Original Article

Impact of Heat Wave in 2005 on Mortality in Guangzhou, China*

YANG Jun[1,△], LIU Hua Zhang[2,△], OU Chun Quan[1,#], LIN Guo Zhen[2], DING Yan[3], ZHOU Qin[2], SHEN Ji Chuan[2], and CHEN Ping Yan[1]

1. Department of Biostatistics, School of Public Health and Tropical Medicine, Southern Medical University, Guangzhou 510515, Guangdong, China; 2. Guangzhou Center for Disease Control and Prevention, Guangzhou 510440, Guangdong, China; 3. Faculty of Medicine, Southern Medical University, Guangzhou 510515, Guangdong, China

Abstract

Objective To assess the impact of the heat wave in 2005 on mortality among the residents in Guangzhou and to identify susceptible subpopulations in Guangzhou, China.

Methods The data of daily number of deaths and meteorological measures from 2003 to 2006 in Guangzhou were used in this study. Heat wave was defined as ≥7 consecutive days with daily maximum temperature above 35.0 °C and daily mean temperature above the 97th percentile during the study period. The excess deaths and rate ratio (RR) of mortality in the case period compared with the reference period in the same summer were calculated.

Results During the study period, only one heat wave in 2005 was identified and the total number of excess deaths was 145 with an average of 12 deaths per day. The effect of the heat wave on non-accidental mortality (RR=1.23, 95% CI: 1.11-1.37) was found with statistically significant difference. Also, greater effects were observed for cardiovascular mortality (RR=1.34, 95% CI: 1.13-1.59) and respiratory mortality (RR=1.31, 95% CI: 1.02-1.69). Females, the elderly and people with lower socioeconomic status were at significantly higher risk of heat wave-associated mortality.

Conclusion The 2005 heat wave had a substantial impact on mortality among the residents in Guangzhou, particularly among some susceptible subpopulations. The findings from the present study may provide scientific evidences to develop relevant public health policies and prevention measures aimed at reduction of preventable mortality from heat waves.

Key words: Heat wave; Mortality; Temperature; China

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INTRODUCTION

The average surface temperature of earth has increased by about 0.8 °C since 1900 and is projected to rise by 1.1 to 6.4 °C during the next hundred years[1]. Global warming contributed to the increased frequency, intensity and duration of extreme weather events. The health impact of these extreme events has therefore become an increasing public health concern. Heat waves, a period of persistent extreme high temperatures, are the most lethal type of weather events. And an astonishing number of excess deaths and hospitalizations occurred during several

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△YANG Jun and LIU Hua Zhang contributed equally to this study.

#Correspondence should be addressed to OU Chun Quan, Ph.D., Tel: 86-20-61360456; Fax: 86-20-61648319. E-mail:ouchunquan@hotmail.com

Biographical note of the first author: YANG Jun, male, born in 1987, master candidate, majoring in environmental epidemiology.

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devastating heat waves in the last decades. For example, the 1987 Athens heat wave caused around 2000 deaths[2]. The 1995 Chicago heat wave led to approximately 700 deaths[3], and the 2003 heat wave in Europe was estimated to cause about 15 000 deaths in France alone during 1-20 August[4]. Furthermore, relatively mild heat waves occur more and more frequently worldwide but their impacts have not yet been well documented.

Some subpopulations may be more vulnerable to extreme temperature than others due to greater exposure, underlying physiological factors (e.g. aging and pre-existing chronic diseases) or poor access to other amenities (e.g. nutritious food, air conditioner and heater and proper health care). Previous studies have indicated that the elderly[5-6], females[6-7], and the black[7] are at higher risk of mortality due to heat waves and elevated temperature. And these findings provided important information for the establishment of heat warning systems and development of other prevention measures targeting the susceptible subpopulations in the West. The magnitude of the effect of heat waves differed by region and time[8-11]. This spatial and temporal heterogeneity may be modified by the characteristics of heat wave (e.g. intensity, duration and timing in the season)[11-12] and previous winter mortality[13-14]. It is also suggested that area-level sociodemographic factors are potential modifiers[8,10]. However, there was no inconclusive evidence of effect modification by socioeconomic factors in the United States[15], Europe[16], and Australia[17]. Individual-level socioeconomic data have greater gradient than area-level data, and therefore may stimulate a more powerful study. However, the private information is generally unavailable in official mortality dataset in the West.

The literatures about the association between heat wave and mortality mainly came from Europe and the United States, but the impact of heat wave has not yet been well characterized in Asia, particularly in tropical or subtropical regions[11,18], where people are more frequently and intensively exposed to extreme high temperature and therefore greater impacts of heat waves are supposed. Therefore, more studies in these regions are needed to better understand the effects of global warming and also to guide local intervention programs. In this study, we used a simple method to calculate excess deaths from all natural causes, cardiovascular diseases and respiratory diseases during a heat wave in Guangzhou. We also identified susceptible subpopulations by gender, age, educational level and occupation class.

MATERIALS AND METHODS

Data Collection

Guangzhou, located at 23° 7’ north latitude, is the largest city in southern China with a typical subtropical climate. It has a population of about 12.7 million, and the population density is 1708 inhabitants/km^2.

Daily non-accidental mortality from January 1, 2003 to December 31, 2006 in Guangzhou were collected from Guangzhou Municipal Health Bureau. The causes of death were coded according to International Classification of Diseases, Revision 10 (ICD-10). The data on mortality were classified into deaths due to all non-accidental causes (ICD-10: A00-R99), cardiovascular diseases (ICD-10: I00-I99) and respiratory diseases (ICD-10: J00-J98). The data were also stratified by gender, age (0-64, 65-74, ≥75 years), educational level and occupation class. Educational level, defined as the highest degree of schooling completed before death, included three degrees: illiterate or semiliterate, primary education and secondary or higher education. Three occupation classes were considered: the unemployed (including housewife), blue-collar and white-collar workers.

Temperature data (daily minimum, maximum, and mean temperature) were derived from China Meteorological Data Sharing Service System[19].

Definition of Heat Wave

A heat wave is a prolonged period of excessive heat. Although several methods exist to give the definition of a heat wave in terms of duration and threshold of heat, there is no universally accepted definition. In the present study, a definition of a “heat day” with daily maximum temperature exceeding 35 °C by Chinese Meteorological Administration was used. A heat wave was defined as ≥7 consecutive heat days and daily mean temperature above the 95th percentile. And this definition has been used in previous research[20]. Based on this definition, we identified a heat wave between July 13 and July 21, 2005 (9 days) in Guangzhou.

Statistical Analysis

To account for the possibility of delayed effects of the heat wave, we extend the case period by three subsequent days beyond the heat wave period[21-22]. Thus, the case period was from 13 to 24 July 2005 (12 days). To control potential time-varying confounding effects in assessing excess deaths associated with the heat wave, we chose a bidirectional near-term reference period of the same summer and with the same distribution of days of the week for the case period. And the periods from 22 to 27 June 2005 and from 9 to 14 August 2005 were defined as the reference period. Similar definitions of reference period by Huang et al. in Shanghai[18] and Knowlton et al. in California[23] were used to estimate the heat-related mortality or morbidity.

We estimated the impact of heat wave by comparing mortality rate during the case period with that during the reference period. Since the population changed little during one summer and the case period had identical length with the reference period, the person-time units in the denominators of the two mortality rates were equivalent for these two periods. This allowed us to calculate the rate ratio (RR) as the ratio between the number of deaths during the case period (C) and deaths during the reference period (R), and excess deaths were calculated as difference in the numbers of deaths during these two periods. RR is not generally asymptotically normal, while the natural logarithm of RR is usually normally distributed. We also calculated the 95% confidence interval (95% CI) of RRc using the following equation[24]:

$$\exp[\ln(RR) \pm 1.96\ \sqrt{1/C + 1/R}]$$

We tested statistically a potential effect modifier by calculating the 95% CI of the relative difference of RRs between two subgroups using the following equation. The relative difference of RRs is actually the ratio of the two RRs, which can be called as relative risk ratio (RRR).

$$\exp[(Q_1 - Q_2) \pm 1.96\ \sqrt{SE_1^2 + SE_2^2}]$$

Where Q_1 and Q_2 are their respective ln(RR) for the two subgroups (e.g., females and males); SE_1 and SE_2 are the standard error of ln(RR)[25]. The effect modification was regarded as statistically significant if the 95% CI of RRR did not include 1.

To determine whether the effect estimate of the 2005 heat waves was robust to the statistical method, we used a time-stratified case-crossover design to re-estimate the effect of the heat wave. In this case-crossover design, each subject acts as their own controls. Control days were matched to the case day (i.e. the day of death) using day of the week within a stratum length of 28 days[26]. Conditional logistic regression was also performed to calculate odds ratio (OR) of mortality for the heat wave by comparing the case day with control days. In addition, a less strict definition of a heat wave was used to detect other potential heat waves during the study period from 2003 to 2006. A heat wave was defined alternatively as a period of at least 5 or 6 consecutive days with daily maximum temperature above 35.0 °C and with daily mean temperature above the 95th percentile of temperature distribution.

All analyses were conducted using R 2.13.1 statistical software package, Vienna, Australia.

RESULTS

From 2003 to 2006, the average daily mean temperature was 23.0 °C (6.3-34.2 °C) in Guangzhou (Table 1), reflecting the characteristic of subtropical climate. The 95th percentile of daily mean temperature was 30.7 °C. A 9-day heat wave was identified during the period from 13 to 21 July 2005. The average daily maximum temperature during the 2005 heat wave was 37.0 °C (35.6 to 39.0 °C). The average daily maximum temperature during the reference period was 31.0 °C (27.4 to 34.2 °C).

During the 2005 heat wave in Guangzhou, there were 145 excess deaths in the study population with an average of 12 deaths per day (Figure 1). Among these deaths, 109 (75.2%) were caused by cardiorespiratory diseases. The heat wave resulted in a 23%, short but intensive, increase of all non-accidental mortality compared with the reference period (RR=1.23, 95% CI: 1.11-1.37). The heat wave led to the obvious increase of deaths from cardiovascular disease (RR=1.34, 95% CI: 1.13-1.59) and respiratory disease (RR=1.31, 95% CI: 1.02-1.69) (Table 2).

Table 1. Summary Statistics of Daily Maximum, Mean, and Minimum Temperature in Guangzhou, 2003-2006

Temperature Measures	Mean	Min.	P_5	Median	P_{95}	Max.	SD
Mean temperature(°C)	22.9	6.3	11.7	24.5	30.7	34.2	6.2
Minimum temperature(°C)	19.7	2.1	8.0	21.1	27.3	30.4	6.2
Maximum temperature(°C)	27.6	7.1	15.3	28.8	35.6	39.1	6.3

Note. P_5 is the 5th percentile and P_{95} is the 95th percentile.

Table 2. Rate Ratio (RR) of Mortality by Cause, Gender, Age, Educational Level, and Occupation Class during Case Period and Reference Period

Variables	Number of Deaths			RR (95% CI)[a]
	Case Period	Reference Period	Excess Deaths	
Cause				
All non-accidental	767	622	145	1.23 (1.11, 1.37)[b]
Cardiovascular	301	225	76	1.34 (1.13, 1.59)[b]
Respiratory	138	105	33	1.31 (1.02, 1.69)[b]
Gender				
Male	390	364	26	1.07 (0.93, 1.24)
Female	377	258	119	1.46 (1.25, 1.71)[b]
Age (years)				
0-64	161	169	-8	0.95 (0.77, 1.18)
65-74	175	164	11	1.07 (0.86, 1.32)
75+	431	289	142	1.49 (1.28, 1.73)[b]
Education				
Illiterate/semiliterate	175	115	60	1.52 (1.20, 1.93)[b]
Primary	333	270	63	1.23 (1.05, 1.45)[b]
Secondary or higher	234	213	21	1.10 (0.91, 1.32)
Occupation class				
White-collar	84	86	-2	0.98 (0.72, 1.33)
Blue-collar	339	244	95	1.39 (1.18, 1.64)[b]
Unemployed	166	147	19	1.13 (0.90, 1.41)

Note. The case period was during 13-24 July 2005 and the reference period was during 22-27, June and 9-14 August 2005. [a]Rate ratios (RRs) were calculated as ratios between the death numbers during the case period and the reference period. [b]Significant at the 0.05 level.

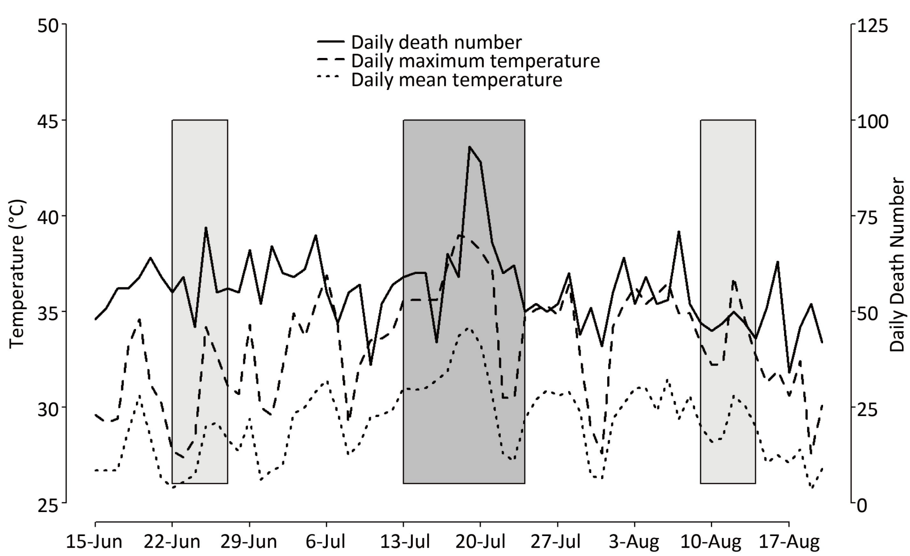

Figure 1. Daily death number, maximum and mean temperature during case period (13-24 July 2005, shown in the central grey quadrangle) and during reference period (22-27 June and 9-14 August 2005, shown in the light grey quadrangle) in Guangzhou.

Table 2 shows the effect estimates of the 2005 heat wave by subpopulations and table 3 presents the differences between strata. Those aged ≥75 years were more likely to be affected by the heat wave for non-accidental mortality compared with those aged <65 years, the difference was statistically significant (RRR=1.565, 95% CI: 1.204-2.034). The risk of heat wave-related mortality in females was significantly greater than that in males (RRR=1.363, 95% CI: 1.101-1.689). A trend of decreased heat-related mortality risk with increased education level was observed. The people receiving no education suffered more from the heat wave than those receiving secondary or higher education (RRR=0.722, 95% CI: 0.534-0.974). We also observed significantly greater effect of the heat wave to the blue-collar workers than to the white-collar workers (RRR =1.422, 95% CI: 1.010-2.004). And the effect differences between subpopulations for cardiovascular and respiratory mortality were generally similar with the differences for non-accidental mortality (Table 3), though some differences were not statistically significant.

We re-estimated the effects of the 2005 heat wave using a case-crossover design. The estimates by case-crossover analyses were similar with those obtained by the primary method. And the estimates were only slightly changed after adjusting for potential confounding variables, such as humidity, barometric pressure and air pollution (Table 4). We also performed sensitivity analysis based on less strict definition of a heat wave. By defining heat wave as ≥6 days with daily maximum temperature above 35 °C and daily mean temperature above the 95th percentile, we identified a 6-day heat wave during 28 June-3 July 2004, during which the average daily maximum temperature was 37.6 °C (36.2-39.1 °C). Given a duration of 5 or more days considered, we identified another 5-day heat wave from 28 July to 1 August 2003, which had an average daily maximum temperature of 36.0 °C (35.2-37.6 °C). We observed a similar effect of the 2004 heat wave and smaller effect of the 2003 heat wave compared with the 2005 heat wave (Table 5).

DISCUSSION

Generalized additive model was widely used to assess health impact of ambient temperatures. However, statistical modeling may be very complicated, and the effect estimates are likely to be biased and undetected due to lack of statistical power in the case of rare events, such as heat waves.

Table 3. Relative Differences of Rate Ratios (RRR) of Heat Wave-related Mortality by Gender, Age, Educational Level and Occupation Class

Effect Modifiers	Relative Difference of Rate Ratio (95% CI)		
	All Non-accidental	Cardiovascular	Respiratory
Gender			
Male (reference group)	—	—	—
Female	1.363 (1.101, 1.689)[b]	1.327 (0.938, 1.879)	1.430 (0.859, 2.382)
Age			
0-64 (reference group)	—	—	—
65-74	1.120 (0.828, 1.517)	0.909 (0.533, 1.551)	2.363 (0.915, 6.110)
75+	1.565 (1.204, 2.034)[b]	1.547 (0.972, 2.457)	2.266 (1.018, 5.038)[b]
Education			
Illiterate/semiliterate (reference group)	—	—	—
Primary	0.811 (0.610, 1.078)	0.846 (0.544, 1.315)	0.851 (0.473, 1.533)
Secondary or higher	0.722 (0.534, 0.974)[b]	0.694 (0.433, 1.115)	0.792 (0.373, 1.684)
Occupation Class			
White-collar(reference group)	—	—	—
Blue-collar	1.422 (1.010, 2.004)[b]	1.034 (0.557, 1.912)	1.334 (0.527, 3.374)
Unemployed	1.156 (0.795, 1.680)	0.934 (0.460, 1.898)	1.071 (0.388, 2.962)

Note. [b]Significant at the 0.05 level.

Table 4. Odds Ratios of Mortality Associated with the 2005 Heat Wave by Cause, Gender, Age, Educational Level, and Occupation Class and by Case-crossover Design

Variables	OR (95% CI)[a]	OR (95% CI)[b]
Cause		
All non-accidental	1.20 (1.09, 1.32)[c]	1.20 (1.08, 1.32)[c]
Cardiovascular	1.40 (1.20, 1.64)[c]	1.37 (1.17, 1.62)[c]
Respiratory	1.25 (1.02, 1.49)[c]	1.24 (1.03, 1.47)[c]
Gender		
Male	1.13 (0.98, 1.29)	1.13 (0.98, 1.30)
Female	1.28 (1.11, 1.47)[c]	1.27 (1.10, 1.47)[c]
Age (years)		
0-64	1.08 (0.88, 1.33)	1.08 (0.88,1.34)
65-74	1.11 (0.92, 1.36)	1.11 (0.90, 1.36)
≥75	1.29 (1.13, 1.47)[c]	1.29 (1.13,1.48)[c]
Education		
Illiterate/semiliterate	1.40 (1.14, 1.72)	1.42 (1.14, 1.77)
Primary	1.17 (1.01, 1.35)[c]	1.17 (1.01, 1.36)[c]
Secondary or higher	1.18 (0,95, 1.47)	1.10 (0.89, 1.36)
Occupation Class		
White-collar	1.22 (0.93, 1.61)	1.25 (0.94, 1.67)
Blue-collar	1.33 (1.12, 1.54)[c]	1.32 (1.10, 1.55)[c]
Unemployed	1.20 (0.95, 1.51)	1.19 (0.93, 1.51)

Note: [a]Case-crossover design; [b]Case-crossover design by adjusting for humidity, barometric pressure, PM_{10}, NO_2, and SO_2; [c]Significant at the 0.05 level.

In the present study, we used a simple method to assess the impact of the 2005 heat wave in Guangzhou by comparing the observed number of deaths during the case period with that during the reference period. By using a time-close reference period, all time-invariant variables (e.g. populations) are controlled. Furthermore, we found that the estimated effect values were very similar with those produced by the case-crossover design, indicating that this simple method is robust. Compared with the case-crossover analysis, this simple method does not need statistical modeling or a long study period, and the results are easy to be interpreted. We believe that this method can be therefore widely applied to assess health impact of any individual extreme weather event.

Table 5. Rate Ratios of Mortality Related to the 2003 and 2004 Heat Waves

Variables	Number of Deaths			RR (95% CI)[a]
	Case Period	Reference Period	Excess Deaths	
2003 heat wave				
All non-accidental	448	413	35	1.08 (0.95. 1.24)
Cardiovascular	159	151	8	1.05 (0.84, 1.32)
Respiratory	81	76	5	1.07 (0.78, 1.46)
2004 heat wave				
All non-accidental	703	549	154	1.28 (1.15,1.43)[b]
Cardiovascular	293	204	89	1.44 (1.20,1.72)[b]
Respiratory	146	105	41	1.39 (1.08,1.79)[b]

Note. [b]Significant at the 0.05 level.

Many previous studies have investigated the association between heat and mortality in the United States[27-28], Europe[9], Korea[11], and Australia[29], but few reported the situation in China. Findings from the present study were about non-accidental mortality[9,18,29]. We found that the 2005 heat wave led to an increase of 23% of non-accidental mortality and an increase of 34% of cardiovascular mortality. A multi-city study in Europe reported 8.5%-33.6% mortality risk for all natural deaths and 3.9%-92.5% for cardiovascular deaths caused by the 2003 heat wave[9].

Our study also found that estimated effect values were markedly higher for cardiovascular and respiratory deaths compared with all non-accidental deaths, consistent with previous studies[5,29-30]. Exposure to extreme heat may lead to direct cardiovascular stress including changes in blood pressure and vasoconstriction, and causes pathological responses of the respiratory epithelium. And this may contribute to increased cardiovascular mortality and respiratory mortality.

Consistent with reports from numerous studies[11,18,31-32], we found higher susceptibility to heat waves among the elderly. Aging induces physiological changes in thermoregulation and homeostasis, together with the increased prevalence of chronic conditions and use of medication, resulting in the susceptibility to heat stress. We observed significantly stronger heat wave-associated mortality in females than in males. This gender difference was also observed in previous epidemiological studies[8,32], and experimental evidence also showed that females were more heat intolerant than males due to potential gender-related physiological and thermoregulatory differences[33-34].

Furthermore, our present study indicated that heat wave-associated mortality was modified by educational level and occupation class. People with less education suffered more from heat waves, consistent with the results reported by cohort studies[6,11]. Notably, education level was generally used as a proxy of socioeconomic status in previous studies. However, there is lack of literature about the role of occupation class in modifying the effects of ambient temperatures. In the present study, we found significant greater mortality risk from the heat wave in blue-collar workers compared with that in white-collar workers. A preliminary explanation was the heterogeneity in exposure level. Blue-collar workers are engaged in manufacturing, mining, construction, maintenance and many other physical works, therefore they are more frequently and intensively exposed to outdoor extremely high temperatures than white-collar workers. In addition, the availability of air conditioning is relatively low for blue-collar workers at their homes and workplaces. Other possible explanation for the increased heat susceptibility due to disadvantaged socioeconomic status may be related to poor baseline health status, limited access to health care and high prevalence of health problems[10].

Some multi-city studies have shown that the impacts of heat waves are influenced by the characteristics of individual heat waves. Heat waves occurring earlier, lasting longer and being more intensive had larger health impacts[11-12]. This was also confirmed by the findings from our sensitivity analysis based on an alternative definition of heat wave. Compared with the 9-day 2005 heat wave occurring on 13 July, the 2004 heat wave occurred earlier (28 June) with a short duration (6 days) and more extremely high temperatures, the average daily maximum temperature was 37.6 °C (37.0 °C for the 2005 heat wave). As a result, these 2 heat waves had similar effects on mortality with the RR of 1.28 and 1.23, respectively. In contrast, the 2003 heat wave occurred later (July 28), lasted less days (5 days) and was milder (an average maximum temperature of 36.0 °C), therefore it yielded smaller impact on mortality with the RR of 1.08.

Some limitations should be noted in the present study. The impact of heat waves on mortality may vary with region and population due to adaptation facilities and acclimatization[10]. Our data are from one single city, it should be used with caution in other geographic areas and under other climatic environments. Moreover, we could not examine the lag distribution and mortality displacement of heat wave effect due to the inherent limitation of the method we applied. However, we considered potential lag effect by taking three lag days into the period of heat wave when comparing with the reference period. And future research is needed to explore the characteristics of health impacts of heat waves.

In conclusion, we observed the significant impact of a heat wave in the subtropical city, Guangzhou. Our findings highlight a need to increase the people’s awareness of heat wave risk and related protection behaviors. The elderly, females, people with low socioeconomic status and those with cardiovascular and respiratory diseases have been identified to be more vulnerable to heat waves. And these findings can be used in establishing heat warning systems and developing prevention programs in order to reduce heat wave-associated mortality.

REFERENCES

1. Mechl GA, Stocker TF, Collins WD, et al. Chapter. 10: Global Climate Projections, Section 10.5: Quantifying the Range of Climate Change. IPCC AR4 WG1, 2007.
2. Katsouyanni K, Trichopoulos D, Zavitsanos X, et al. The 1987 Athens heatwave. Lancet, 1988; 2, 573.
3. Kaiser R, Le Tertre A, Schwartz J, et al. The Effect of the 1995 Heat Wave in Chicago on All-Cause and Cause-Specific Mortality. Am J Public Health, 2007; S97, 158-62.
4. Le Tertre A, Lefranc A, Eilstein D, et al. Impact of the 2003 heatwave on all-cause mortality in 9 French cities. Epidemiology, 2006; 17, 75-9.
5. Basagaña X, Sartini C, Barrera-Gómez J, et al. Heat Waves and Cause-specific Mortality at all Ages. Epidemiology, 2011; 22, 765-72.
6. Hajat S, Kovats RS, Lachowycz K. Heat-related and cold-related deaths in England and Wales: who is at risk?. Occup Environ Med, 2006; 64, 93-100.
7. Schwartz J. Who is sensitive to extremes of temperature?: A case-only analysis. Epidemiology, 2005; 16, 67-72.
8. Basu R. High ambient temperature and mortality: a review of epidemiologic studies from 2001 to 2008. Environ Health, 2009; 8, 40.
9. D'Ippoliti D, Michelozzi P, Marino C, et al. The impact of heat

waves on mortality in 9 European cities: results from the EuroHEAT project. Environ Health, 2010; 9, 37.
10. Hajat S, Kosatky T. Heat-related mortality: a review and exploration of heterogeneity. J Epidemiol Community Health, 2009; 64, 753-60.
11. Son JY, Lee JT, Anderson GB, et al. The impact of heat waves on mortality in seven major cities in Korea. Environ Health Perspect, 2012; 120, 566-71.
12. Anderson GB, Bell ML. Heat Waves in the United States: Mortality Risk during Heat Waves and Effect Modification by Heat Wave Characteristics in 43 U.S. Communities. Environ Health Perspect, 2010; 119, 210-8.
13. Stafoggia M, Forastiere F, Michelozzi P, et al. Summer temperature-related mortality: effect modification by previous winter mortality. Epidemiology, 2009; 20, 575-83.
14. Ha J, Kim H, Hajat S. Effect of previous-winter mortality on the association between summer temperature and mortality in South Korea. Environ Health Perspect, 2011; 119, 542-6.
15. Basu R, Ostro BD. A Multicounty Analysis Identifying the Populations Vulnerable to Mortality Associated with High Ambient Temperature in California. Am J Epidemiol, 2008; 168, 632-7.
16. Ishigami A, Hajat S, Kovats RS, et al. An ecological time-series study of heat-related mortality in three European cities. Environ Health, 2008; 7, 5.
17. Yu W, Vaneckova P, Mengersen K, et al. Is the association between temperature and mortality modified by age, gender and socio-economic status? Sci Total Environ, 2010; 408, 3513-8.
18. Huang W, Kan H, Kovats S. The impact of the 2003 heat wave on mortality in Shanghai, China. Sci Total Environ, 2010; 408, 2418-20.
19. China Metrorological Adminstration. China Meteorological Data Sharing Service System. Available at: http://cdc.cma.gov.cn/ (accessed on 12 July 2012).
20. Ma W, Xu X, Peng L, et al. Impact of extreme temperature on hospital admission in Shanghai, China. Sci Total Environ, 2011; 409, 3634-7.
21. Yip FY, Flanders WD, Wolkin A, et al. The impact of excess heat events in Maricopa County, Arizona: 2000-2005. Int J Biometeorol, 2008; 52, 765-72.
22. Antics A, Pascal M, Laaidi K, et al. A simple indicator to rapidly assess the short-term impact of heat waves on mortality within the French heat warning system. Int J Biometeorol, 2012.
23. Knowlton K, Rotkin-Ellman M, King G, et al. The 2006 California heat wave: impacts on hospitalizations and emergency department visits. Environ Health Perspect, 2009; 117, 61-7.
24. Rothman KJ, Greenland S, Lash TL. Modern epidemiology. Lippincott Williams &Wilkins, Philadelphia, PA, 2008.
25. Schenker N, Gentleman JF. On judging the significance of differences by examining the overlap between confidence intervals. Am Stat, 2001; 55, 182-6.
26. Tong S, Wang XY, Guo Y. Assessing the short-term effects of heatwaves on mortality and morbidity in Brisbane, Australia: comparison of case-crossover and time series analyses. PLoS One, 2012; 7, e37500.
27. Gasparrini A, Armstrong B. The Impact of Heat Waves on Mortality. Epidemiology, 2011; 22, 68-73.
28. O'Neill MS, Zanobetti A, Schwartz J. Modifiers of the temperature and mortality association in seven US cities. Am J Epidemiol, 2003; 157, 1074-82.
29. Tong S, Ren C, Becker N. Excess deaths during the 2004 heatwave in Brisbane, Australia. Int J Biometeorol, 2010; 54, 393-400.
30. Anderson BG, Bell ML. Weather-Related Mortality. Epidemiology, 2009; 20, 205-13.
31. Baccini M, Biggeri A, Accetta G, et al. Heat effects on mortality in 15 European cities. Epidemiology, 2008; 19, 711-9.
32. Barnett AG. Temperature and Cardiovascular Deaths in the US Elderly. Epidemiology, 2007; 18, 369-72.
33. Druyan A, Makranz C, Moran D, et al. Heat tolerance in women--reconsidering the criteria. Aviat Space Environ Med, 2012; 83, 58-60.
34. Racine M, Tousignant-Laflamme Y, Kloda LA, et al. A systematic literature review of 10 years of research on sex/gender and experimental pain perception - part 1: are there really differences between women and men? Pain, 2012; 153, 602-18.