

The impact of a heat wave on mortality in the emergency department

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Abstract

Extreme heat wave increases the number of emergency department (ED) admissions and mortality rates. The purpose of our study is to investigate the effects of the heat wave experienced in Izmir province of Turkey on mortality.

During a 9-day period between 17th and 25th June 2016 (study period), air temperature values were higher than the seasonal norms in Izmir, Turkey. In this cross-sectional study, nontraumatic admissions and in-hospital mortality rates were compared this historical interval of the extreme heat wave with the same period of the previous year and the other 21 days of June 2016.

The average air temperature between 17th and 25th June 2016, was higher than the average air temperature of the previous year's same period and the average air temperature from the other 21 days of June 2016 ($27.8 \pm 3.6^\circ\text{C}$, $24.5 \pm 1.9^\circ\text{C}$, $24.1 \pm 2.1^\circ\text{C}$, respectively) ($P < .01$)

During the study period, the mean number of ED visits and mortality rates were significantly higher than the previous year's same period ($320 \pm 30/\text{day}$ vs $269 \pm 27/\text{day}$, [$P < .01$], and 1.6% vs 0.7% , [$P < .01$]).

Although the admission rate was similar between the study period and the other 21 days of June 2016 ($320 \pm 30/\text{day}$ vs $310 \pm 32/\text{day}$, [$P = .445$]); in-hospital mortality rate was significantly higher during study period (1.6% vs 0.7% , [$P < .01$]).

During the extreme heat waves, ED admissions and in-hospital mortality rates are increased. Precautions should be addressed for adaptation of people to extreme hot weather.

Abbreviations: BUN = blood urea nitrogen, ED = emergency department.

Keywords: emergency department, extreme heat, heat wave, mortality, temperature

1. Introduction

Global warming is one of the biggest environmental problems in the current time. Under the impact of global warming, heat-related mortality is expected to represent a severe public health problem in the near future. Extreme heat, particularly in the summer, is an important health problem in many regions of the world. Hospitalization and overall mortality are reported to increase when the air temperature exceeds the seasonal normal.^[1–4] Studies from different countries and years have shown that the numbers of patients presenting to the emergency department (ED), admitted to hospital from the ED, and dying all increase in extreme heat.^[1,5–13] ED presentations that are associated with cardiovascular, renal and mental causes increase significantly compared to other causes at such times. Elderly patients are particularly affected by extreme heat.^[14–17]

Izmir, the third largest province in Turkey, is located in the mid-latitude climate zone and on the coast of the Aegean Sea, and it has a Mediterranean climate.^[18] The Governor's Office issued a warning that Izmir would be affected by a heat wave from North Africa on June 17–25, 2016, and the maximum temperature on those dates was measured at 36 to 39.6°C . A heat wave is defined as mean temperatures on 2 or more consecutive days exceeding the 95%, 97%, or 99% percentile values compared to other days.

In this study, we aimed to determine the effect of the extreme heat wave and in-hospital mortality of patients presenting to a tertiary university hospital's ED.

2. Materials and methods

This observational, cross-sectional study was performed at the Dokuz Eylul University Hospital ED, after receiving ethics committee approval.

2.1. Study location

Izmir is Turkey's third-largest city and is located on the coast of the Aegean Sea. Its population in 2015 was approximately 4.2 million. People aged 65 years or older constitute 10% of that population. The province of Izmir is located in the mid-latitude climate zone and the city is a coastal city, meaning that a Mediterranean-type climate prevails. In general, summers are hot and dry, winters are warm and rainy; spring and autumn transition features are frequently seen. In Izmir, the hottest months are July and August, and the coldest are January and February. The June temperature mean was 26.0°C between 1981 and 2010, and average temperatures still exhibit a rising trend till today. The highest daytime temperature record measured to date was 41.3°C (106.34°F) in 28th of June 1982.^[18] From the 17th to the 25th of June 2016, according to the General Directorate of

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Meteorology data, the air temperature was higher than the seasonal averages and higher than the other days of June and the same period of June 2015.

2.2. Data collection

Data for daily minimum, maximum and mean temperatures (°C); the daily minimum, maximum and mean humidity (%); and the wind speed for June 2015 and 2016 were obtained from national weather forecast reports published by the General Directorate of Meteorology on its official web site (<https://www.mgm.gov.tr/>). The General Directorate of Meteorology is a public body that monitors and reports weather events and the climate in Turkey.

Dokuz Eylul University Hospital is Izmir's second largest university hospital with a bed capacity of 1.135 beds. The number of patients presenting to the ED and hospital on a daily basis in July 2015 and 2016, and also mortality rates, were obtained from the hospital data management system. Trauma-related presentations and patients whose file data were unavailable were excluded from the study. The age, sex, causes of death and laboratory findings for non-surviving patients were obtained through archive scanning.

In our study, the days of the heat wave from the 17th to the 25th of June 2016, were classified as the "heat wave period"; except than the period from 17th to the 25th days, the other days of June 2016 were classified as the "reference period 2016" and the same period of the previous year, from the 17th to the 25th of June 2015 were classified as the "reference period 2015"

2.3. Data analysis

Statistical Package for Social Sciences for Windows 20.0 (SPSS Inc., Chicago, IL) was used for all data analyses. The Kolmogorov–Smirnov test was used to assess the homogeneity of the groups. During intergroup comparison, the Student *t* test was used to compare quantitative variables between groups and the chi-square analysis was used for qualitative variables. *P* values <.05 were considered statistically significant.

3. Results

3.1. Meteorological data

Mean daily temperatures, minimum and maximum temperatures, the daily minimum–maximum difference, and the daily mean, minimum, and maximum humidity data were higher during the heat wave period compared to reference period 2015.

Other parameters, with the exception of daily minimum humidity and daily mean wind speed, were higher during the heat wave period compared to reference period 2016 (Table 1).

3.2. Mortality data

The ED received a total of 117.194 adult presentations in 2016. In June, 2016, a total of 9.112 patients had presented to the ED; where 2.783 were in "heat wave period" and 6.329 were in "reference period 2016". In "reference period 2105", a total of 2.335 patients also had presented to the ED (Table 2).

The mortality rate of "heat wave period" was significantly higher than both the "reference period 2016" and "reference period 2015" (respectively, 1.6% vs 0.7%, and 0.7%; *P*<.001 and *P*<.003, Table 2).

Although the mean admissions rates were significantly similar in "heat wave period and the reference period 2016" respectively, 320±30 visits per day versus 310±32 visits per day, *P*=.445), both of them were significantly higher than "reference period 2015" (*P*=.002, Table 2).

The mean ages of patients died during these 3 periods were 76.7±12.4 years, 72.2±10.3 years and 76.1±11.6 years, respectively. The differences between the mean ages were not significant (Table 2). Analysis of in-hospital mortality showed that the majority of deaths occurred in the ED.

The number of patients presenting to the ED (448 more ED visits, 19.2%) and mortality (29 more deaths, 181.3%) increased during the heat wave period compared to reference period 2015 (RR:2.36, 95% CI: 1.34–4.17; Table 2 and Fig. 1). A similar increase was observed in the numbers of patients aged 65 years or who presented to hospital during these dates (18.4%), while the increase in mortality (208%) was even higher. Patients aged 65 years or older represented 6.9% of all patients presenting to the ED during the heat wave period, compared to 2.7% in the reference period 2015 and 3.3% in reference period 2016.

Relative risk of mortality during the heat wave period and reference period 2016 were compared was calculated at 2.03 (95% CI: 1.41–2.94).

Among the 45 patients who died during the heat wave period in our ED, the body temperature of 18 patients was more than 38°C. The most common comorbidities of patients as below: Hypertension (*n*=17, 37.8%), malignancy (*n*=12, 26.7%), dementia (*n*=10, 22.2%), coronary artery disease (*n*=9, 20%), diabetes (*n*=6, 13.3%), and history of cerebrovascular accident (*n*=6, 13.3%).

Daily maximum temperature data and numbers of patients dying in June 2016 are shown in Figure 2. Mean temperature was 8.1°C higher, minimum temperature was 6.2°C higher and

Table 1

Meteorological data for the study periods.

	Mean ± SD (Min-Max)	Mean ± SD (Min-Max)	<i>P</i> *	Mean ± SD (Min-Max)	<i>P</i> †
Daily mean temperature, °C	32.6 ± 0.9 (31.0–33.7)	24.5 ± 1.9 (22.2–28.5)	<.01	25.8 ± 1.9 (22.5–28.7)	<.01
Daily minimum temperature, °C	25.7 ± 2.8 (20.9–29.8)	19.5 ± 1.5 (17.8–22.4)	<.01	20.8 ± 2.6 (15.3–25.7)	<.01
Daily maximum temperature, °C	38.0 ± 1.0 (36.0–39.6)	28.3 ± 2.5 (24.9–32.3)	<.01	30.7 ± 2.2 (26.5–33.9)	<.01
Daily min-max difference of temperature, °C	12.3 ± 2.3 (8.0–15.1)	8.8 ± 1.7 (6.3–11.4)	<.01	9.8 ± 2.1 (6.4–14.7)	<.01
Daily mean humidity, %	38.3 ± 3.6 (32.3–44.3)	54.1 ± 8.3 (40.7–67.3)	<.01	48.2 ± 8.9 (33.0–60.3)	<.01
Daily minimum humidity, %	31.3 ± 5.3 (22.0–40.0)	43.4 ± 10.1 (24.0–59.0)	<.01	37.0 ± 9.0 (25.0–52.0)	<.01
Daily maximum humidity, %	45.2 ± 5.0 (36.0–52.0)	63.7 ± 8.0 (49.0–74.0)	<.01	58.8 ± 10.0 (34.0–73.0)	<.01
Daily mean wind speed, m/sec	26.56 ± 5.0 (22.0–37.0)	29.67 ± 7.8 (20.0–40.0)	.33	31.6 ± 9.9 (17.0–57.0)	.16

* Heat Wave Period versus Reference Period 2015.

† Heat Wave Period versus Reference Period 2016.

Table 2
Information for ED presentations and mortality.

	Heat Wave Period	Reference Period 2015		Reference Period 2016	
	n, %	n, %	P*	n, %	P†
All-cause ED visits					
Total ED visits	2.783	2.335		6.329	
Average daily ED visits	320 ± 30	269 ± 27	<.01	310 ± 32	.45
Age					
18–65y	2.203 (79.2%)	1.845 (79.0%)		5.151	
>65y	580 (20.8%)	490 (21.0%)	.90	1.178	.13
All-cause Mortality					
Total deaths	45 (1.6%)	16 (0.7%)	<.01	47 (0.7%)	<.01
Gender					
Female	21 (46.7%)	5 (54.2%)		28 (59.6%)	
Male	24 (53.3%)	11 (45.8%)	.45	19 (40.4%)	.30
Age					
Mean ± SD	76.7 ± 12.4	72.2 ± 10.3	.11	76.1 ± 11.6	.83
18–65 y	5 (11.1%)	3 (18.7%)		8 (17.0%)	
>65y	40 (88.9%)	13 (81.3%)	.44	39 (83.0%)	.55
In hospital mortality					
ED	34 (75.6%)	9 (56.3%)		27 (57.5%)	
ICU	9 (20.0%)	5 (31.3%)		8 (17.0%)	
Others	2 (4.4%)	2 (12.5%)	.30	12 (25.5%)	.19

* Heat Wave Period versus Reference Period 2015.

† Heat Wave Period versus Reference Period 2016.

ED=emergency department, ICU=intensive care unit, SD=standard deviation.

maximum temperature was 9.7°C higher during the heat wave period compared to the reference period 2015.

3.3. Laboratory data

Laboratory tests for non-surviving patients revealed no significant differences between the heat wave period and reference period 2015 or reference period 2016 in terms of mean blood urea nitrogen (BUN), creatinine, electrolyte, and complete blood count values (Table 3).

4. Discussion

Heat waves increase the numbers of patients presenting to the ED, and also cause an increase mortality rates, which is

supported by studies from various countries.^[1,5–13] Our study shows that the number of patients presenting to the ED and the number of non-surviving patients increased significantly during the heat wave in the province of Izmir on the Aegean coast with its Mediterranean climate. These data are the first to be reported from our region, and they are consistent with previous results.

In June 2016, there were 33.875 people died in the country and 2.434 deaths occurred in Izmir. It was reported that 30.576 deaths nationwide and 1.805 deaths in Izmir in June 2015. Interestingly, in June 2016 compared to the same period of the previous year, while the increase in the number of deaths in the country was 10.8%, it was 3 times more in Izmir (34.9%).^[19] The number of patients presenting to the ED rose by 13% between June 2015 and June 2016, and the number of fatalities increased by 132%. However, the number of patients presenting

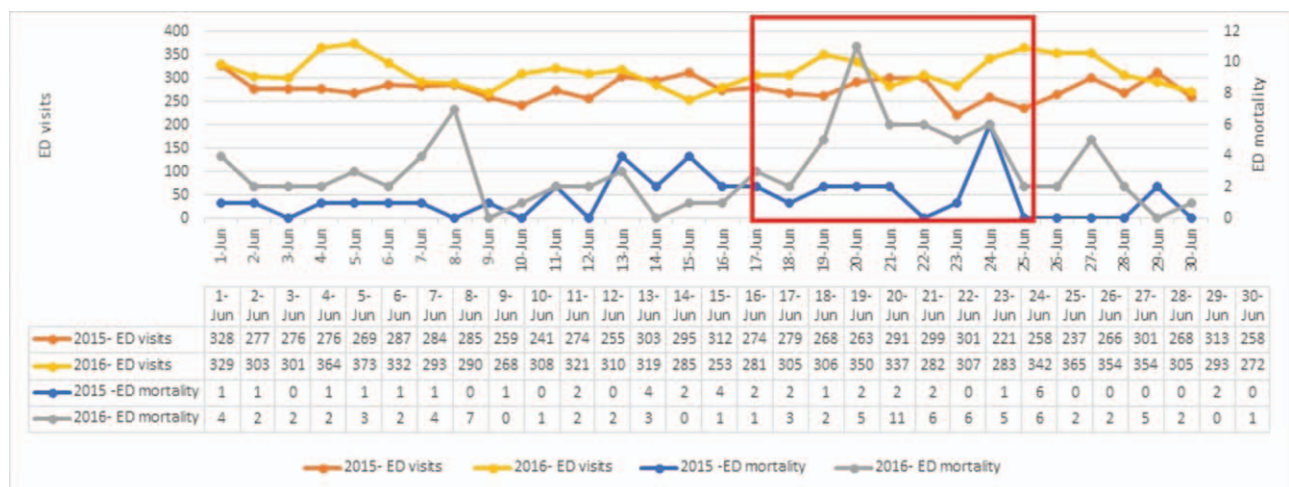


Figure 1. Numbers of patients presenting to the ED and numbers of deaths in June 2015 and 2016. ED=emergency department.

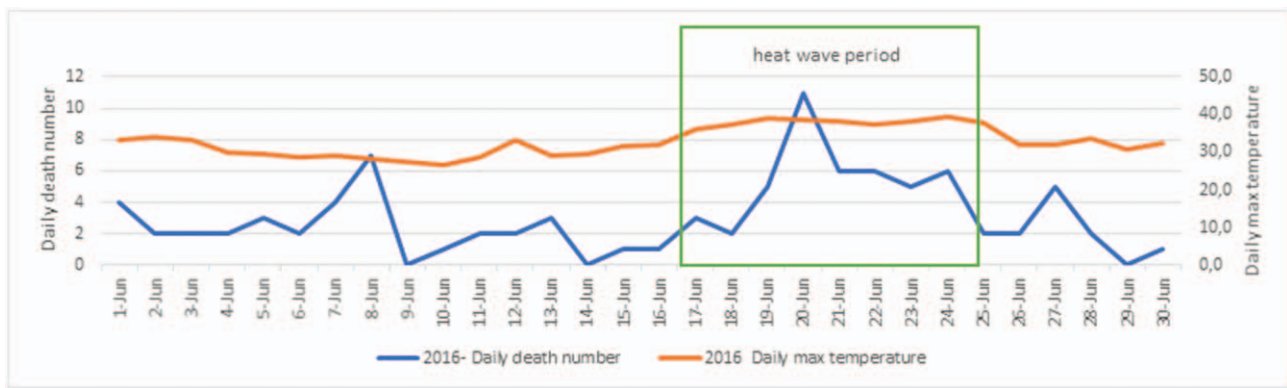


Figure 2. Numbers of deaths per day and maximum temperatures during June 2016.

increased by 19% and the number of fatalities increased by 181% during the heat wave period compared to reference period 2015. Relative risk of mortality was calculated at 2.03 between the heat wave period and reference period 2016. Our results are similar to those of other studies and confirm an increase in the number of patients presenting to the ED and mortality rates in hot weather.

Studies have shown that an increase in temperature increases cardiovascular and respiratory mortality in all age groups.^[20] Causes of death were not investigated separately in our study, only overall mortality.

The elderly is known to be particularly affected by heat.^[12–15] In their meta-analysis, Bunker et al reported that high temperatures increased mortality associated with cerebrovascular, cardiovascular and respiratory diseases. Additionally, they reported that morbidity associated with diabetes and cardiovascular, respiratory, genitourinary and infectious diseases also increased.^[15] The region served by our hospital has a large elderly population. People aged 65 years or older constitute 8.3% of the population in Turkey overall, but 10% of the population in Izmir. Total life expectancy at birth is 78 years in Turkey, 75.3 years in men and 80.7 years for women. The mean age of patients who died during the heat wave in our study was 78 years. These figures are compatible with the mean figures for Turkey. In contrast to other studies, the mean age of patients who died during the heat wave period was not different from other periods in our study.^[14,15–17] Additionally, there was no variation in terms of sex in our study.

The heat wave had a significant impact on patients aged 65 years and older who presented to the hospital, as previously published.^[12–17] Zhang et al also reported an increase in levels of patients from all age groups presenting to the ED during a heat wave (3.6%), but stated that the greatest impact was in the 65 and over age group (8.9%).^[9] In our study, however, while there was a similar level of increase in the numbers of patients aged 65 years and older presenting to hospital during the heat wave period, the increase in mortality was significantly higher (208%). Mortality among all patients presenting to the ED during the heat wave period was 6.9%, compared to 2.7% in reference period 2015 and 3.3% in reference period 2016. These results confirm the higher mortality in the elderly.

Levels of acute kidney failure and fluid electrolyte disorders may be expected to increase in hot weather in association with losses caused by evaporation and insufficient fluid intake. Two different studies reported that, risk factors for heat related death during the August 2003 heat wave period in Paris were dehydration, hyperthermia, malaise, hyponatremia, renal failure, more severe clinical condition on admission, higher values of blood glucose, troponin, and white blood cell count; lower values of serum protein and prothrombin levels.^[12,13] Bobb et al reported that heat wave periods were associated with increased risk of hospitalization for fluid and electrolyte disorders, renal failure, urinary tract infection, septicemia, and heat stroke-related hospitalization in elderly patients.^[21] Knowlton et al reported that “ED visits also showed significant increases for

Table 3

Laboratory test results for non-surviving patients.

	Heat wave period			Reference period 2015				Reference period 2016			
	N	Mean ± SD	Min–Max	n	Mean ± SD	Min–Max	P*	n	Mean ± SD	Min–Max	P†
BUN, mg/dL	23	42.2 ± 30.2	12.9–150.6	11	48.9 ± 31.4	10.2–96.6	0.53	36	49.1 ± 32.6	7.9–154.3	.36
Creatinine, mg/dL	33	1.8 ± 1.4	0.4–7.5	11	2.2 ± 1.1	0.6–4.3	0.41	36	2.0 ± 1.6	0.5–6.9	.71
Na ⁺ , mmol/L	33	138.3 ± 10.8	113–172	11	124.9 ± 34.6	23–152	0.23	38	138.0 ± 9.9	114–177	.88
K ⁺ , mmol/L	33	4.3 ± 0.9	2.9–7.3	11	4.8 ± 1.2	3.6–7	0.19	38	4.4 ± 1.0	2.0–6.8	.78
Cl ⁻ , mmol/L	33	103.7 ± 11.1	81–139	11	103.3 ± 10.3	86–122	0.92	38	101. ± 11.1	84.0–141.0	.43
Hemoglobin, g/dL	33	11.1 ± 2.5	6.7–15.9	12	10.5 ± 2.7	4.8–16.6	0.51	39	12.2 ± 2.2	8.7–17.8	.03
Hematocrit, %	33	34.0 ± 7.4	20.9–49.5	12	33.2 ± 7.6	19.2–51.8	0.75	39	37.3 ± 6.8	26–54	.05
WBC (10 ³ /μL)	33	18.2 ± 32.3	0.1–193.7	12	13.1 ± 7.6	1.3–27.9	0.59	38	12.0 ± 8.7	0.3–50.7	.25
Platelet (10 ³ /μL)	33	210.7 ± 105.8	5–409	12	288.1 ± 179.8	21–597	0.18	38	227.6 ± 163.3	14–894	.61

* Heat Wave Period versus Reference Period 2015.

† Heat Wave Period versus Reference Period 2016.

BUN=blood urea nitrogen, WBC=white blood cell.

acute renal failure, cardiovascular diseases, diabetes, electrolyte imbalance, and nephritis”.[1] Similarly in our study, examination of the data for non-surviving patients showed that renal function markers such as BUN and creatinine were higher than normal. Electrolyte levels were within normal limits. However, we determined no difference between the mean renal functions of patients dying in 2015 and 2016. These functions would be expected to be impaired in the majority of fatal diseases. Had we been able to compare healthy subjects or other presentations associated with heat but with no mortality, we think that different results might have been obtained. The causality of death was not investigated in our study. However, the most common comorbidities of patients were hypertension, malignancy, dementia, coronary artery disease, diabetes and history of cerebrovascular accident.

Daily mean temperature data have been reported to be a better predictor of mortality when evaluating the effects of a heat wave.[22] In our study, daily mean temperature, minimum and maximum temperature, and the difference between minimum and maximum temperatures were significantly higher during the heat wave period. Mean humidity and minimum and maximum humidity percentages were also significantly higher in the heat wave period and in June 2016 compared to other periods. Humidity plays a significant role in the health effects of ambient temperature. Prior studies have shown that humidity can increase the risks of angina pectoris and visits to mental health EDs increased with humidity.[23,24] However, mean and maximum daily temperatures were the most commonly used indicators in the included studies, which did not indicate the effect of humidity on health. Apparent temperature, heat index and humidex are commonly used synthetic indices for evaluating the association between meteorology and human health. These indices incorporate temperature, humidity and sometimes wind speed, which could reflect relative human discomfort from heat and cold. Therefore, the apparent temperature, heat index and humidex are considered to be better temperature exposure metrics than temperature alone, especially for the effects of heat exposure on morbidity or mortality.[25,26]

5. Limitations

Our study was performed at a single center and in a single region. Our findings cannot be generalized to other hospitals in the province of Izmir or to the entire Mediterranean region. Specific causes of death and heat-related diagnoses were not investigated separately in this study, only overall mortality. Mortality calculations were performed based on the day of presentation to the ED. We did not analyze how many days after presentation patients died or whether the causes were associated with heat.

6. Conclusion

Heat waves can increase the number of patients who present to the ED and increase in-hospital mortality. It is important for both the general public and health workers to heed meteorological warnings concerning heat waves and to take appropriate precautionary measures.

Author contributions

Author contribution statement: NCO, EA: study design, conducted the study, data analysis, and wrote the manuscript;

DO, BB: conducted the study and data analysis; and RA: study design and manuscript preparation. All authors discussed the results and approved the final version of the manuscript.

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