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Heat wave impact on mortality in Pudong New Area, China in 2013

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HIGHLIGHTS

- The heat wave had a significant impact on mortality.
- Females and people aged ≥80 years old were significantly vulnerable to the heat wave.
- The cardiovascular excess mortality was higher than that of all-cause deaths.
- The respiratory excess mortality was higher than that of all-cause deaths.

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ABSTRACT

Background: In 2013 southeast China suffered from an unusual high temperature, which had broken the heat records in the past 141 years. Few studies have examined the impact of heat waves on mortality in Asia.
Objective: To estimate the impact of the heat wave in 2013 on mortality among the registered permanent residence population and identify susceptible subpopulations in Pudong New Area.
Methods: To model the relationship between the maximum temperature and mortality, a quasi-poisson generalized additive model was applied using data from 1 January 2008 to 15 June 2013. Extrapolating the model the estimated daily expected number of deaths was calculated over the period of 16 June 2013 to 15 September 2013.
Results: There were four heat waves in 2013, causing 167 (95% CI: 46–280) excess deaths in all-cause mortality, corresponding to an excess mortality of 10.51%. After the first two heat waves, the cumulative excess death counts gradually reduced to the level before the start of the heat waves. In contrast, the cumulative excess death numbers increased rapidly during the last two heat waves, without decreasing after the heat waves. Females (male: 10.43%, female: 11.79%) and people aged ≥80 years old (excess deaths were 129 (95% CI: 47–203) and excess mortality was 16.64%) were strongly affected by the heat waves. The excess mortalities of cardiovascular and respiratory disease were 22.34% and 20.68% respectively, which were higher than that of all-cause deaths.
Conclusions: The 2013 heat wave had a significant impact on mortality even after the considered "mortality displacement". Females and people aged ≥80 years old were significantly vulnerable to the heat waves. The observed excess mortalities of cardiovascular and respiratory disease were higher than all-cause deaths. These results could provide scientific evidences for policy makers to frame heat wave-related prevention measures, which may help in reducing the mortality.

1. Introduction

Climate change is the biggest global health threat of the 21st century and it affects most populations directly or indirectly (Haines et al., 2009). One of the indisputable consequences of climate change is the increasing frequency and intensity of heat waves (IPCC, 2012). Several recent studies indicated that heat wave events may have considerable adverse impacts on mortality, even in developed countries. A heat wave occurred in Europe during summer 2003, had caused many excess deaths, including 15,000 in France (Fouillet et al., 2006), 3134 in Italy (Conti et al., 2005) and 975 in Switzerland (Grize et al., 2005). The heat wave that hit California for two weeks in 2006 led to an excess of at least 140 deaths (Knowlton et al., 2009). In July 2010 in Québec, the crude daily rates showed a significant increase of 33% in deaths (Bustinza et al., 2013). There was 13% excess of mortality in Sydney,

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Table 1
Baseline characteristics of daily meteorological data and mortality during the period from 16 June to 15 September (2008–2013).

	2013			2008–2012		
	Total	Median (quartile)	Range	Total	Median (quartile)	Range
Maximum temperature (°C)	–	34.6 (31.5, 37.1)	22.7–40.9	–	33.6 (31.5, 35.0)	26.7–40.5
Minimum temperature (°C)	–	26.6 (24.2, 27.8)	19.9–29.3	–	26.6 (25.5, 27.5)	21.5–31.0
Mean temperature (°C)	–	30.1 (27.0, 31.6)	21.1–34.8	–	29.4 (28.0, 30.4)	24.7–34.7
Ave-humidity (%)	–	71.2 (65.0, 77.3)	50–95.5	–	74.4 (69.8, 80.8)	52.7–92.8
Wind speed (m/s)	–	18.2 (14.9, 24.2)	6.0–46.5	–	10.0 (1.8, 20.3)	0.4–60.5
Rainfall (mm)	–	0.0 (0.0, 0.7)	0–143.3	–	0.0 (0.0, 3.1)	0.0–164.5
All-cause mortality	4677	50 (46, 63)	30–79	4388	48 (43, 54)	27–78
Gender						
Male	2494	27 (24, 30)	15–45	2352	25 (21, 30)	13–44
Female	2183	23 (20, 27)	13–42	2035	22 (18, 26)	11–42
Age group						
<65 years	951	10 (8, 13)	3–19	973	11 (8, 13)	3–18
65–79 years	1334	15 (12, 17)	6–22	1372	15 (12, 17)	7–27
≥80 years	2392	25 (22, 28)	12–50	2042	22 (18, 26)	6–41
Cardiovascular mortality	1591	17 (14, 20)	10–33	1419	15 (12, 19)	4–27
Respiratory mortality	365	4 (2, 4)	0–10	400	4 (3, 6)	0–14

Australia, 2011 (Schaffer et al., 2012). However, we still have little knowledge about the heat wave impact in Asia, as few studies were conducted.

From 16 June 2013 to 15 September 2013, southeastern China suffered an unusually high temperature which had broken the heat records in the past 141 years. Pudong New Area, the largest district in Shanghai, had suffered 41 days high temperature with a daily maximum temperature that exceeded 35° Celsius (°C), ranging from 35 °C to 40.9 °C. The purpose of this study is to estimate certain excess mortality impacts of the 2013 heat wave in Pudong New Area, furthermore, to give practical advice on health management for heat wave related diseases.

2. Materials and methods

2.1. Study area

Pudong New Area, with a north subtropical monsoon climate, whose real-time population at present totaled to 5.26 million, including 2.81 million registered permanent residence populations that occupied 1430 km^2, is considered to be the engine of the economic and social development of China.

2.2. Data collection

We obtained daily mortality data from the Center for Disease Control and Prevention of Pudong New Area from the period of 1 January 2008 to 15 September 2013. Deaths that were not from the registered permanent residence population were excluded from the analysis. Mortality variables included daily deaths which were counted by gender, age and causes of deaths. According to the International Classification of Diseases, 10th revision (ICD-10), the death counts of cardiovascular diseases (ICD-10: I00–I99) and respiratory diseases (ICD-10: J00–J98) were classified by the causes of deaths.

Meteorological data came from the Weather Office in Pudong New Area, including the mean temperature, maximum temperature, minimum temperature, the relative humidity, the wind speed, the rainfall and the atmospheric pressure.

2.3. Data analysis

Heat wave definition: There is no consistent definition for heat wave worldwide, because people may have acclimatized to their local climatic zones (Tong and Khan, 2011), and different studies have applied various temperature metrics (Kinney, 2008). Heat waves are usually defined by absolute or relative temperature threshold within consecutive days. In this study, we used the Chinese Meteorological Administration's definition, which defined heat wave as “at least three consecutive days with maximum temperature exceeding 35 °C”.

Excess mortality estimation: The observed excess mortality was defined as the difference between the observed number of deaths and the estimated number of deaths. The estimated number of deaths was predicted by a quasi-poisson generalized additive model. First, we built a model between daily deaths and daily maximum temperature from 1 January 2008 to 15 June 2013. Second, we replaced the actual maximum temperature, which was higher than 35 °C during these days between 16 June 2013 and 15 September 2013, by the historical average of the maximum temperature in the same day. Third, we obtained the estimated number of deaths by extrapolating the model with replaced maximum temperature.

Statistical analysis: Descriptive analysis characterized the baseline characteristics of daily meteorological data and daily fluctuation of mortality. Then Pearson correlation analysis was used for meteorological variables. It showed that mean temperature, maximum temperature, minimum temperature and atmospheric pressure had strong significant correlations, and the correlation coefficients were more than 0.7. Therefore, to avoid multicollinearity, only maximum temperature was used for the four variables. Meanwhile, relative humidity, wind speed and rainfall were chosen.

To adjust long-term trends, seasonal variation, day of week, corresponding terms were included in the quasi-poisson generalized additive model. Meteorological variables for the same day (lag 0) up to lag days (lag 6) and cumulative lags by 2 (average of lag 1 and 2), 3 (average of lag 1, 2 and 3) to 6 days (average of lag 1–6) were tested in each model. The lag day with meteorological variables that yielded the largest χ^2 value obtained from the change in deviances was chosen.

Table 2
Characteristics of the heat wave in 2013 in Pudong New Area.

Heat wave no.	Date of start	Total duration (days)	Highest maximum temperatures		Number of days exceeded 38 °C
			°C	Number of days after the start	
1	02/07	4	37.8	3	0
2	07/07	5	37.4	4	0
3	21/07	12	40.0	6	10
4	03/08	12	40.9	4	6

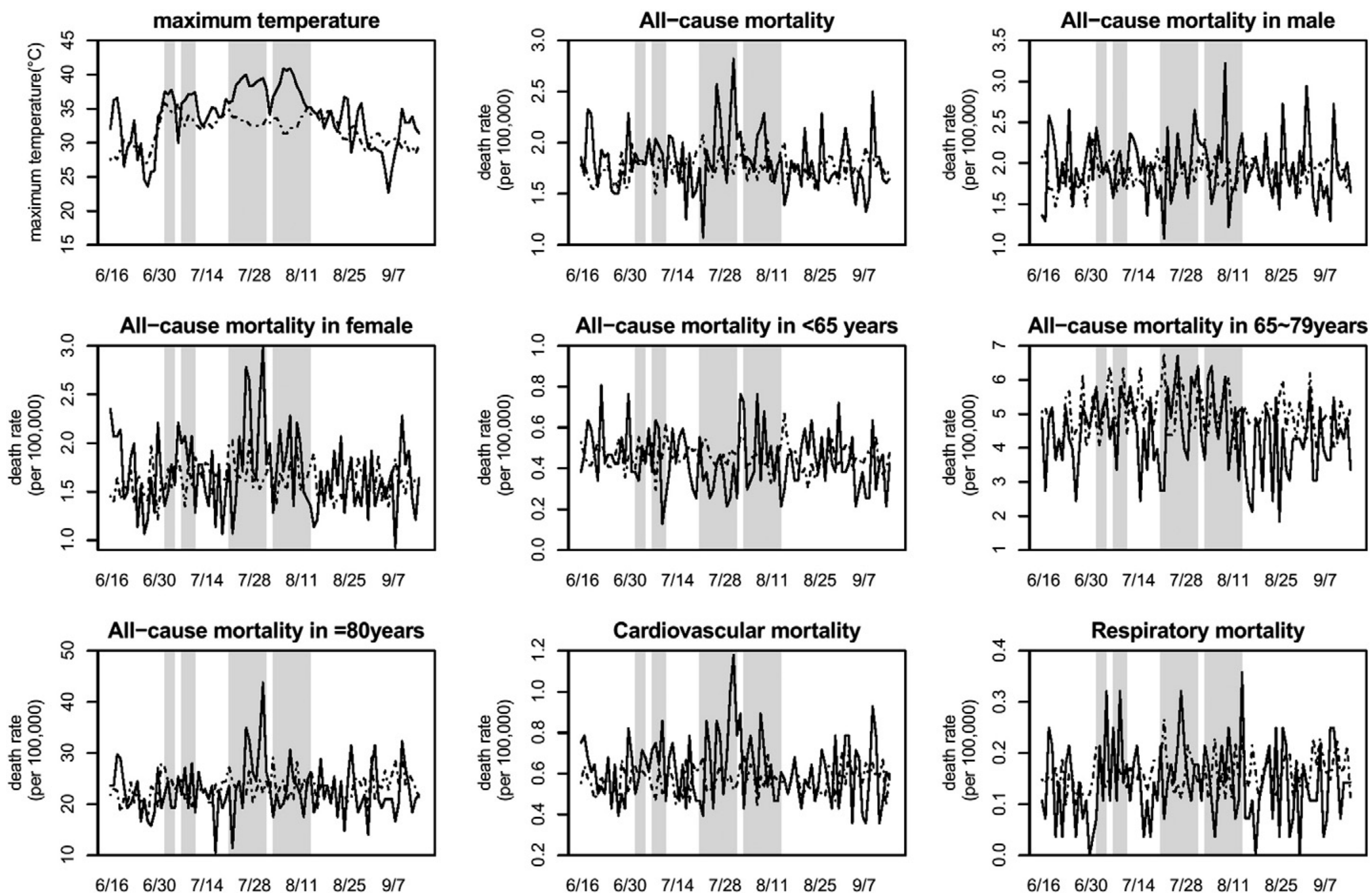

Fig. 1. Daily mortality rate and maximum temperature in Pudong New Area from 16 June to 15 September in 2013 (bald solid line ________) plotted against the average of daily mortality rate and maximum temperature in the same period from 2008 to 2012 (broken line). Light gray background presents the heat wave.

Several models which were based on the different combination of weather covariates were fitted for the data between 1 January 2008 and 15 June 2013. The generalized cross-validation (GCV) criterion (Gu, 2002) and Akaike information criterion for quasi-poisson (Q-AIC) values that evaluate the predictive ability were computed for each model.

Data were analyzed using the MGCV package in the R software version 3.0.1 (R Foundation for Statistical Computing, Vienna, Austria).

3. Results

Table 1 shows summary statistic characteristics in Pudong New Area. From June 16 to September 15 in 2013, the average daily mean temperature was 30.1 °C (range from 27 °C to 31.6 °C), the average daily maximum temperature was 34.6 °C (range from 22.7 °C to 40.9 °C), and the average daily relative humidity was 71.2%. There were total 4677 all-cause deaths, including 2494 males and 2183 females. 19.9% of all-cause deaths was younger than 65 years old, 30.5% was between 65 and 79 years old, and 49.6% was older than 79 years old. Cardiovascular and respiratory death counts were 1591 and 365 respectively during the period.

Table 2 shows that there were 4 heat waves in 2013 and daily maximum temperature during that period exceeded 35 °C. Furthermore, there were 16 days in which the maximum temperature was over 38 °C. The first heat wave began from July 2 to July 5 and the highest maximum temperature was 37.8 °C. The second one began at July 7 lasting for 5 days in which the highest maximum temperature was 37.4 °C. Both of the third and fourth heat waves lasted 12 days and the highest maximum temperature was 40 °C and even higher. There were no days that the maximum temperature exceeded 38 °C in the first and the second heat waves, but there were 10 days in the third

Table 3
Observed excess deaths and mortality ratio in 2013 heat waves.

Characteristics	Pop	Baseline deaths	Observed deaths	Mortality ratio	Number of excess deaths	Net excess mortality rate per 100,000
All-cause deaths	2,798,219	1588	1755	1.1051	167 (46, 280)	5.968
Male	1,395,249	823	909	1.1043	86 (12, 154)	6.164
Female	1,402,970	684	757	1.1179	89 (9, 162)	6.344
<65 years	2,355,965	331	316	0.9552	−15 (−41, 9)	–
Male	1,191,908	227	220	0.9678	−7 (−29, 13)	–
Female	1,164,057	104	96	0.9253	−8 (−22, 5)	–
65–79 years	328,039	480	534	1.1130	54 (19, 87)	16.461
Male	159,498	301	306	1.0150	5 (−22, 29)	3.135
Female	168,541	178	228	1.2809	50 (31, 67)	29.666
≥80 years	114,215	776	905	1.1664	129 (47, 203)	112.945
Male	43,843	300	383	1.2773	83 (41, 120)	189.312
Female	70,372	474	522	1.1021	48 (−14, 103)	68.209
Cardiovascular deaths	2,798,219	501	613	1.2234	112 (57, 162)	4.002
Respiratory deaths	2,798,219	135	163	1.2068	28 (−7, 55)	1.001

one and 6 days in the fourth one that the maximum temperature exceeded 38 °C.

Fig. 1 shows the comparison of daily fluctuation of death rate from June 16 to September 15 in 2013 and the same period from 2008 to 2012. All-cause mortality had two peaks during the third heat wave and one peak in the fourth one. All-cause mortality for the males had a peak in the fourth heat wave and two peaks in the third heat wave for the females. All-cause mortality in aged 80 years and more had two peaks in the third heat wave, but there was no obvious peak in other age group. The peaks in daily fluctuation of cardiovascular mortality centered in the third and fourth heat waves, but the main peak in respiratory mortality was nearby the end of the last heat wave.

Table 3 shows the impact of heat waves in 2013 on Mortality in Pudong New Area. During the 2013 heat wave, 167 excess deaths (95% CI: 46–280) were observed, equivalent to an excess mortality of 10.51%. The excess mortality was higher in females than that in males (male 10.43%, female 11.79%). For subjects aged 65–79 years, the observed number of excess deaths was 54 (95% CI: 19–87). For subjects aged 80 years and more, the observed number of excess deaths was 129 (95% CI: 47–203), and the excess mortality was much higher in females (male 1.50%, female 28.09%) in this age group. The observed excess deaths of cardiovascular and respiratory diseases were 112 and 28 respectively, equivalent to an excess mortality of 22.34% and 20.68%. Fig. 2 shows the daily relative risk of mortality of the heat-

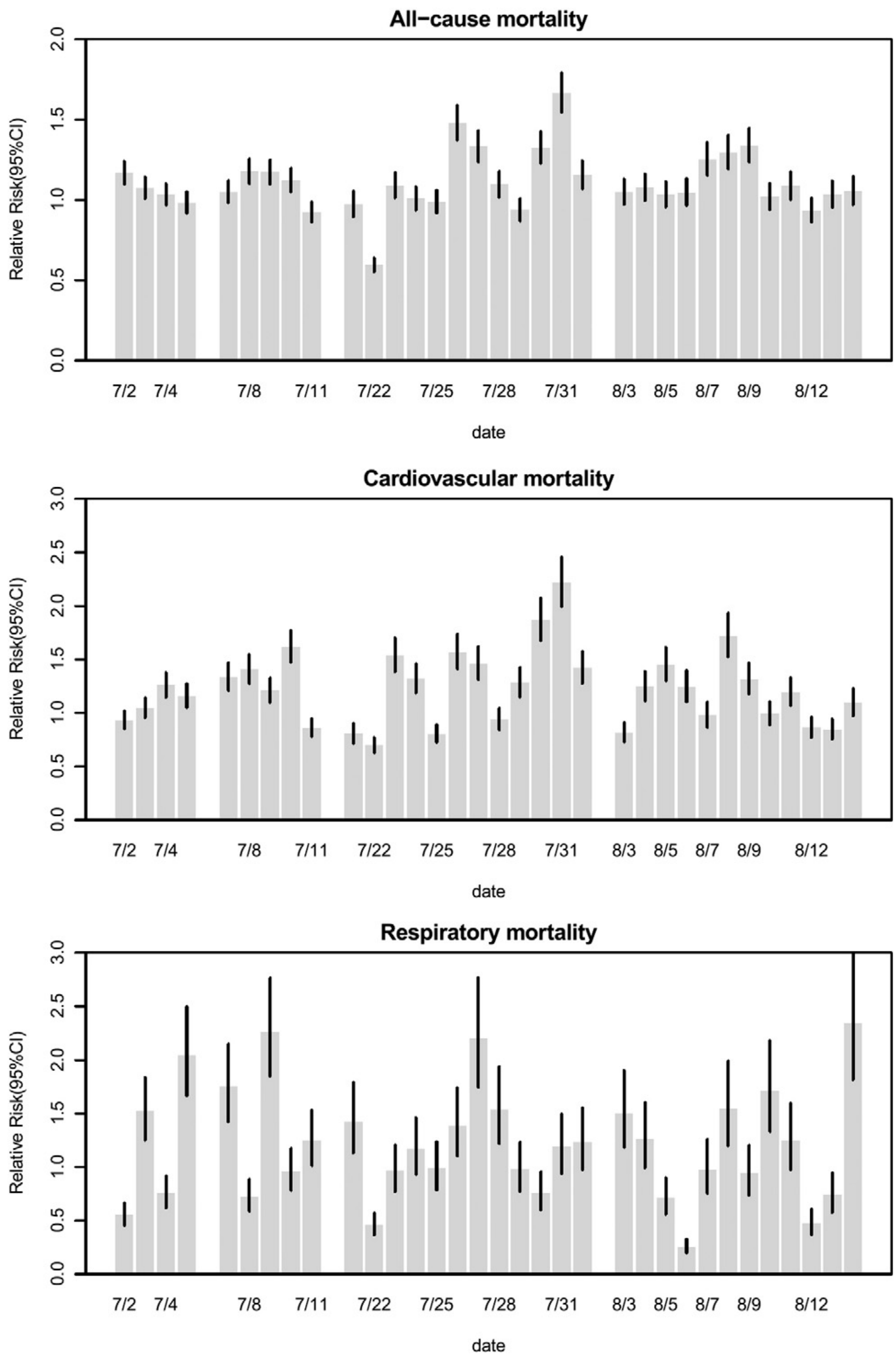

Fig. 2. Relative risk associated to the heat wave and 95% confidence interval during 2013 heat waves.

wave effect during the 2013 heat wave. The maximum relative risk of all-cause death ($RR = 1.6638$, 95% CI: 1.5443–1.7925) and cardiovascular death ($RR = 2.2137$, 95% CI: 1.9953–2.4560) occurred at July 31 in the third heat wave, while the maximum relative risk of respiratory death ($RR = 2.3404$, 95% CI:1.8175–3.0139) occurred at August 14 in the fourth heat wave.

Fig. 3 presents the cumulative excess death numbers from July 2 to September 15 in 2013. After the first and second heat waves, the cumulative excess death numbers increased and gradually reduced to the level before the start of the heat waves. While during the third and fourth heat waves, the cumulative excess death numbers were growing rapidly and remained elevated after the end of the heat waves.

4. Discussion

The comparison of the observed and estimated mortalities during the 2013 heat waves has shown that 167 excess deaths occurred in all-cause mortality in Pudong New Area, corresponding to an excess mortality of 10.51%. The 2013 heat waves in Pudong New Area included respective 33 days of maximum daily temperatures exceeding 35 °C, which were more extreme than 2003 heat waves in France (15 days of maximum daily temperatures exceeding 35 °C). However, the excess mortality in Pudong New Area is much lower than 60% of that in France (Fouillet et al., 2006; Vandentorren et al., 2004). The possible reason for that is that the public is more effective in preventing health damage caused by health events due to the increase in such incidents. More and more people know that heat-related deaths are largely avoided through timely communication and appropriate prevention. So the effective prevention and proactive cognitive could partly explain why the lower excess mortality occurred in the more extreme heat waves. This situation could also be partly explained by the gradual changes in the population's behavior during heat waves, notably the increasing use of air conditioning systems.

In this study, the observed numbers of excess deaths were 129 in the oldest age group (≥80 years old), but there were 54 excess deaths in the age group between 65 years old and 80 years old and 15 excess deaths in age group less than 65 years old, so older people were more strongly affected by the heat waves, consistent with reports from numerous studies (Son et al., 2012; Baccini et al., 2008). Physiological changes in thermoregulation and homeostasis change with age and so together with the increasing prevalence of chronic conditions, using of medication and sedentary lifestyles, and reducing body temperature regulation and dehydration, which result in the susceptibility to heat stress (Åström et al., 2011; Kenney and Munce, 2003).

Both females and males have been reported to have higher mortality ratios than the opposite gender (Rooney et al., 1998; R B., 2009; Michelozzi et al., 2005; Whitman et al., 1997). In this study, the overall excess mortality for females was higher than that for males, which may be explained by the greater longevity of females. While the difference needs to be elucidated, it would be imprudent to consider that only women are exposed to the risk of death in heat waves (Fouillet et al., 2006). But study evidence also showed that females were more heat intolerant than males because of potential gender-related physiological and thermoregulatory differences (Druyan et al., 2012; Racine, 2012).

Fig. 3 shows that the cumulative excess death numbers were gradually reduced to the level before the start of the heat waves. This may be explained by "mortality displacement", which means that the deaths of patients who are supposed to be dead in the coming days or weeks are shifted forward (Schaffer et al., 2012). If all excess mortalities were due to "mortality displacement", cumulative excess mortality would drop back to zero shortly after the heat wave. But the cumulative excess death counts grew rapidly and remained elevated after the last heat wave. This represents that mortality displacement accounts for a small part of the excess deaths, consistent with France and Chicago in 2003 and 1995 (Le Tertre et al., 2006; Kaiser et al., 2007), but inconsistent with results from other studies (Martiello and Giacchi, 2010).

Consistent with previous studies (Tong et al., 2010; Basagaña et al., 2011; Yang et al., 2013), this study found that estimated effect values were higher for cardiovascular and respiratory deaths compared with all-cause deaths. Exposure to heat wave may lead to cardiovascular stress which includes changes in blood pressure and vasoconstriction, and causes pathological responses of the respiratory epithelium. This may contribute to increased cardiovascular mortality and respiratory mortality (Yang et al., 2013).

The present analysis has some noteworthy limitations. First, as the Weather Office in Pudong New Area can't provide the daily air pollution information, the present analysis had to be based on meteorological data only. Many previous studies indicated that the ozone had strong associations with temperatures and mortality (Pascal et al., 2012; Filleul, 2006). Second, the analysis was conducted based on a relatively small number of heat waves and deaths compared with other studies, and many potential confounding factors, such as the heat prevention measures that could not be considered.

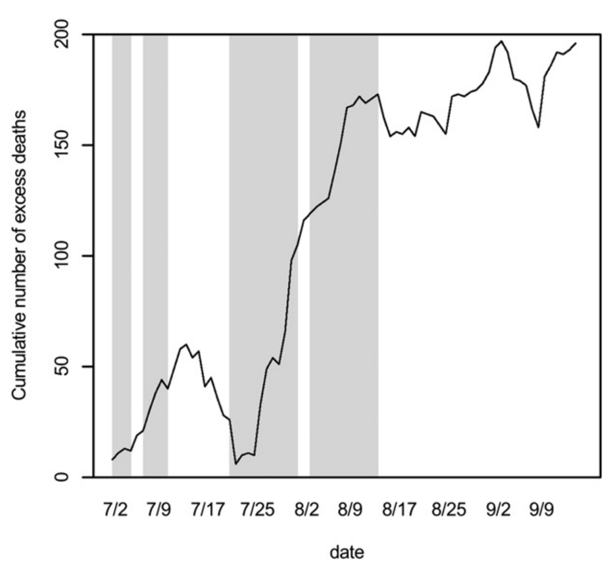

Fig. 3. Cumulative excess death numbers from 2 July to 15 September 2013. Light gray background presents the heat wave.

5. Conclusions

Excess death counts during the first and second heat waves were probably caused by "mortality displacement", but the continuous high temperature caused excess death counts during the third and fourth heat waves. Therefore, the 2013 heat wave still had a significant impact on mortality among the registered permanent residents in Pudong New Area, particularly among some susceptible subpopulations. These results could provide scientific evidences for policy makers to make relevant public health policies and prevention measures for reducing mortality caused by heat waves.

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References

Åström DO, Forsberg B, Rocklöv J. Heat wave impact on morbidity and mortality in the elderly population: a review of recent studies. Maturitas 2011;69(2):99–105.

Baccini M, Biggeri A, Accetta G, Kosatsky T, Katsouyanni K, Analitis A, et al. Heat effects on mortality in 15 European cities. Epidemiology 2008;19(5):711–9.

Basagaña X, Sartini C, Barrera-Gómez J, Dadvand P, Cunillera J, Ostro B, et al. Heat waves and cause-specific mortality at all ages. Epidemiology 2011;22(6):765–72.

Bustinza R, Lebel G, Gosselin P, Belanger D, Chebana F. Health impacts of the July 2010 heat wave in Quebec, Canada. BMC Public Health 2013;13:56.

Conti S, Meli P, Minelli G, Solimini R, Toccaceli V, Vichi M, et al. Epidemiologic study of mortality during the Summer 2003 heat wave inItaly. Environ Res 2005;98(3):390–9.

Michelozzi P, de Donato F, Bisanti L, Russo A, Cadum E, DeMaria M, et al. The impact of the summer 2003 heat waves on mortality in four Italian cities. Euro Surveill 2005;10(7):161–5.

Druyan A, Makranz C, Moran D, Yanovich R, Epstein Y, Heled Y. Heat tolerance in women—reconsidering the criteria. Aviat Space Environ Med 2012;83(1):58–60.

Filleul LCSMS. The relation between temperature, ozone, and mortality in nine French cities during the heat wave of 2003. Environ Health Perspect 2006;114(9):1344–7.

Fouillet A, Rey G, Laurent F, Pavillon G, Bellec S, Guihenneuc-Jouyaux C, et al. Excess mortality related to the August 2003 heat wave in France. Int Arch Occup Environ Health 2006;80(1):16–24.

Grize L, Huss A, Thommen O, Schindler C, Braun-Fahrlander C. Heat wave 2003 and mortality in Switzerland. Swiss Med Wkly 2005;135(13–14):200–5.

Gu C. Smoothing spline ANOVA models. New York: Springer; 2002.

Haines A, McMichael AJ, Smith KR, Roberts I, Woodcock J, Markandya A, et al. Public health benefits of strategies to reduce greenhouse-gas emissions: overview and implications for policy makers. Lancet 2009;374(9707):2104–14.

IPCC. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. [C.B.Field CB, V.Barros V, T.F.Stocker TF, D.Qin D, D.J.Dokken DJ, K.L.Ebi KL, M.D.Mastrandrea MD, K.J.Mach KJ, G.-K.Plattner G-K, S.K.Allen SK, M.Tignor M, P.M.Midgley PM (eds.)]. Cambridge, UK, and New York, NY, USA: Cambridge University Press; 2012.

Kaiser R, Le Tertre A, Schwartz J, Gotway CA, Daley WR, Rubin CH. The effect of the 1995 heat wave in Chicago on all-cause and cause-specific mortality. Am J Public Health 2007;97(Suppl. 1):S158–62.

Kenney WL, Munce TA. Invited review: aging and human temperature regulation. J Appl Physiol (1985) 2003;95(6):2598–603.

Kinney PL, O'Neill MS, Bell ML, Schwartz J. Approaches for estimating effects of climate change on heat-related deaths: challenges and opportunities. Environ Sci Pol 2008;11:87–96.

Knowlton K, Rotkin-Ellman M, King G, Margolis HG, Smith D, Solomon G, et al. The 2006 California heat wave: impacts on hospitalizations and emergency department visits. Environ Health Perspect 2009;117(1):61–7.

Racine M, Tousignant-Laflamme Y, Kloda LA, Dion D, Dupuis G, Choinière M. 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(3):602–18.

Le Tertre A, Lefranc A, Eilstein D, Declercq C, Medina S, Blanchard M, et al. Impact of the 2003 heat wave on all-cause mortality in 9 French cities. Epidemiology 2006;17(1):75–9.

Martiello MA, Giacchi MV. High temperatures and health outcomes: a review of the literature. Scand J Public Health 2010;38(8):826–37.

Pascal M, Le TA, Saoudi A. Quantification of the heat wave effect on mortality in nine French cities during summer 2006. PLoS Curr 2012;4:N1307.

R.B. High ambient temperature and mortality: a review of epidemiologic studies from 2001 to 2008. Environ Health 2009;16:8–40.

Rooney C, McMichael AJ, Kovats RS, Coleman MP. Excess mortality in England and Wales, and in Greater London, during the 1995 heatwave. J Epidemiol Community Health 1998;52(8):482–6.

Schaffer A, Muscatello D, Broome R, Corbett S, Smith W. Emergency department visits, ambulance calls, and mortality associated with an exceptional heat wave in Sydney, Australia, 2011: a time-series analysis. Environ Health 2012;11(1):3.

Son JY, Lee JT, Anderson GB, Bell ML. The impact of heat waves on mortality in seven major cities in Korea. Environ Health Perspect 2012;120(4):566–71.

Tong S, Ren C, Becker N. Excess deaths during the 2004 heatwave in Brisbane, Australia. Int J Biometeorol 2010;54(4):393–400.

Tong S, Kan H. Heat waves: what is in a definition? Maturitas 2011;69(1):5–6.

Vandentorren S, Suzan F, Medina S, Pascal M, Maulpoix A, Cohen JC, et al. Mortality in 13 French cities during the August 2003 heat wave. Am J Public Health 2004;94(9):1518–20.

Whitman S, Good G, Donoghue ER, Benbow N, Shou W, Mou S. Mortality in Chicago attributed to the July 1995 heat wave. Am J Public Health 1997;87(9):1515–8.

Yang J, Liu HZ, Ou CQ, Lin GZ, Ding Y, Zhou Q, et al. Impact of heat wave in 2005 on mortality in guangzhou, china. Biomed Environ Sci 2013;26(8):647–54.