Al-Mustansiriyah Journal of Science
ISSN: 1814-635X (print), ISSN:2521-3520 (online) Volume 31, Issue 2, 2020 DOI: http://doi.org/10.23851/mjs.v31i2.753

Research Article **Open Access**

The Effect of The Extremes Heat Waves on Mortality Rates in Baghdad During the Period (2004-2018)

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Article Info

Received
15/10/2019

Accepted
06/01/2020

Published
15/04/2020

ABSTRACT

In a previous couple of decades, serious heatwaves were illustrative of the climate conditions in different pieces of the world. They had unmistakably negative effects on people, plants, creatures, and distinctive monetary segments. Especially in urban areas, where most people are living, their prosperity, productivity and wellbeing were influenced, which even caused a generally high death rate. This is the reason an enormous intrigue still exists to analyze heat waves in the past by utilization of measurable strategies. As an examination on heatwaves isn't accessible for the domain of Baghdad city up to now, a review examination was directed. Its primary points were (1) to decide the recurrence of heatwave scenes for this nation and (2) to analyze their spatiotemporal dissemination, term, and force. Based on Baghdad city, from the Iraqi Meteorological Organization and Seismology and Ministry of Health day by day estimations of most extreme air temperature (Tmax) in summer months (June to August) were utilized to decide heatwave scenes as indicated by the definition prescribed by the IPCC. For all stations, total and dependable Tmax time arrangements were accessible for the period 2004–2018 concerning a few stations. We tried the 95th thresholds percentile. The extra wave impacts were assessed utilizing a one-stage model to guarantee that their belongings were evaluated subsequent to expelling the general impact of temperature.

KEYWORDS: Heat waves; Extreme weather; Maximum air temperature; Mortality rate; Baghdad.

الخلاصة

في العقدين الماضيين، كانت موجات الحر الخطيرة تبرز الظروف المناخية في أجزاء مختلفة من العالم. كان لها آثار سلبية لا لبس فيها على الناس والنباتات والمخلوقات والقطاعات الاقتصادية المميزة. في المناطق الحضرية ، حيث يعيش معظم الناس ، تأثرت حياتهم وإنتاجيتهم ورفاهيتهم، مما تسبب في ارتفاع نسبة الوفيات بشكل عام، هذا هو السبب وراء وجود أسباب لتحليل موجات الحرارة في الماضي من خلال استخدام استراتيجيات قابلة للقياس، نظراً لعدم إمكانية الوصول إلى اختبار الموجات الحرارية في نطاق مدينة بغداد حتى الآن، فقد تم اعادة توجيه الاختبار من خلال هذه النقاط الرئيسية (١) هي تقرير تكرار مشاهد موجات الحر لهذه المحافظة (٢) تحليل انتشارها الزماني والمكاني لمدينة بغداد، حيث تم اخذ بيانات يومية من الهيئة العامة للانواء الجوية العراقية والرصد الزلزالي وبيانات شهرية من وزارة الصحة العراقية، حيث تم اخذ درجات حرارة الهواء (Tmax) في أشهر الصيف (يونيو، يوليو، أغسطس) بالنسبة لمحافظة بغداد للفترة ٢٠٠٤-٢٠١٨. حيث تم اخذ متسوى التطرف ٩٥% ، حيث تم تقييم تأثيرات الموجة باستخدام نموذج من مرحلة واحدة لدرجات الحرارة.

INTRODUCTION

Scenes in summer with a considerably high temperature of the near-surface water *T*a for a couple of days or more describe as heat waves (Robinson, 2001; Lau and Nath, 2012). Below a meteorological point observation, they are mostly connected and quasi-stationary anticyclone circulation abnormality, which product drop off, pure skies, advection of the hot air and extends it's hot estate in the nearby-surface weather (Fischer *et al.*, 2007; Barriopedro *et al.*, 2011). Due for these weather events, heat waves can happen in various place from the world (Fischer *et al.*, 2012a, 2012b; Vizy and Cook, 2012). Heat waves resemble natural danger and there's a lot familiar about the effects on humans (Kovats and Hajat, 2008). You've got important influence it's on productive, capacity and veracity of human bening, which can command to remarkable stumpy-term swell morbidity and mortality-rate

(Kovats and Ebi, 2006; Basu, 2009; Gosling *et al.*, 2009), mostly in cities, where most human bening they're alive. The general effects of a heat wave (hereinafter mention to as HW), which isn't endanger only human bening veracity but it's also about command to misfortunes in economical sector like agribusiness or ranger service, consist on a numeral of factors inclusive HW measure, seasonal pacing, adaptation human bening to HW events and public health response.

Over the last few decades, the numeral of HWs has swell worldwide. Extreme HWs were spotted in June and August 2003 in Central Europe (Fink *et al.*, 2004; Rebetez *et al.*, 2006) and in June and July 2006 (Fouillet *et al.*, 2008; Gosling *et al.*, 2009; Rebetez *et al.*, 2009; Kysel´y, 2010; Monteiro *et al.*, 2013). A essentially extreme heat wave happened not only in Eastern Europe but also in Western Russia in July and August 2010. (Barriopedro *et al.*, 2011; Grumm, 2011; Rahmstorf and Coumou, 2011; Otto *et al.*, 2012). Due to its distance in interval of fullness and the volume of storage, it's been estimated as a mega HW by (Barriopedro *et al.*, 2011). Phenomenal heat and bad air kind occasion by wildfires (Konovalov *et al.*, 2011) prompted a major swell in mortality-rate in Moscow and other locations in Western Russia (Dole *et al.*, 2011). Statistical analyzes of HW advantage you've already been there pilot for countries all over the world (e.g. China: Tan *et al.*, 2007; Czech Republic: Kysel´y, 2002; France: Fouillet *et al.*, 2008; Portugal: Monteiro *et al.*, 2013; Spain: D´ıaz *et al.* 2006 and USA: Gershunov *et al.*, 2009), basically after drastic HW events. Therefore, the aim of this study is to determine the relationship between extreme maximum air temperature and mortality rate and to assess the effects of these temperatures on mortality rates. This study helps to gain a better understanding of some key methodological issues in assessing the effects of temperature on mortality rate.

MATERIALS AND METHODS

Percentile method

In this work used data for daily maximum air temperature for the period (2004-2018) covering Baghdad city (the whole period for which data are available) were obtained the Iraqi Meteorological Organization and Seismology. It used 95% confidence level analysis. Then fitted a Bayesian model to estimate any extra effects from heat waves, test whether these effects depended on the timing, length or frequency of the waves. We used this one-stage method to ensure that after eliminating the overall effects of temperature and season the wave effects are estimated.

Extreme temperature indices were computed from the daily data besides annual and seasonal summer trends of maximum temperatures 14 indicators related to extreme temperature were analyzed in this methods. The Expert Team on Climate Change Detection and Indices (ETCGDI). Defined 27 daily temperature extreme indices which are statistically robust, cover a wide range of climates, and have a high signal-to-noise ratio (Zhang *et al.* 2011). Table 1 considering their importance in city of Baghdad.

Table 1. Definition of selected indices used for analysis of extreme temperature in city of Baghdad (Zhang *et al.* 2011).

Indicator	Description of indices	Unit
Ex95	"Number of days with max temperature > 95^{th} percentile of maximum air temperature of years (2004-2018)"	Day

This indices was calculated on annual basis and based on threshold defined as percentile considering is importance in Baghdad. This percentile was calculated on the reference period (2004-2018) which is an atmosphere typical period characterized by World Meteorological Organization (WMO, 2016).

Study area and data

Baghdad is the capital of republic of Iraq and is located in the middle of it along the Tigris River. This divides Baghdad in half and the eastern half is called Risafa and the western half is called Karakh (see Figure 1).

Geographically, Baghdad is situated at Lat. 33.6 – 33.5^{o} N, Long, 44.25 – 44.5^{o} E and 30 – 38 m above sea level. It covers an area of 857.3 km^{2} and forms 0.2 percentage of an overall Iraq area. The land is almost entirely flat and low- lying.

The climate of Baghdad has a subtropical desert climate (Köppen climate classification BWH) featuring extremely hot, dry summer and mild, damp winter (Roth, 2007). The average temperature between May and September is 40 °C and in July and August the temperature

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reaches 40 °C, while annual range of the mean daily sunshine duration is about 10–14 hrs with mean of 7.5hr

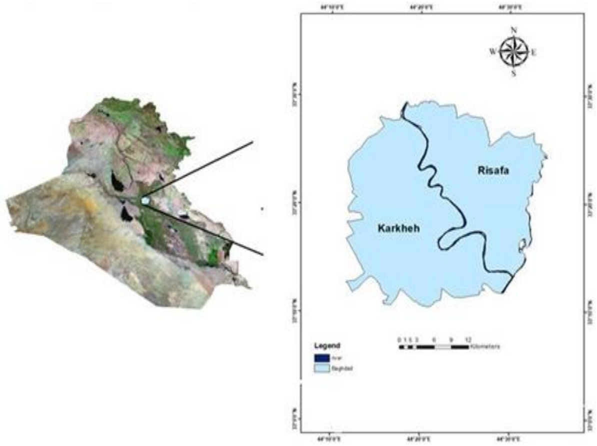

Figure 1. Map of Baghdad.

Three data sets are used to excite this study first daily maximum air temperature for the period from 2004 to 2018 (the whole period for which data are available) were obtained from the Iraqi Meteorological Organization and Seismology, second number of deaths set were taken from Ministry of Health database available from (2014 – 2018) are reported on Table 3 based on the information of medical government and private hospital and medical centers their numbers are reported on Table 2 on both sides (Al-Karkh & Al-Rusafa). All deaths among residents from the two areas of study and data on in - and-out movements of the study area was reported.

Table 2. The number of health facilities in Iraq by health directorates, which includes (government hospitals, private hospitals and health centers).

Health directorates	Government hospital & specialized centers with impatient		Private hospital	Main health care center	Health sub-center	Allergies & asthma center	Training health center	Total
	Technique	Non technique						
Al-Karkh	5	9	15	99	31	1	3	163
Al-Rusafa	14	21	32	112	9	1	6	195

The information included the start date (birth, enumeration or immigration), the last event date (death, departure or exit), sex, age, and death's cause. Nevertheless, we found mortality for this study, and third population data were obtained from the office of the Ministry of Planning.

Table 3. Number of deaths for the three summer months (June, July, August) and average maximum air temperature for the period from (2014-2018).

Years	Number of deaths		
	Male	Female	Total
2014	761	485	1246
2015	917	622	1534
2016	1953	1562	3515
2017	2326	1594	3920
2018	2375	1608	3983

Annual average of maximum air temperature

The maximum daily air temperature data has been converted to annual time serious to revere the general behavior in annual varying temperatures. Air temperature is one of the important elements in the atmosphere due to its wide effects on climate variables. The results show that the general trend of temperature has increased over time, despite the variation in these rates as shown in Figure 2.

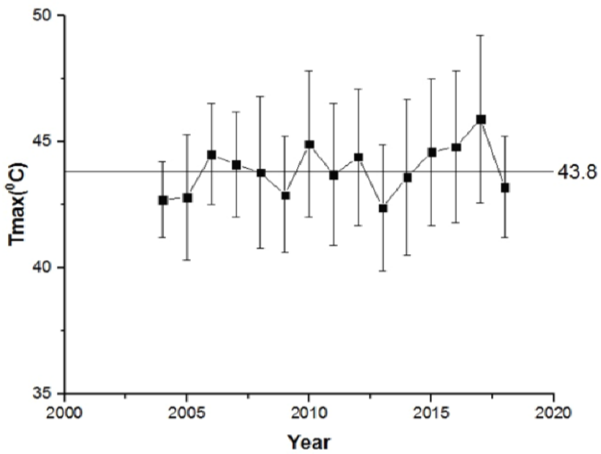

Figure 2. Average maximum air temperature for the period from 2004 to 2018.

RESULTS AND DISCUSSION

Heat extremes and waves

A heat wave, or heatwave (www.oxfordlearnersdictionaries.com) is a time of excessively hot weather, followed by high humidity, especially in oceanic climatic countries. Although definitions vary (Meehl, 2004), a heat wave is usually measured with respect to the area's daily climate and with respect to average seasonal temperatures. Air temperatures that are considered normal by people from a hotter climate can be called a heat wave in a cooler area if they are outside the normal climate pattern in that area (Robinson, 2001).

The word refers both to variations in warm weather and to extreme hot spells that can only occur once a century. Severe heat waves have resulted in catastrophic crop failures, thousands of hyperthermic deaths. A heat wave is considered extreme weather, and a risk because the human body may be overheated by heat and sunlight. Using predictive instruments, heat waves can usually be detected.

The air temperature is a significant of weather elements, which is influences on the weather state. So it effects on the life. Extreme and heat waves air temperature in Iraq extracted from 15 summer seasons (June, July and August from 2004 to 2018) used the data from (Iraqi Meteorological Organization and Seismology) to the Baghdad city for the 95th threshold percentile.

Table 4. Number of heat extremes and waves for the period (2004-2018).

Years	No. of Extremes	Duration (d)		
		2 – 3	4 – 5	> 6
2005	1	-	-	-
2006	2	1	-	-
2007	1	1	1	-
2008	4	-	1	-
2010	4	2	-	-
2011	1	2	-	-
2012	-	1	-	1
2015	2	1	-	-
2016	-	1	-	-
2017	5	5	-	-
2018	-	-	-	-

In this work, the result was large or equal (47.6 °C), and Table 5 above represents behavior of extreme and heat waves in Baghdad city for 15 summer seasons, shown great fluctuation. It was lowest in 2006 from (47.5 – 48.3 °C), while the greater was 2010, 2012 and 2017. The events centered for midsummer season (between of July and beginning of August). Table 4 presents the Number of heat extremes and waves such as the dates and durations. It can be noted that the year 2017 is more serious event which characterizes frequent extremely maximum air temperature and heat waves.

Table 5. The dates and numbers of heat extremes and waves with their maximum air temperature for the period (2004-2018).

Date	Extreme Temp. (°C)	Heat waves (°C)		
		2 – 3 days	4 – 5 days	> 6 days
18/7/2005	47.6	-	-	-
13/8/2006	48.3	-	-	-
17-18/8/2006	-	47.7, 48	-	-
26/8/2006	47.9	-	-	-
25-28/7/2007	-	-	49, 48.2, 49, 48	-
30-31/7/2007	-	47.7, 49	-	-
1/8/2007	48.3	-	-	-
28/6/2008	48	-	-	-
22/7/2008	48.3	-	-	-
26/7/2008	48.5	-	-	-
22/8/2008	48	-	-	-
27-30/8/2008	-	-	49.1, 47.6, 47.6, 48.5	-
14/6/2010	48.6	-	-	-
10-12/7/2010	-	40, 50, 50.6	-	-
31/7/2010	49.3	-	-	-
7/8/2010	48.6	-	-	-
11-13/8/2010	-	48.4, 48.4, 48.6	-	-
24/8/2010	48.6	-	-	-
14/7/2011	48.7	-	-	-
29-31/7/2011	-	48.4, 49.4, 49.8	-	-
1-2/8/2011	-	50.4, 50.9	-	-
19-20/7/2012	-	49, 50	-	-

ISSN: 1814-635X (print), ISSN:2521-3520 (online) Volume 31, Issue 2, 2020 DOI: http://doi.org/10.23851/mjs.v31i2.753

22-27/7/2012	-	-	-	49.5, 50.2, 49.6, 48.6, 49, 48.8
29-31/7/2015	-	49.4, 51, 49.5	-	-
4/8/2015	50	-	-	-
20/8/2015	49.4	-	-	-
20-21/7/2016	-	50 , 49.5	-	-
28/6/2017	49.6	-	-	-
4-6/7/2017	-	49.4, 49.4, 49.8	-	-
17-19/7/2017	-	49.7, 50.5, 49.5	-	-
22-23/7/2017	-	50.2, 49.5	-	-
2/8/2017	50.2	-	-	-
6/8/2017	49.5	-	-	-
7/8/2017	49.5	-	-	-
8-9/8/2017	-	50, 49.7	-	-
10/8/2017	50	-	-	-
12-13/8/2017	-	49.5, 49.7	-	-

Heat waves frequency

Summary statistics such as relative frequencies were applied on the number heat waves. The hottest heat wave had a median of Baghdad city during (2004-2018). In this work the total period of this study (15 years) is divided into equally three miner periods: 2004-2008, 2009-2013, and 2014-2018. Each period has 460 days of summer months (June, July and August). Table 6 show the Lowest maximum air temperature of heat waves. Based on the highest rates, the heat wave showed the greatest increase in death numbers. Increasing the degrees of freedom for mean temperature generally results in smaller heat wave effects. This is because increased flexibility captures better the non-liner hazard transition at extreme temperature.

Table 6. Lowest maximum air temperature of heat waves for three periods at confidence level 95%.

Interval	No. of extremes	Lowest of limited (°C)	Percent of frequency (%)
2004-2008	20	47.56	4.347
2009-2013	24	48.4	5.217
2014-2018	25	49.4	5.434
2004-2018	69	46.6	5.000

Calculate mortality rate

A mortality rate is a measure of the frequency of occurrence of death in a defined population during a specified interval. The formula for calculating the mortality rate follows as (Palmore and Gardner, 1996):

$$\text{Mortality} = \frac{\text{number of deaths in a given time period}}{\substack{\text{population from which the deaths occurred} \\ \text{in the same time period}}} \times 10^{n} \qquad (1)$$

Based on vital statistics, the mortality rate (e.g. counts of birth or death certificates, age and sex), typically, the denominator is the population at the midpoint of the time period, values of 1000 and 100000 are both used for 10^n for most types of mortality types.

Mortality rate

In this work show number of monthly deaths this data was taken from Ministry of Health available for the period (2014-2018) these data are monthly number of deaths (summer and winter) are presented in Figure 3, the data show a clear increase in the number of deaths during the three summer months (June, July and August) and the increase in deaths due to diseases affected by high temperatures. Also we took the population data from the office of the Ministry of Planning. Mortality rate computed using Eq. (1). Also monthly air temperature data was taken for all years (2004-2018). The study showed that the number of deaths in the summer months were more than the spring and autumn months, as well as the total number of deaths for the years from (2015-2018). As well as the total number of deaths for the years from (2015-2018) increased in the summer months except in 2014 where the numbers of deaths were low due to low temperatures as shown in Figure (3) that the number of deaths for men are more than those for women and this is due to the fact that the immune factor in men is lower than the immune factor in women Because of the high estrogen in women which strengthens the immune system (WMO, 2016).

And therefore Show that the relationship between temperatures and numbers of deaths is a direct relationship as temperature increases. The number of deaths is increasing as shown in Table 7.

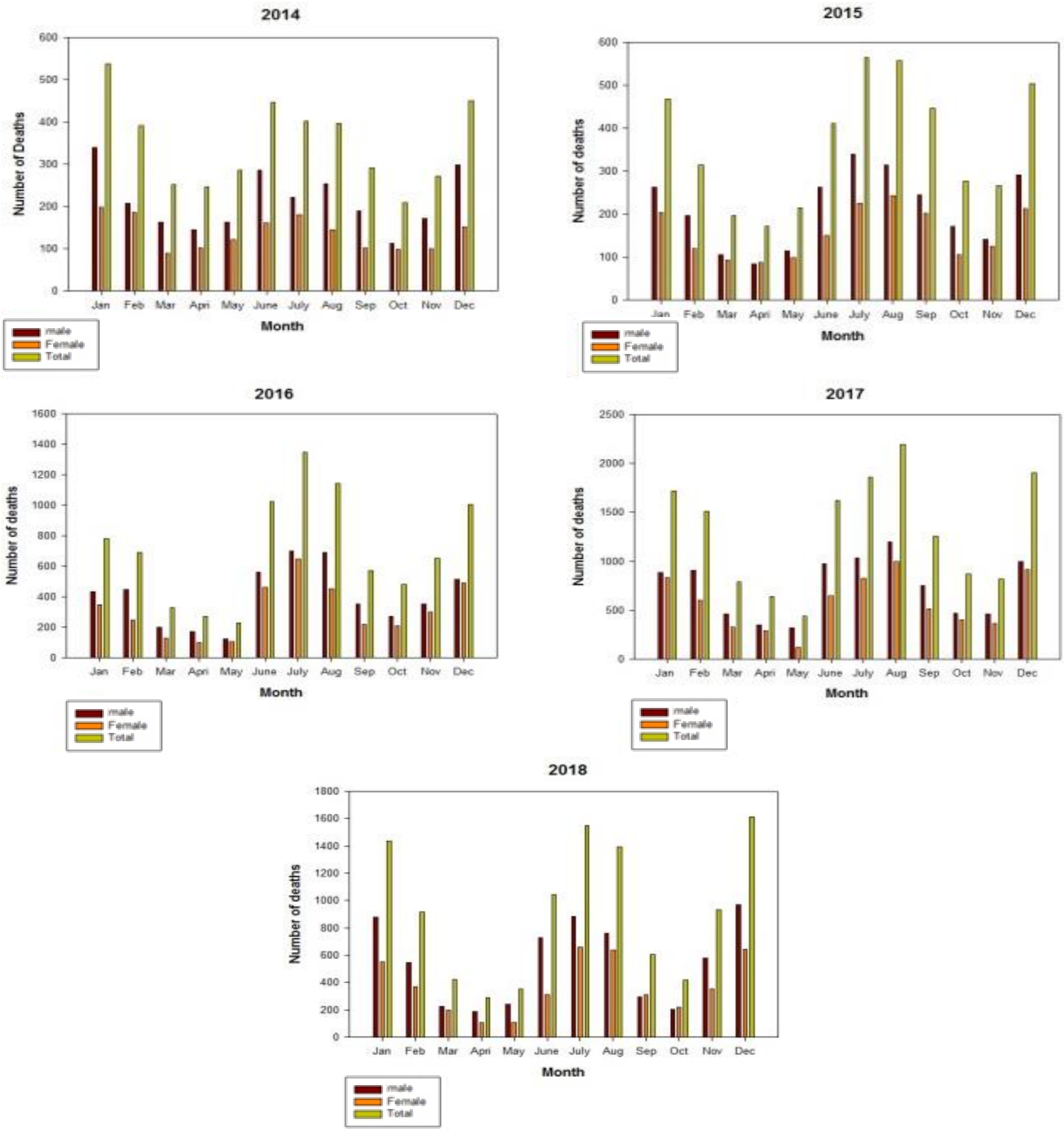

Figure 3. shows the number of deaths of every month for period (2014-2018) for age group (10-60 years) for threshold 95th percentile.

Table (7) shows the total mortality rate for diseases affected by extreme temperatures for the years from (2014 to 2018) this data was taken from the Ministry of Health for age group (10-60 years) as well as the proportion of the annual population from (2014 to 2018) obtained by the Ministry of Planning and linked with maximum air temperature. Equation (1) was used to calculate mortality rate extract values through this equation and arranged in Table (7), where it turns out from Table (7) that the increase in mortality rate increases with increasing temperatures and thus be a direct relationship between high temperature and mortality.

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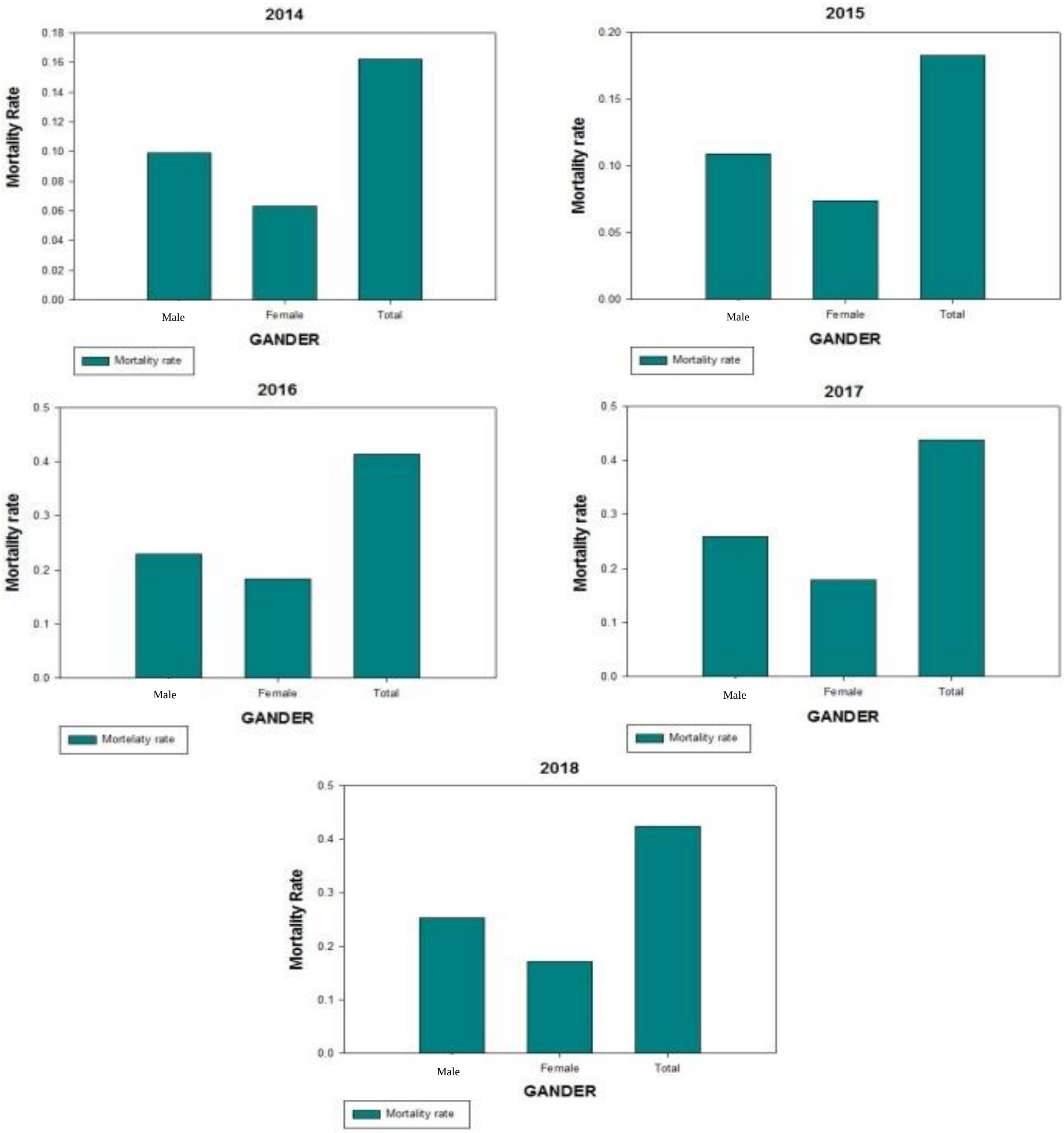

Figure 4. Shows the mortality rate of three month (June, July, August) for period (2014-2018) for age group (10-60 years) for threshold 95th percentil.

Table 7. Mortality rate for three summer months, population and average annual maximum air temperature.

Years	Population	Mortality rate			Tmax (°C)
		Male	Female	Total	
2014	7,665,000	0.0992	0.0632	0.1625	43.5
2015	8,405,172	0.0109	0.0740	0.1825	44.5
2016	8,500,000	0.2297	0.1837	0.4135	44.7
2017	8,953,110	0.2597	0.1780	0.4378	45.8
2018	9,400,000	0.2526	0.1710	0.4237	43.1

CONCLUSIONS

This paper presents a detail study of the effects of the heat extremes and waves in Baghdad represented by daily maximum air temperature and their impact on mortality rate. In this research accumulated evidence that indicates a causal relationship between mortality rate and extreme weather. It was found that there are diseases to which human beings cause death due to high temperatures. Knowing the attitudes and behavior of people towards extremes of the climate is important for better targeted awareness campaigns to reduce the health burden of exposure to temperature. The findings also point to the need to consider environmental exposures in an effort to reduce the burden of disease among the urban poor.

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