Supplementary Material

Mortality data

This study includes six causes of mortalities: Non-accidental mortality (ICD-10:A00-R99), Circulatory system disease (ICD-10:I00-I99), Cerebrovascular disease (ICD-10:I60-I69), Ischemic Heart Disease (ICD-10:I20-I25), Myocardial infarction (ICD-10:I21-I23), and Stroke (ICD-10:I60-I64). They are classified by the International Statistical Classification of 10th Revision (ICD-10; World Health Organization 2007).

Meteorological data

Temperature and dewpoint temperature during summer of 2013 to 2018 in 130 counties were collected from the European Centre for Medium-Range Weather Forecasts (https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-land?tab=form). First, we calculated the daily temperature and dewpoint temperature in each county by using R software (version 4.0.0; The R Foundation for Statistical Computing); then, according to the equation, we calculated daily relative humidity by temperature and dewpoint temperature for each county.

$$e = 6.11 * 10^{\left(\frac{7.5*T_d}{237.3+T_d}\right)}$$

$$e_s = 6.11 * 10^{\left(\frac{7.5*T}{237.3+T}\right)}$$

$$rh = \frac{e}{e_s} * 100$$

In the formula, T was temperature (℃), T_d was dewpoint temperature (℃), e was the actual vapor pressure, e_s was saturated vapor pressure, rh was the relative humidity (%).

Statistical model

$$LogE(Y_t) = Intercep_t + \beta_1 Var_t + \beta_2 RHmean_t + ns(time, df) + dow$$

In the formula, t was the day of observation; Y_t was the observed daily death counts on day t; β_1 was the regression coefficient of Var_t; β_2 represented regression coefficient of daily mean relatively humidity; Var_t was the observed variable of daily mean temperature, daily maximum temperature, daily minimum temperature on day t; $RHmean_t$ represented mean relative humidity at day t; ns ($time$, df) represented the natural-spline function of time trend and was used a natural cubic regression spline with 3 degrees of freedom (df) in summer of per year to control the long-term and seasonal trends; dow was a dummy variable to control the week effect.

Lagged effect of high temperature

In this study, we studied the lag structures for high temperature and cause-specific mortality. The association between the current day (lag0) of high temperature and cause-specific mortality was tested. What is more, the moving average lag of 1 day to the moving average lag of 7 days of high temperature were also examined in this study. The mortality effect of moving average exposure of previous 1 day and current day (lag 01) was highest among all the lagged exposures (Supplementary Figure S2).

Z test

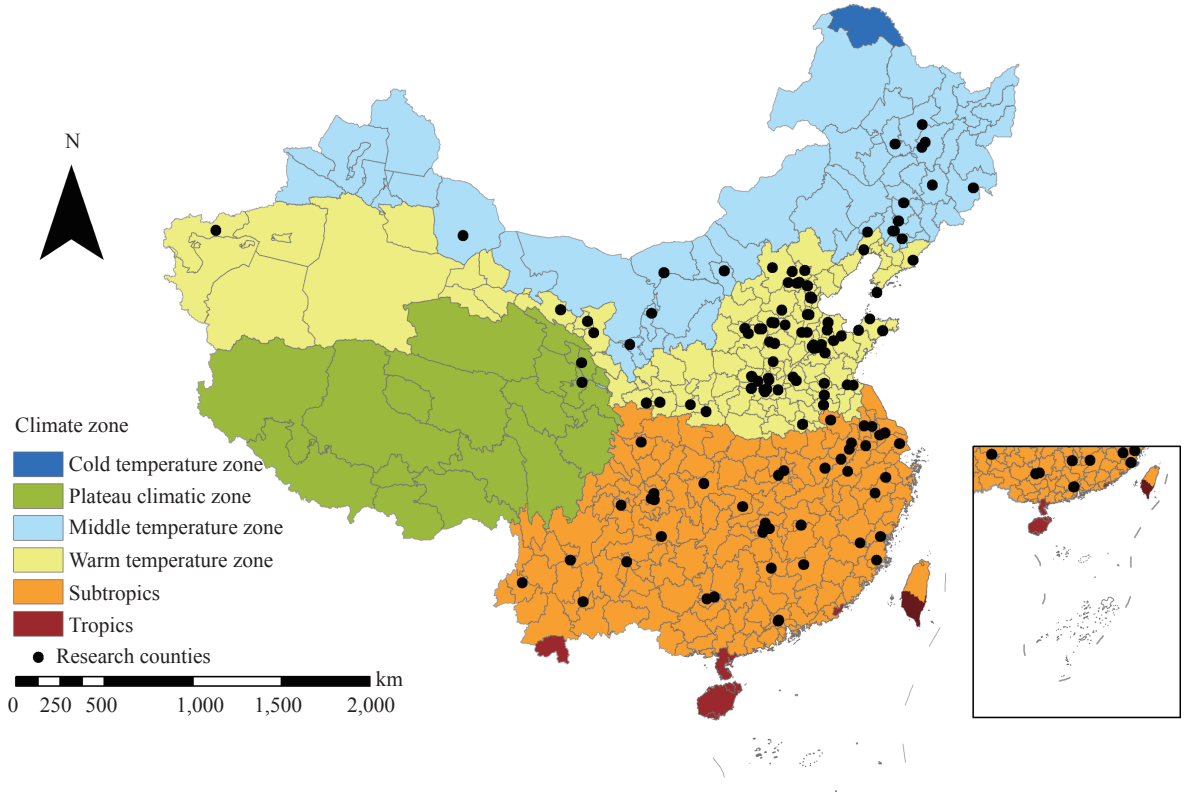
To determine if the risk estimates of high temperature indicators were statistically different, we used the daily mean temperature as a reference and compared it with the daily maximum and minimum temperature respectively (Supplementary Table S2).

$$z = \frac{\beta_1 - \beta_2}{\sqrt{se_1(\beta_1)^2 + se_2(\beta_2)^2}}$$

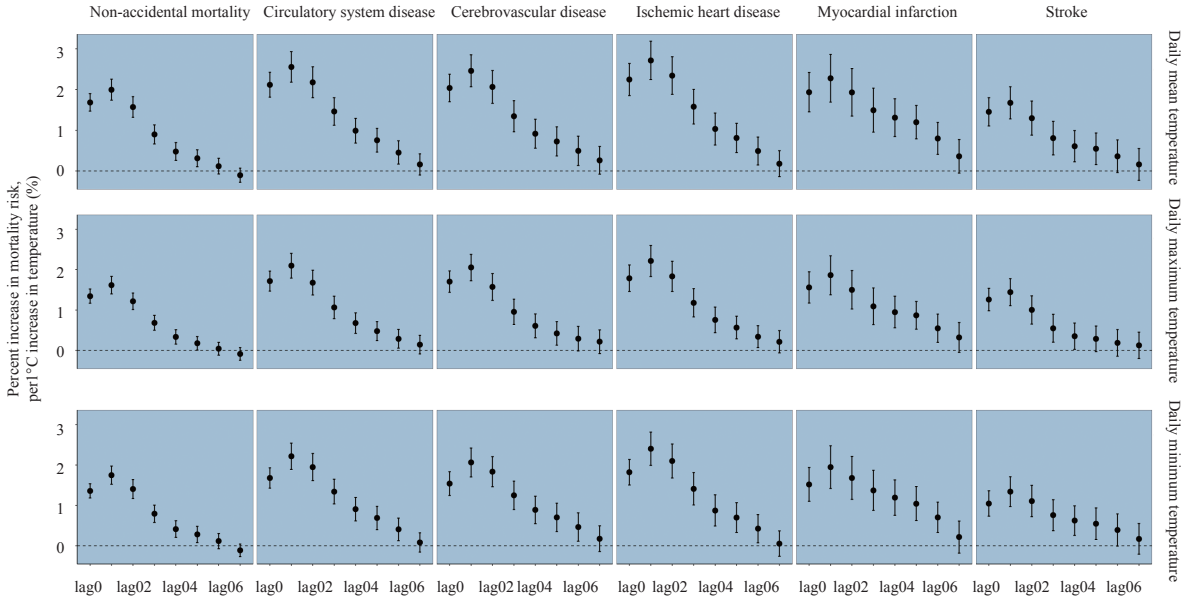
The formula z value was the Z test score for pairwise comparison; the β_1 was the regression coefficient of the daily mean temperature; β_2 was the regression coefficient of the daily maximum temperature or daily minimum temperature; se_1 represented the standard error of daily mean temperature; se_2 represented the standard error of daily maximum temperature or daily minimum temperature.

Sensitivity analysis

Table S3 showed the sensitivity analysis results of daily mean temperature and non-accidental mortality: first, specification of degrees of freedom in the smooth functions of time (df_{time}=2, 4) to observe whether the effect estimation changed; second, inclusion of $PM_{2.5}$ and O_3 as potential confounders on the relationship between high temperature and health, respectively. Sensitivity analysis showed that the core model was robust (Table S3).



SUPPLEMENTARY FIGURE S1. The map of climatic-zones and the distribution of the surveyed 130 counties in China.



SUPPLEMENTARY FIGURE S2. Percent increase in mortality risk due to lagged effect of heat exposure for summer months in 2013 to 2018 nationwide.

SUPPLEMENTARY TABLE S1. Descriptive analysis of daily cause-specific mortality and meteorological data for the summer months in 2013 to 2018 at four climatic zones.

Item	Subtropics	Warm-temperature zone	Middle-temperature zone	Plateau climatic zone
Number of counties	42	71	15	2
Causes of death (Mean ± SD)				
Non-accidental mortality	9 ± 6	9 ± 7	8 ±6	1 ± 1
Circulatory system disease	4 ± 3	4 ± 4	4 ± 3	1 ± 1
Cerebrovascular disease	2 ± 2	2 ± 2	2 ± 2	0 ± 1
Ischemic heart disease	1 ± 1	2 ± 2	2 ± 2	0 ± 0
Myocardial infarction	1 ± 1	1 ± 1	1 ± 1	0 ± 0
Stroke	1± 1	1±2	1 ± 1	0 ± 1
Meteorological factors (Mean ± SD)				
Daily mean temperature (℃)	26 ± 4	24 ± 4	21 ± 5	11 ± 4
Daily maximum temperature (℃)	29 ± 4	29 ± 4	26 ± 5	16 ± 5
Daily minimum temperature (℃)	22 ± 4	20 ± 4	16 ± 5	6 ± 5
Daily mean relative humidity (%)	80 ± 10	68 ± 15	64 ± 20	69 ± 16

SUPPLEMENTARY TABLE S2. Z test of different heat temperature indicators on cause-specific mortality risk for the summer months in 2013 to 2018 nationwide.

Item	Percent increase in mortality risk (%)(95%CI)					
	Non-accidental mortality	Circulatory system disease	Cerebrovascular disease	Ischemic heart disease	Myocardial infarction	Stroke
Indicator						
Daily mean temperature*	2.00 (1.74–2.25)	2.56 (2.18–2.93)	2.46 (2.07–2.85)	2.71 (2.25–3.19)	2.28 (1.70–2.86)	1.67 (1.28–2.07)
Daily maximum temperature	1.61 (1.40–1.83) †	2.10 (1.79–2.41) †	2.05 (1.72–2.38) †	2.21 (1.82–2.60) †	1.86 (1.37–2.35) †	1.44 (1.11–1.77) †
Daily minimum temperature	1.75 (1.52–1.97) †	2.21 (1.89–2.54) †	2.06 (1.71–2.42) †	2.40 (1.99–2.81)	1.94 (1.42–2.47) †	1.34 (0.97–1.71) †

* Daily mean temperature as a reference.
† Z test: p value<0.05.

SUPPLEMENTARY TABLE S3. Summary estimates of sensitivity analysis for daily mean temperature and non-accidental mortality.

Item	No. of Counties	Percent increase in mortality risk (%)(95%CI)
The main analysis		
df_{time}=3	130	2.00 (1.74–2.25)
Alternative degrees of freedom		
df_{time}=2	130	1.51 (1.29–1.74)
df_{time}=4	130	1.94 (1.70–2.18)
Adjusted by adding air pollutants		
$PM_{2.5}$	130	2.19 (1.89–2.49)
O_3	130	2.08 (1.79–2.38)