EnvironmentAsia
The international journal by the Thai Society of Higher Education Institutes on Environment

EnvironmentAsia 12(1) (2019) 83-92
DOI 10.14456/ea.2019.10
ISSN 1906-1714; ONLINE ISSN: 2586-8861

Trends of Heat-Related Mortality and Association with Weather Variables in the Northeast, Thailand

Thiwakorn Rachutorn[1]*, Benjawan Twatsupa[2], Uraiwan Inmuong[3]

[1]*Public Health Program, Faculty of Public Health, Khon Kean University, Thailand*

[2]*Division of Health Impact Assessment, Department of Health, Ministry of Public Health, Thailand*

[3]*Department of Environmental Health Occupational Health and Safety, Faculty of Public Health,Khon Kean University, Thailand*

* Corresponding author : thiwakorn.ph7@gmail.com
Received: March 15, 2018; Accepted: August 7, 2018

Abstract

Heat-related morbidity and mortality are recognized as public health threat. However, little evidence has been reported for cause-specific mortality from heat. The aims of this study is to explore trends in diseases of heat-related mortality in the northeast among selected specific-cause mortality, in the Northeast Thailand. We used a national database from the Strategy Planning Division, Ministry of Public Health for cause-specific mortality from heat in 4 groups including malignant neoplasm, diseases of the circulatory system, diseases of the respiratory system, diseases of the genitourinary system. Daily weather data provided by the Meteorological Department included temperature, humidity, precipitation, and wind speed for twenty provinces in the northeastern region of Thailand from 2006 to 2015. Joinpoint regression analysis and Poisson regression model was used for estimation the effect of heat on mortality. Results, the trend of annual specific-cause mortality increased with the Annual Percent Change (APC) of 7.74% of Malignant neoplasm, 9.80% for diseases of respiratory system, 12.03% for diseases of the circulatory system and 2.16% for diseases of the genitourinary system. A one-degree Celsius increase with the daily mean temperature was significantly associated with a 16% risk in all included mortalities used as an indicator for heat-related mortality (95% CI IRR= 1.11-1.21, p-value =<0.001), A one-degree Celsius increase in the daily maximum temperature was significantly associated with a 9% decreased risk in the same mortality (95% CI IRR=0.88-0.96, p-value < 0.001). In conclusion, trend analysis showed that heat-related mortality increased significantly during the period. Increased in daily temperature were positively associated with mortality in the northeast of Thailand. This suggested that there is a need to initiate any public health prevention and climate change adaptation from heat as to reduce the adverse effects of heat extremes on health.

Keywords: Health and climate change impact; Heat-related mortality; High temperature; Northeast Thailand

1. Introduction

The association between high temperature and mortality and morbidity is well established and being a public health concern in many part of the world (Basu, 2009; Heaviside *et al.,* 2016; Mo *et al.*, 2014).Extreme temperature has adverse health impacts, including higher rates of all-cause mortality and cardiovascular, respiratory, stroke, ischemic heart disease mortality and emergency hospitalizations (Chen *et al.,* 2017, Li *et al.*, 2017). Furthermore, highest-ever temperature in India killed people more than 2,500 in the summer, 2015.The latest assessment report revealed that there would be more frequent hot weather over most land areas on daily and seasonal timescales as the mean of global temperature increased (IPCC, 2014). Heat waves pose a great threat to human health and increase the morbidity and mortality from cardiovascular, cerebrovascular, respiratory, and heat-related illness (Basu, 2009; Tan *et al.*, 2007; Ye *et al*.,2012). Impact of climate change on excessive heat and extreme weather can cause the development of heatstroke can cause the development of heatstroke, heat exhaustion, heat cramps, heat syncope, heat edema and heat rush. Heat can cause severe dehydration, acute cerebrovascular accidents and contribute to thrombogenesis. It can further aggravate chronic pulmonary conditions, cardiac conditions, kidney disorders, psychiatric illness, diseases of the genitourinary system and malignant neoplasm or lung (WHO, 2015).

The projections is estimated that approximately 90,000 heat-related deaths worldwide in 2030 and more than 25,000 in 2050 (Simon Hales, 2007). Thus, heat has been identified as a public health concern in many part of the world. Consequently, developing public health plans, it is to reduce the deleterious health impact from heat is urgent. To develop such plans, it is necessary to have comprehensive and in-depth understanding of the adverse effects of extreme heat in a local text, because the health effects vary depending on the climate change and population. However, few studies have estimated the impact of heat on causes of death in Thailand (Tawatsupa *et al.,* 2014; Guo *et al.,* 2012) . Among completed studies to the authors' knowledge, the results have shown a statistically significant association between temperature and mortality in Thailand (Tawatsupa, 2014) and that 20 percent of workers experienced occupational heat stress (Tawatsupa, 2013). Thailand is also projected to have a high temperature in the future.Over thirty-two percentage of Thai population live in the northeast region in twenty provinces (Department of Provincial Administration, 2016). The Climate in the northeast is topical regions, with hot dry summers and rainy. During the summer, temperatures are consistently high, the maximum temperature in warmer months (April and May)is around 44 °C (Meteorological department, 2016) and its expected health effects in Thailand are now receiving more attention as the Ministry of Public Health of Thailand is now drafting the national adaptation plan for the public health sector (2017 – 2030). However, there are few published studies on the association between heat and health impacts in overall Thailand (Tawatsupa *et al.*, 2012; Guo *et al.,* 2012). There is a study among a large national cohort of adult workers and found that occupational heat stress related to kidney disease and psychological distress (Tawatsupa *et al.,* 2014). Thus, heat-related morbidity and mortality are recognized as public health threats in Thailand; however, there is limited evidence in the Northeast of Thailand on cause-specific mortality and on the sub-national level for the region which Northeast Thailand is a tropical savannah, with distinct dry and rainy seasons and generally warm to hot temperature throughout. During the summer temperature is consistently highest when maximum daily temperatures can reach 44 °C and the average temperature have been highest in Thailand (Meteorological Department, 2016).

Therefore, this study aims to explore trends in diseases of heat-related mortality in the northeast among selected specific-cause mortality in northeastern Thailand. The results of this study can support development of a heat-health warning system in northeastern Thailand.

2. Materials and Methods

2.1 Site Description

The Northeast Thailand consists of 20 provinces, including over 32 percent of Thailand's population living in the region's twenty provinces (Department of Provincial Administration 2016).The Climate in the Northeast is a tropical savannah, with distinct dry and rainy seasons and generally warm to hot temperatures throughout.

2.2 Study design

This research was conducted with cross-sectional analytic study design. Descriptive statistics and database management used STATA version 13.1 (Stata 2013).We used three national databases covering the time period from 2006 to 2015 and included data weather conditions, mortality, and population.

2.2.1 Weather data

We obtained daily weather data from the Meteorological Department, Ministry of Digital Economy and Society for a total of 19 stations in 20 provinces from 2006 to 2015 (Meteorological Department 2016).Data included six variables for calculating monthly weather profiles of the northeast region: daily average, minimum, and maximum temperature (°C), daily average relative humidity (%), daily total precipitation (mm) and daily average wind speed (knot/h).

2.2.2 Mortality data

Monthly mortality records from 2006 to 2015 specific to the twenty provinces in the northeast region of Thailand were obtained from the Strategy Planning Division, Ministry of Public Health. The International Statistic Classification of Diseases and Related Problems 10th version (ICD-10) was used to explore the cause of death. We included the following causes according to the ICD System: C349-Malignant neoplasm of unspecified part of bronchus or lung, I00-I99-Diseases of the circulatory system, J00-J99-Diseases of the respiratory system, and N00-N98-Diseases of the genitourinary system.

2.2.3 Population data

We used the national database from the Ministry of Interior, Department of Provincial Administration for mid-year population of twenty provinces in the Northeast from 2006 to 2015 (Department of Provincial Administration 2016).

2.3 Statistical analysis

2.3.1 Descriptive statistics

Descriptive statistics, including total and percentage, were computed for cause of death, a categorical variable, from the mortality database. Descriptive statistics, including mean, standard deviation, median, minimum, and maximum, were computer for the weather variables, continuous variables.

2.3.2 Regression Trend Analysis

The Joinpoint Regression Analysis program version 4.5.0.0 (Joinpoin Program, Version 4.5.0.0, 2017) was used to examine trends in mortality rates. The Joinpoint program selects the best fitting piecewise continuous log-linear model. For the study period, we utilized trend analysis for selected mortality, estimated and displayed graphically the annual percent change (APC) with 95%confidence interval at significance level of 0.5.

2.3.3Analysis of Association between Mortality and Weather Conditions

We used Poisson regression model to analyze the association between weather condition and mortality rate in the northeast region during 2006 to 2015 (10 years) on a monthly time scale. We also tested assumption of Poisson regression with overdispersed and zero inflated. Six weather factors were included as variables: monthly averages of the daily mean, minimum, and maximum temperatures; daily mean humidity; daily total precipitation; and daily mean wind speed, resulting in the computation of incident rate ratio (IRR), 95% confidence interval (95% CI), and P-value.

3. Results

3.1 Descriptive Statistics.

The total number of deaths attributed to a specific-cause of death were totaled for the 10-year period (Table 1).The most commonly cited cause of death was diseases of the circulatory, genitourinary, malignant neoplasm and respiratory system, accounting for 51.4%, 22.9%, 16.9% and 8.8% respectively of the 141,938 deaths included within this analysis.

Annual summary statistics were computed for the six included weather factors—four of which are reported in Table 2. The mean temperature in 2006 to 2010 was around 27 °C, while the mean temperature was around 30 °C in 2011 to 2015. The maximum temperature of 42.2 °C occurred in 2015. Precipitation was also higher in 2013 to 2015 as compared to previous years. The mean relative humidity was around 72 % as well as wind speed approximately 10 knot/hr.

3.2 Trend Regression Analysis

Trends analysis demonstrated that mortality rates in the selected indicator causes of death are increasing rapidly (Figure 1). Annual Percent Change (APC) for diseases of the circulatory system was 12.03%; for diseases of the respiratory system was 9.80%; for malignant neoplasm was 7.74% and for diseases of the genitourinary system was 2.16% (alpha= 0.5 level). Figure 2 Trends analysis illustrated that averaged of climate variables from 2006 to 2015 were significantly associated with overall mortality rate for four causes of deaths (per 100,000 population). Annual Percent Change (APC) of weather variables for temperature was 11.69%, for humidity was 11.72%, for precipitation was 11.95% and for wind speed was 11.70% (alpha=0.5 level).

3.3 Association between Mortality and Weather Factors

Association between mortality rate and weather factors were similar among the selected causes of death (Figure 3). Higher mean daily temperature and wind speed increased risk of death at a significant level in all four causes of death when using the adjusted IRR. On the other hand, increased daily minimum and maximum temperatures decreased risk of death in nearly all causes of death when using the adjusted IRR (minimum temperature was not significant in diseases of the genitourinary system).

Relative humidity and precipitation generally did not show significant associations, except for in diseases of the respiratory system.

Thus, considering the overall mortality among the four heat-related causes of death, a one-degree Celsius increase in the daily mean temperature was associated with a 16% increase in mortality (95% CI: 1.11 to 1.21, p-value = 0.004).

Table 1 Number and percentage deaths, according to specific-cause of deaths, from 2006 to 2015

Characteristics	Number	Percent (%)
Specific-cause of deaths		
Malignant neoplasm of unspecified part of bronchus or lung	24,038	16.9
Diseases of the circulatory system	72,909	51.4
Diseases of the respiratory system	12,550	8.8
Diseases of the genitourinary system	32,441	22.9
Over all selected-deaths	141,938	100

Table 2 Characteristics of Weather variables from 2006 to 2015

Year	Temperature (°C)		Relative Humidity (%)		Precipitation (mm)		Wind speed (kont/h)	
	Mean ± SD*	Median	Mean ± SD*	Median	Mean ± SD*	Median	Mean ± SD*	Median
2006	(Min:Max)	27(16:33.9)	(Min:Max)	71(39:98)	(Min:Max)	0(0:203)	(Min:Max)	9(0:120)
2007	26.9 ±2.84	27(16.9:34.8)	71.4±10.34	71(40:98)	4.14 ±11.87	0(0:127.6)	9.53 ±9.56	9(0:240)
2008	26.1 ±2.91	27(15.3:32.5)	73.8±9.68	74(36:97)	4.60 ±12.91	0(0:221.9)	10.11 ±5.57	10(0:180)
2009	26.8 ±2.86	28(14.7:33.2)	72.6±9.41	73(44:98)	4.09 ±12.12	0(0:162.6)	10.03 ±4.87	8(0:190)
2010	27.5 ±2.85	28(15.6:34.9)	71.0±10.62	72(39:99)	4.02 ±11.98	0(0:166.8)	11.46±6.33	11(0:217)
2011	28.9 ±4.17	29(14.5:39.4)	73.3±9.88	72(42:97)	4.99 ±14.49	0(0:405.9)	11.09±5.66	10(0:220)
2012	30.2 ±3.63	30(18.1:39.7)	73.3±8.26	73(46:98)	3.64 ±11.02	0(0:182.3)	12.16 ±4.53	10(0:50)
2013	29.8 ±4.52	30(15.2:42)	71.9±10.45	72(39:72)	5.41 ±14.52	0(0:279.5)	11.59 ±4.53	11(0:50)
2014	29.9 ±4.39	30(14.6:40.6)	72.5±9.59	72(41:98)	8.33 ±16.07	0(0:160.5)	12.12±6.02	12(2:310)
2015	30.4 ±4.32	30(16.4:42.2)	71.7±10.43	71(38:98)	7.87 ±15.55	1.5(0:166.8)	12.13±4.56	12(2:45)

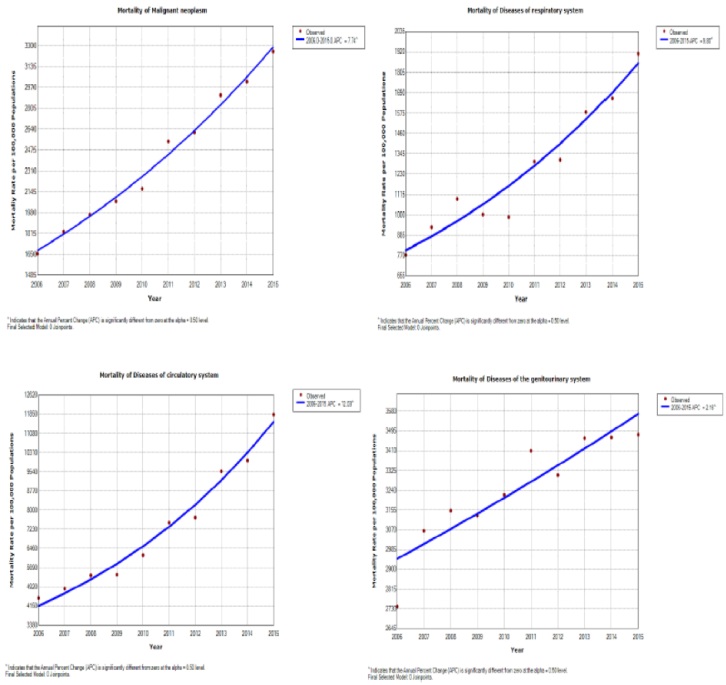

Figure 1 Trend Regression Analysis of four causes of death in Northeast, Thailand 2006 to 2015: malignant neoplasms, diseases of respiratory system, diseases of circulatory system and diseases of genitourinary system

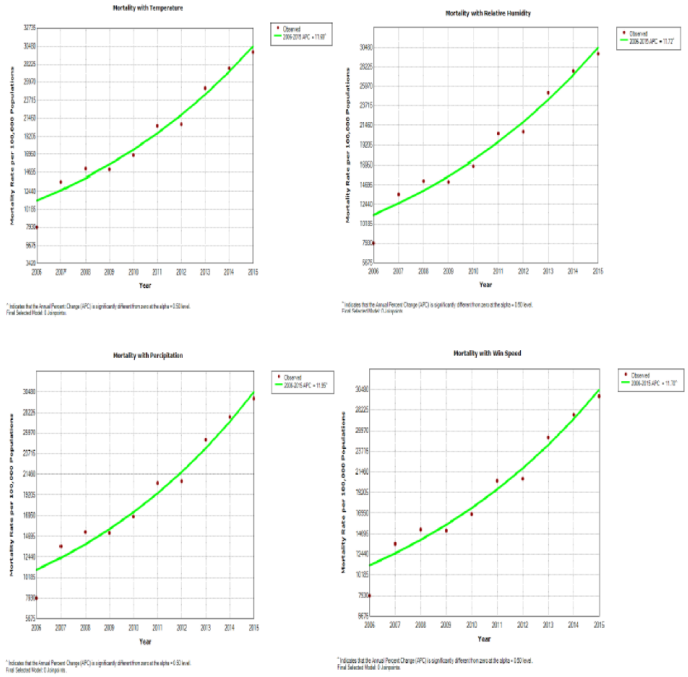

Figure 2. Trend Regression Analysis of Weather variables with heat-related mortality in Northeast, Thailand from 2006 to 2015

Factors	Forest plot	Crude IRR	IRR (adjusted)	95% CI	P-value
Malignant neoplasm					
Mean temperature		1.04	1.11	1.07 to 1.14	0.000
Min temperature		1.00	0.96	0.94 to 0.98	0.002
Max temperature		1.01	0.95	0.92 to 0.98	0.010
Relative humidity		1.02	1.01	0.98 to 1.02	0.596
Precipitation		1.00	1.00	0.98 to 1.07	0.794
Win speed		1.11	1.04	1.03 to 1.16	0.000
	0 0.50 1 2 3 α				

Factors	Forest plot	Crude IRR	IRR (adjusted)	95% CI	P-value
Diseases of the circulatory					
Mean temperature		1.04	1.16	1.03 to 1.20	0.000
Min temperature		0.99	0.94	0.92 to 0.96	0.000
Max temperature		0.99	0.90	0.87 to 0.93	0.000
Relative humidity		0.99	0.98	0.96 to 1.00	0.085
Precipitation		1.00	1.03	1.02 to 1.06	0.000
Win speed		1.14	1.05	1.14 to 1.16	0.009
	0 0.50 1 2 3 α				

Factors	Forest plot	Crude IRR	IRR (adjusted)	95% CI	P-value
Diseases of the respiratory					
Mean temperature		1.03	1.11	1.07 to 1.16	0.000
Min temperature		0.98	0.96	0.93 to 0.99	0.006
Max temperature		1.00	0.92	0.88 to 0.92	0.000
Relative humidity		0.99	0.98	0.96 to 1.00	0.028
Precipitation		1.00	1.04	1.01 to 1.06	0.002
Win speed		1.16	1.03	0.99 to 1.08	0.000
	0 0.50 1 2 3 α				

Factors	Forest plot	Crude IRR	IRR (adjusted)	95% CI	P-value
Diseases of the genitourinary					
Mean temperature		1.00	1.02	1.00 to 1.04	0.011
Min temperature		0.98	0.99	0.98 to 1.00	0.327
Max temperature		0.98	0.97	0.95 to 0.99	0.006
Relative humidity		1.00	0.99	0.98 to 1.00	0.657
Precipitation		1.00	1.01	1.00 to 1.02	0.317
Win speed		1.02	1.00	0.99 to 1.03	0.000
	0 0.50 1 2 3 α				

Factors	Forest plot	Crude IRR	IRR (adjusted)	95% CI	P-value
Overall Death					
Mean temperature		1.05	1.16	1.11 to 1.21	0.004
Min temperature		1.00	0.96	0.92 to 0.97	0.001
Max temperature		1.00	0.91	0.88 to 0.96	0.000
Relative humidity		0.99	0.99	0.98 to 1.02	0.825
Precipitation		1.00	1.01	0.99 to 1.03	0.313
Win speed		1.13	1.03	1.00 to 1.08	0.017
	0 0.50 1 2 3 α				

Figure 3. Forest plots and incidence rate ratio of weather variables separated by caused of heat-related deaths

4. Discussion

In the northeast of Thailand, high temperature are associated with heat-related mortality during 2006 to 2015 overall of 141,938 deaths over twenty provinces have increasing trend year by year (Chen *et al.*, 2017; Klein *et al.,* 2014). Increasing mortality rates in diseases, such as malignant neoplasm of unspecified part of bronchus or lung, diseases of the circulatory system, diseases of the respiratory system, and diseases of the genitourinary system, are consistent with other findings (Basu 2009; Tan *et al.,* 2007; Tawatsupa *et al.,* 2014; Dear *et al.,* 2014). In addition, this is the first study of diseases with heat-related mortality trends in Thailand utilizing Joinpiont regression analysis. Increased heat-related mortality is not only health outcome related to high temperature; heat is also reported to lead to increased hospitalization and illness (Astrom *et al.*, 2013; Lin *et al.,* 2009). For example, the association between synoptic weather types and cardiovascular and respiratory hospital admissions was investigated from April to September 2004–2008 in Cyprus (Tsangari *et al.*, 2015b). Climate change is likely to exacerbate health impacts in Thailand, through of weather variables, in addition increased temperature associated high mortality (Heaviside *et al.,* 2016). Furthermore, we found increases of annual climate parameters are associated with mortality rate per 100,000 population showed by the Annual Percent Change (APC).

We should be concerned especially with vulnerable groups, including the elderly, pregnant, children, and outdoor workers in northeastern Thailand. However, this study is specific to heat-related mortality. In the future, heat-related illness should also be studied, using primary data collection or qualitative studies with risk groups or vulnerable groups, such as farmers, outdoor workers, industrial workers, and the military. In addition, the public health sector must prepare preventive plans. A heat-health warning system is of utmost importance for dealing with the problem from climate change effectively.

5. Conclusion

This study identified the impact of climate change on heat-related mortality from 2006 to 2015 in the Northeast of Thailand. We found that higher daily mean temperatures were significantly associated with increased mortality rate in selected causes of death commonly associated with heat-related deaths. We also found that higher daily maximum temperatures were significantly associated with decreased risk of mortality in the heat-related causes of death. As well, trend regression analysis clearly showed the heat-related mortality (i.e., the mortality rates of these causes) has been increasing significantly for the 10-year period. These results found important information about heat-related mortality in northeastern Thailand. Additional research is needed to optimize the heat-health warning systems and heat response plans, in order to protect the public's health.

6. Limitation

This study have limited data analysis that does not use mortality daily. In the future should be studies weather variables with daily mortality because can explain detail information the associated daily mortality. However, in this study is annual and monthly mortality data were only to indicate the trend of deaths.

Ethical Approval

We obtained ethical approval from Ethical Review committee of the Khon Kaen University Ethics Committee in Human Research for this study (Ref No.HE602193)

Conflicts of Interests

The authors declare that they have no competing interests.

Acknowledgments

This study was supported by the Strategy and Planning Division, Health ImpactAssessment Division at Department of Health Ministry of Public Health (MOPH) the Meteorological Department of Thailand, the Meteorological Department, Ministry of Digital Economy and

Society for providing the weather and mortality data in this study. Great appreciation to the National Research Council of Thailand for support funding to this research. We also appreciate contribution from Khon Kaen University and Nakhonratchasima Rajabhat University, Thailand.

References

Astrom C, Orru,H, Rocklov J, Strandberg G, Ebi,K.L, Forsberg B. Heat-related respiratory hospital admissions in Europe in a changing climate: a health impact assessment 2013; BMJ Open 3.

Bai L. The effects of summer temperature and heat waves on heat-related illness in a coastal city of China 2011–2013; Environ Res 2014; 132: 212-219.

Barreca A.I. Climate change humidity and mortality in the United States.Environ Econ Manage 2012; 63(1): 19-34.

Bassil K.L.Temporal and spatial variation of heat-related illness using 911 medical dispatch data. Environ Res 2009; 109(5): 600-606.

Basu R.High ambient temperature and mortality:a review of epidemiologic studies from 2001 to 2008. Environ Health 2009; 8: 40.

Bethel J.W, Harger R.Heat-related illness among Oregon farmworkers.Int J Environ Res Public Health 2014; 11(9): 9273-9285.

Bobb JF.Heat-Related Mortality and Adaptation to Heat in the United States. Environmental Health Perspectives (Online) 2014; 122(8): 811.

Bunker A. Effects of Air Temperature on Climate-Sensitive Mortality and Morbidity Outcomes in the Elderly; a Systematic Review and Meta-analysis of Epidemiological Evidence. EBioMedicine 2016; 6: 258-268.

Chen K.Impact of climate change on heat-related mortality in Jiangsu Province, China. Environ Pollut 2017; 224: 317-325.

Gasparrini A.Mortality risk attributable to high and low ambient temperature:a multicountry observational study.The Lancet 2015; 386 (9991): 369-375.

Guo Y. The impact of temperature on mortality in Tianjin, China: a casecrossover design with a distributed lag nonlinear model. Environ. Health Perspect 2012; 119 (12), 1719–1725.

Gu S. Heat-related illness in China, summer of 2013. Int J Biometeorol 2016; 60(1): 131-137.

Heaviside C. Heat-related mortality in Cyprus for current and future climate scenarios. Sci Total Environ 2016; 569-570: 627-633.

Intergovernmental Panel on Climate Change. Climate Change: Synthesis Report Contribution of Working Groups I, II and III to the Fifth Assessment Report. New York, USA. 2014

Joinpoint Program Version 4.5.0.0. Data Management and Statistical Analysis Center, Faculty of Public Health Khon Kaen University, 2017.

Kim EJ, Kim H. Effect modification of individual- and regional-scale characteristics on heat wave-related mortality rates between 2009 and 2012 in Seoul, South Korea. Sci Total Environ 2017; 595: 141-148.

Klein Rosenthal J. Intra-urban vulnerability to heat-related mortality in New York City, 1997–2006. Health Place 2014; 30: 45-60.

Lin S, Luo M, Walker RJ, Liu X, Hwang SA, Chinery R.Extreme high temperatures and hospital admissions for respiratory and cardiovascular diseases. Epidemiology 2009; 20, 738–746.

Li J. Ambient high temperature and mortality in Jinan, China:A study of heat thresholds and vulnerable populations.Environ Res 2017; 156: 657-664.

Mo WC.Heat-related illness in Jinshan District of Shanghai:A retrospective analysis of 70 patients. World J Emerg Med 2014; 5(4): 286-290.

Ng CF.S.Heat-related mortality:Effect modification and adaptation in Japan from 1972 to 2010. Global Environmental Change 2016; 39: 234-243.

Ostro B.The impact of future summer temperature on public health in Barcelona and Catalonia, Spain. Int J Biometeorol 2012;

56(6): 1135-1144.
Rosich del Cacho M.Heat stroke related to the use of topiramate. The importance of prevention. Anales de Pediatría (English Edition) 2014; 81(3): 181-184.
Simon Hales S.K.S.L. Quantitative Risk Assessment of the Effects of Climate Change on Selected Causes of Death, 2030s and 2050s. 2007.
Stata Corp Stata Version 13.1 for Windows. Stata Corporation, College Station TX. Data Management and Statistical Analysis Center, Faculty of Public Health Khon Kaen University, 2017.
Tsangari H, Paschalidou A.K, Kassomenos A.P, Vardoulakis S, Heaviside C, Georgiou K.E. Extremeweather and air pollution effects on cardiovascular and re-spiratory hospital admissions in Cyprus. Sci Total Environ 2015; 542: 247–253.
Tawatsupa B. The association between temperature and mortality in tropical middle income Thailand from 1999 to 2008. Int J Biometeorol 2014; 58(2): 203-215.
Tawatsupa B. Association between heat stress and occupational injury among Thai workers: findings of the Thai Cohort Study. Ind Health 2013; 51(1): 34-46.
Thai Department of Provincial Administration Mid-year population of Northeast Regional, Bangkok, Thailand. 2016.
Thai Meteorological department Annual Weather Summary over Thailand in 2006-2015 Meteorological Department, Bangkok, Thailand. 2016.
World Health 0rganization. Heatwaves and Health. Guidance on Warning-System Development. 2015.
Wang Y. Heat stroke admissions during heat waves in 1,916 US counties for the period from 1999 to 2010 and their effect modifiers. Environ Health 2016; 15(1): 83.
Xiang J. Workers' perceptions of climate change related extreme heat exposure in South Australia: a cross-sectional survey. BMC Public Health 2016; 16: 54