, as they are more sensitive to extreme heat.

The majority of deaths occur outdoors rather than inside buildings or homes, similar to study of Sally Ann Iverson et al.⁽¹⁶⁾ with more death tolls occurring outdoors compared to indoors.

Regarding the risk behaviors of the deceased, the most common was the absence of specified risk behaviors, followed by regular alcohol consumption, and the combined habit of regular alcohol consumption and smoking, similar to the findings of other studies Natthita Thepnarin,⁽¹⁷⁾ which found that the behavior of drinking alcohol and smoking was more prevalent in this group compared to others, based on the results of the heat injury prevention program for new soldiers in the Army.

The statistical analysis of the number of heat-related deaths each year revealed a significant difference in the number of deaths between years, with $p < 0.001$. This indicated that the number of heat-related deaths might vary significantly each year, potentially depending on climatic factors or annual temperatures, as well as the reporting of data to the surveillance system. From 2020 to 2022, fewer heat-related deaths were reported (Table 4), likely due to the global COVID-19 pandemic. Thailand had to manage and control COVID-19, and the personnel responsible for reporting heat-related deaths were the same as those handling COVID-19 duties. Consequently, their workload increased beyond normal circumstances, and they were unable to monitor or report other diseases as usual.⁽¹⁸⁾ Additionally, the COVID-19 pandemic led to a reduction in the incidence of other communicable and non-communicable diseases and other health hazards. The mortality rate in 2019, was higher than that in other years. When compared to the temperatures of each year, it was found that the number of deaths and

mortality rates corresponded with the increasing temperatures each year. The distribution of deaths by provinces and regions showed that, Chonburi province, which is in the central region, had the highest number of deaths. However, an analysis of the distribution by provinces (Figure 3) indicated that deaths were reported in every region of Thailand, particularly in the northern, central, and northeastern regions, with consistently reporting of deaths every year, except for the southern region, which reported fewer death tolls than other regions. Most of the death causes were unspecified or unknown, followed by 19 deaths from cardiovascular disease, and only 9 deaths were specifically identified as related to heat conditions. Therefore, it is necessary to continue studying the heat-related death surveillance in Thailand in the future.

Conclusion

The number of heat-related deaths were found significantly differences across each year with $p < 0.001$. Overall, there was a trend of increasing death tolls from heat-related causes in Thailand each year, correlating with higher temperatures. Males were more likely to die from heat-related conditions when compared to females. Occupational groups working outdoors or exposing to outdoor environments confronted with higher risks. Elderly individuals and those with conditions were also at increased risk of heat-related fatalities. Heat-related deaths had been reported from all regions and provinces of Thailand, Therefore, preventing measures, warnings, and monitoring systems should be taken to focus at high-risk groups to reduce fatalities. The primary cause of death in many cases remained undetermined or unknown.

Recommendation

1) There should have clear policies and measures for preventing and monitoring diseases related to heat-related death, including comprehensive training and education, especially targeted high-risk groups, to enable self-protection.

2) There should have set guidelines for ICD-10 on diagnosis, reporting, identifying causes of death, and recording data due to the significant number of cases where information is unknown or unspecified.

3) There should have collaboration with relevant agencies, which is crucial for integrating data collection, including surveillance information and death certificates or autopsy reports (if available), to ensure timely and accuracy of the disease control and prevention measures.

Limitations

1) Surveillance the data of heat-related deaths is a passive surveillance system and is not legally mandated for reporting officially. This may lead to under-reporting coverage the number of deaths or cases. Therefore, there should have a policy to encourage relevant areas or agencies to continuously report into the system.

2) This surveillance system monitoring by Meteorological Department's announcements regarding the annual onset of summer in Thailand, thus its scope dose not cover a year-round. Furthermore, the calculated mortality rates should be used to analyze trends in heat-related deaths for the same specific period of each year in Thailand, and should not be directly compared with the all-cause annual mortality rates.

3) As the retrieved data are secondary data some values may have been missing and incomplete

such as underlying diseases, place of death, alcohol consumption, drug use or any activity related to heat. As the result, it is essential to closely monitor and verify to ensure that the data completeness and accuracy must be kept.

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