

Supplementary Information for

Avoidable heat-related mortality in China during the 21st Century

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Supplementary Table 1 Annual heat-related mortality in China and the subregions for present day

	All forcings (95% CI)	Natural forcings only (95% CI)
China	0.017‰ (0.012–0.022‰)	0.015‰ (0.010–0.019‰)
NE	0.006‰ (0.004–0.008‰)	0.004‰ (0.003–0.006‰)
NC	0.007‰ (0.004–0.010‰)	0.005‰ (0.003–0.008‰)
NW	0.005‰ (0.001–0.008‰)	0.004‰ (0.000–0.006‰)
EC	0.028‰ (0.021–0.034‰)	0.024‰ (0.018–0.031‰)
CC	0.007‰ (-0.005–0.018‰)	0.006‰ (-0.006–0.016‰)
SW	0.016‰ (0.011–0.021‰)	0.012‰ (0.007–0.016‰)
SC	0.035‰ (0.028–0.042‰)	0.030‰ (0.023–0.036‰)

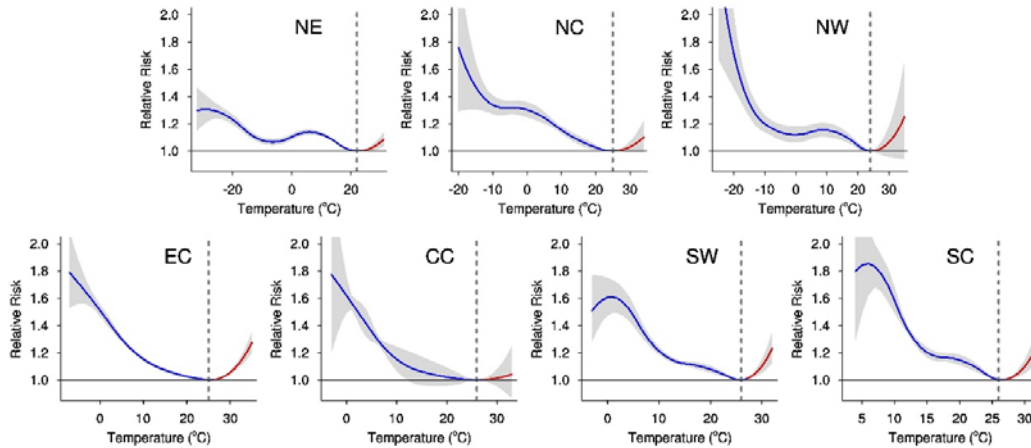
Supplementary Table 2 Summary of the mortality and temperature for the 195 locations during the present day.

Province	City	Locations (n)	Mortality (‰)	Annual temperature (°C)
Anhui	Anqing	1	5.64	15.35
Anhui	Chaohu	1	6.86	15.21
Anhui	Hefei	8	3.99	15.29
Anhui	Maanshan	2	5.08	15.13
Anhui	Chuzhou	2	6.06	15.05
Anhui	Huainan	1	4.80	15.32
Anhui	Lu'an	4	6.66	15.33
Anhui	Wuhu	1	6.86	15.28
Beijing	Beijing	16	3.94	9.26
Gansu	Baiyin	1	4.56	6.32
Gansu	Dingxi	2	6.07	4.89
Gansu	Lanzhou	7	4.35	4.62
Gansu	Linxia	5	5.95	3.50
Hebei	Baoding	1	6.26	10.60
Hebei	Shijiazhuang	21	5.87	10.84
Heilongjiang	Daqing	1	4.19	3.64
Heilongjiang	Harbin	12	4.73	3.04
Heilongjiang	Suihua	2	5.82	3.19
Hubei	Jinmen	1	5.15	14.14
Hubei	Wuhan	1	4.29	15.75
Jilin	Jilin	4	4.29	3.16
Jilin	Liaoyuan	2	5.55	4.71
Jilin	Siping	3	4.89	4.63
Jilin	Changchun	10	4.95	3.86
Jiangsu	Changzhou	2	5.26	15.05
Jiangsu	Nanjing	11	4.58	15.02
Jiangsu	Yangzhou	3	7.46	14.92
Jiangsu	Zhenjiang	3	6.18	14.95
Liaoning	Fushun	2	6.6	6.46
Liaoning	Liaoyang	6	5.54	7.33

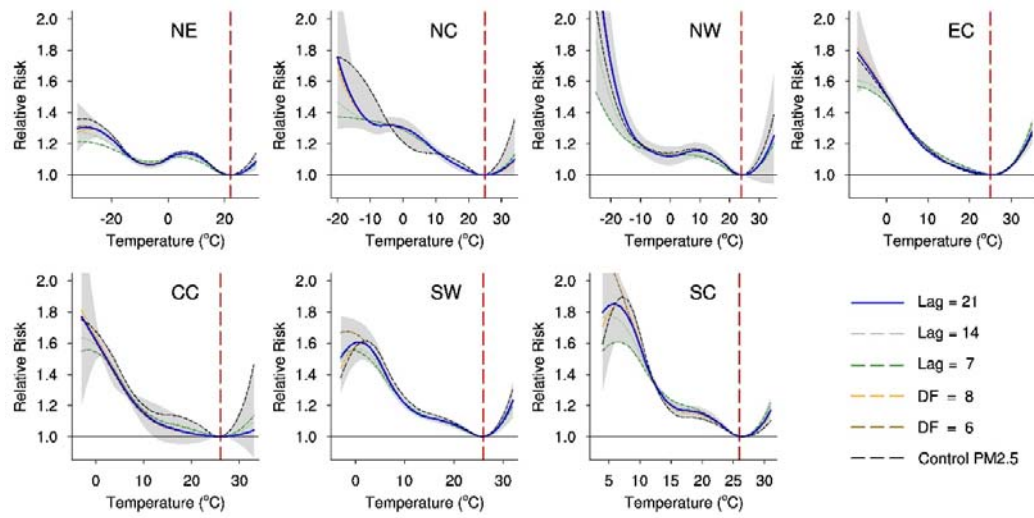
Liaoning	Shenyang	13	6.37	6.63
Liaoning	Tieling	1	6.25	5.95
Qinghai	Haidong	1	5.92	9.95
Qinghai	Xining	1	4.29	0.54
Shanxi	Xi'an	1	4.28	10.50
Shanxi	Yulin	1	5.64	7.72
Shanghai	Shanghai	16	4.96	16.37
Sichuan	Chengdu	16	4.83	11.52
Sichuan	Deyang	1	7.15	12.17
Sichuan	Meishan	3	7.52	11.57
Tianjin	Tianjin	1	4.14	11.08
Xinjiang	Urumqi	1	2.46	5.03
Yunnan	Kunming	1	6.1	15.10
Zhejiang	Hangzhou	1	4.83	15.52
Guangdong	Guangzhou	1	3.63	21.73

Supplementary Table 3 Basic information about the climate model simulations used in this study.

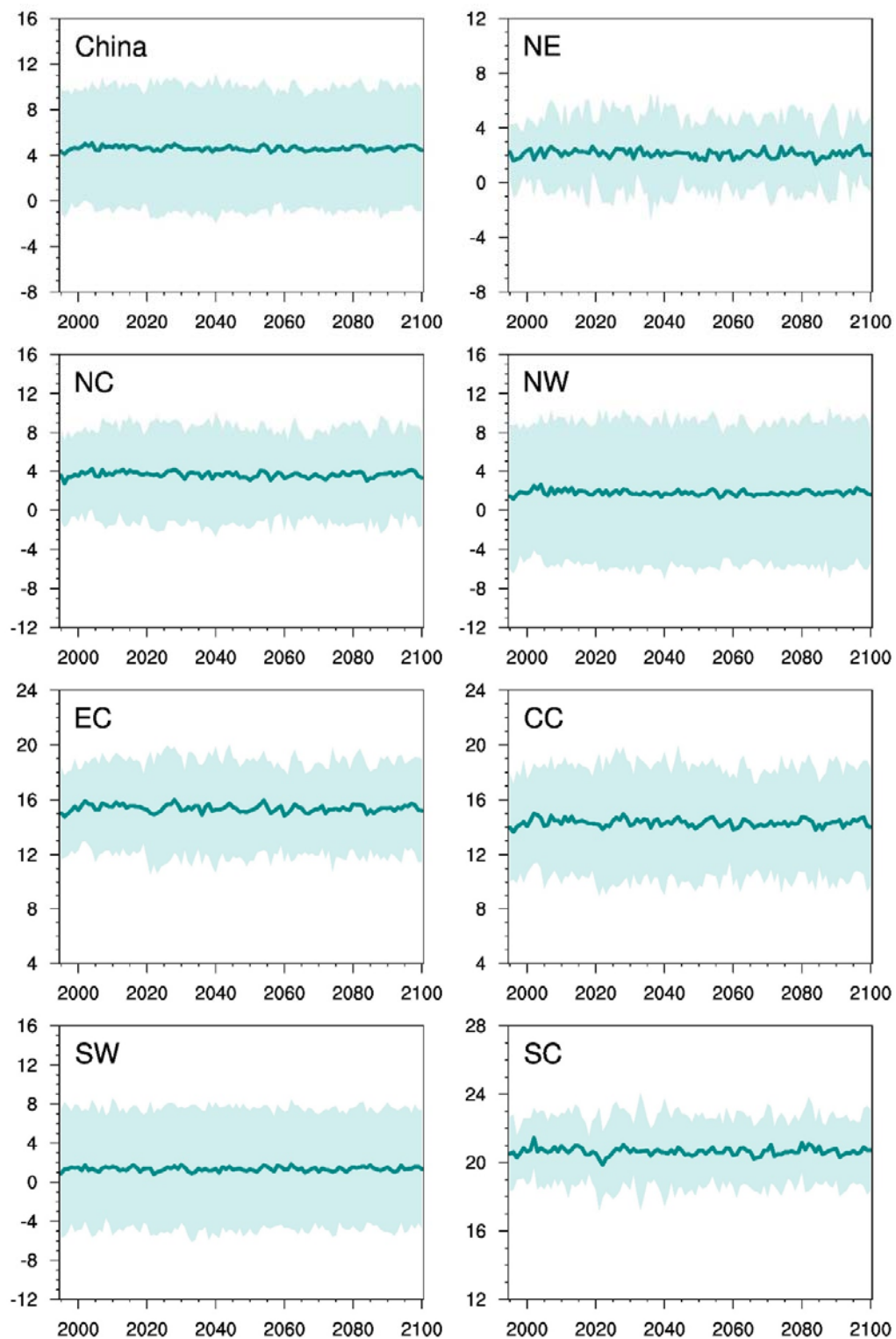
Models	Institution	Country	Resolution	Member
ACCESS-ESM1-5	CSIRO	Australia	145 × 192	rlilplfl
BCC-CSM2-MR	BCC	China	160 × 320	rlilplfl
CanESM5	CCCma	Canada	64 × 128	rlilplfl
CESM	NCAR	USA	192 × 288	rlilplfl
CNRM-CM6-1	CNRM-CERFACS	France	128 × 256	rlilplf2
FGOALS-g3	CAS	China	80 × 180	rlilplfl
GFDL-ESM4	MOHC	UK	144 × 192	rlilplfl
IPSL-CM6A-LR	IPSL	France	143 × 144	rlilplfl
MIROC6	MIROC	Japan	128 × 256	rlilplfl
MRI-ESM2-0	MRI	Japan	160 × 320	rlilplfl
NorESM2-LM	NCC	Norway	96 × 144	rlilplfl



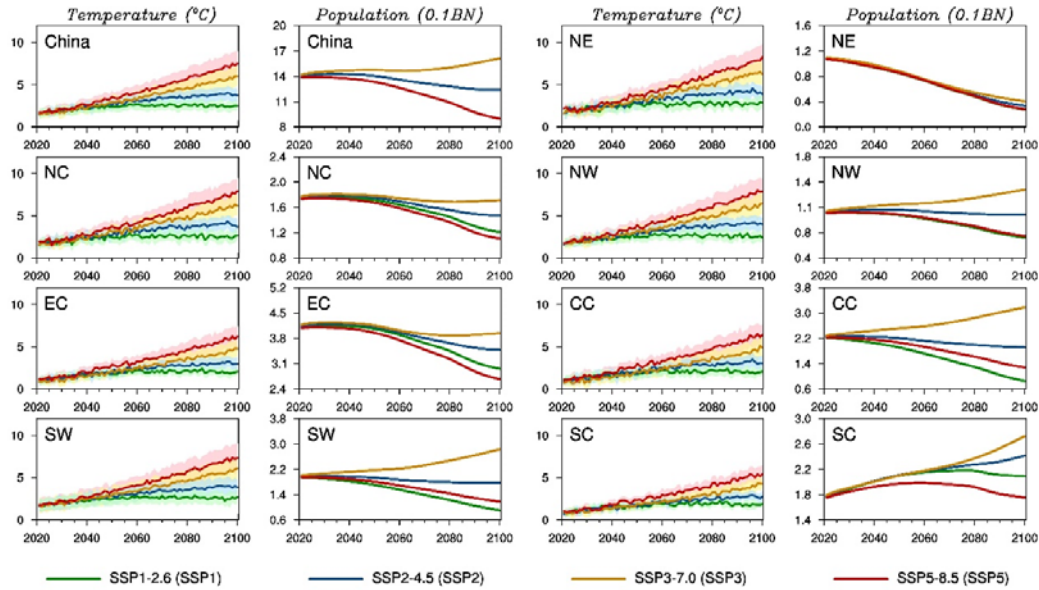
Supplementary Figure 1 Pooled cumulative nonlinear relationships between temperature and daily mortality over 0–21 lag days for each subregion in China. Curve lines denote the relative risk of temperature compared with the optimum temperature (i.e., the minimum mortality temperature corresponding to the lowest risk, indicated by the vertical gray dashed lines). The red and blue curve lines represent the heat and cold effect. The shaded areas denote the 95% CI.



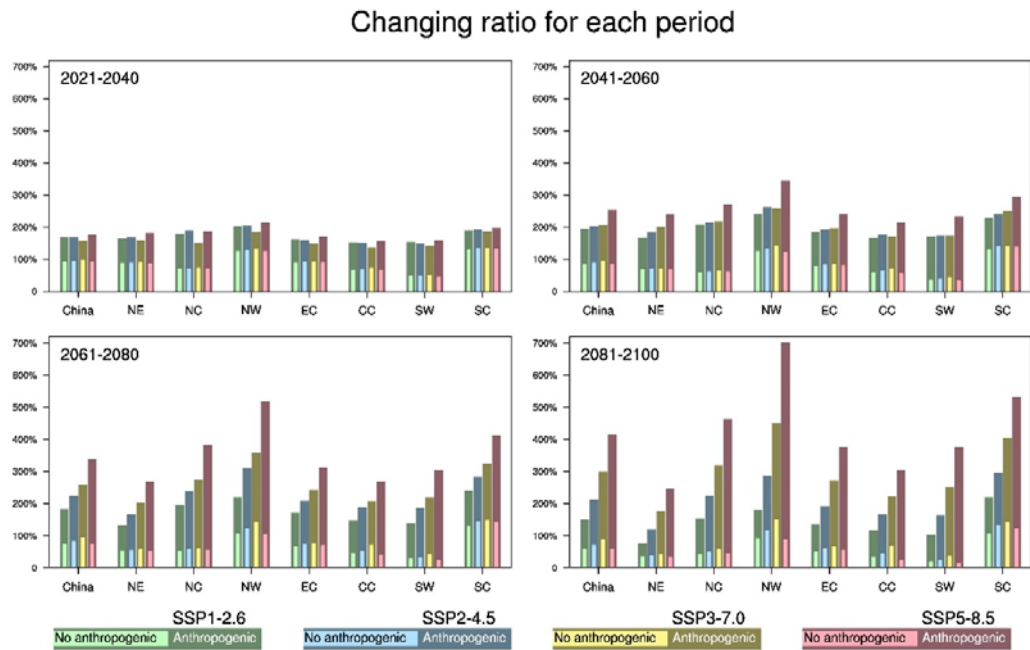
Supplementary Figure 2 Pooled cumulative nonlinear relationships between temperature and daily mortality for each subregion in China. The same as Supplementary Figure 1, but for tests with different lag and df , as well as controlling pollutants.



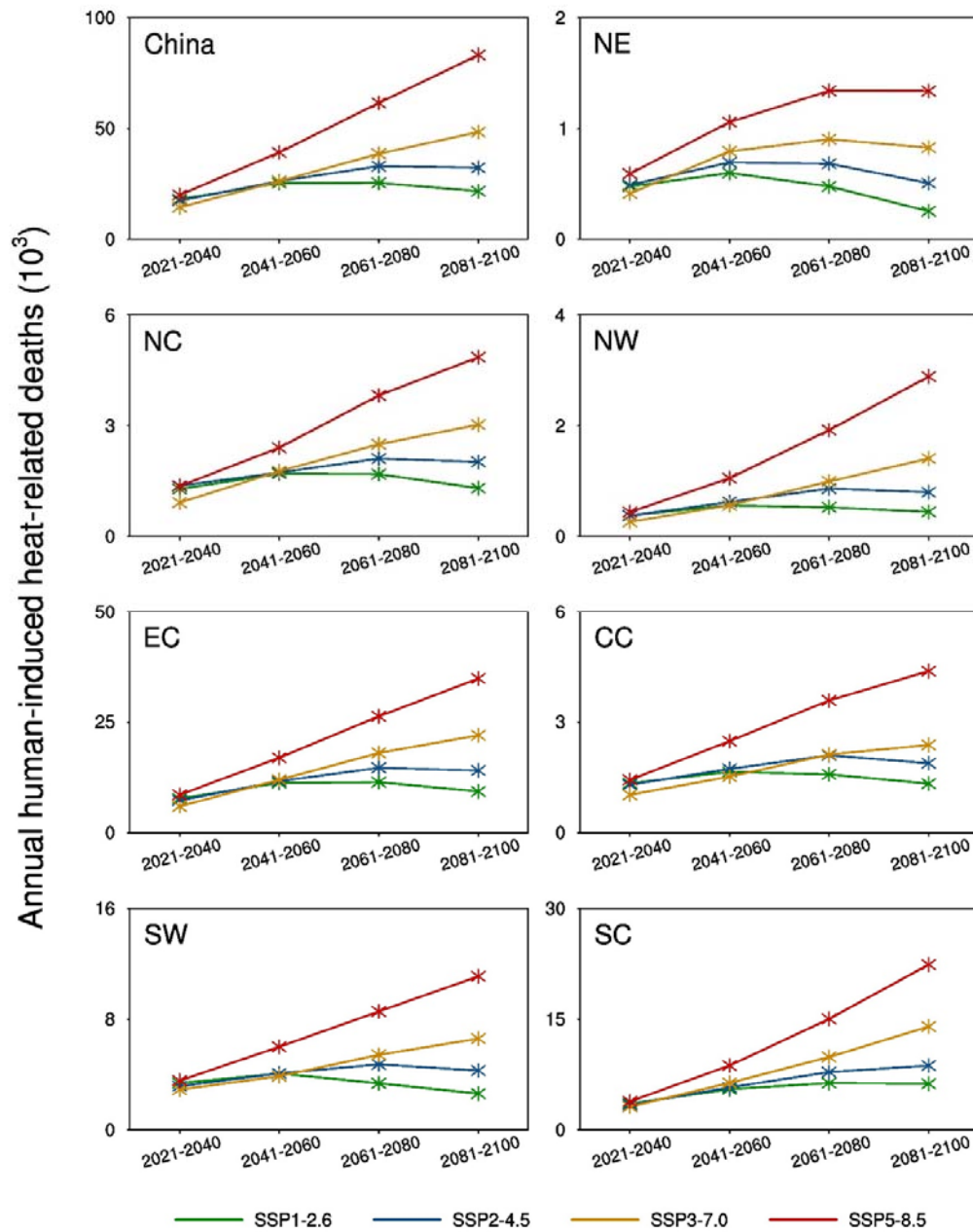
Supplementary Figure 3 Annual regional mean temperature of China and seven subregions without anthropogenic emissions. Lines (shaded areas) indicate the outcomes (model spreads with 95% CI) simulated by NAT during 1995-2100 (units: °C).



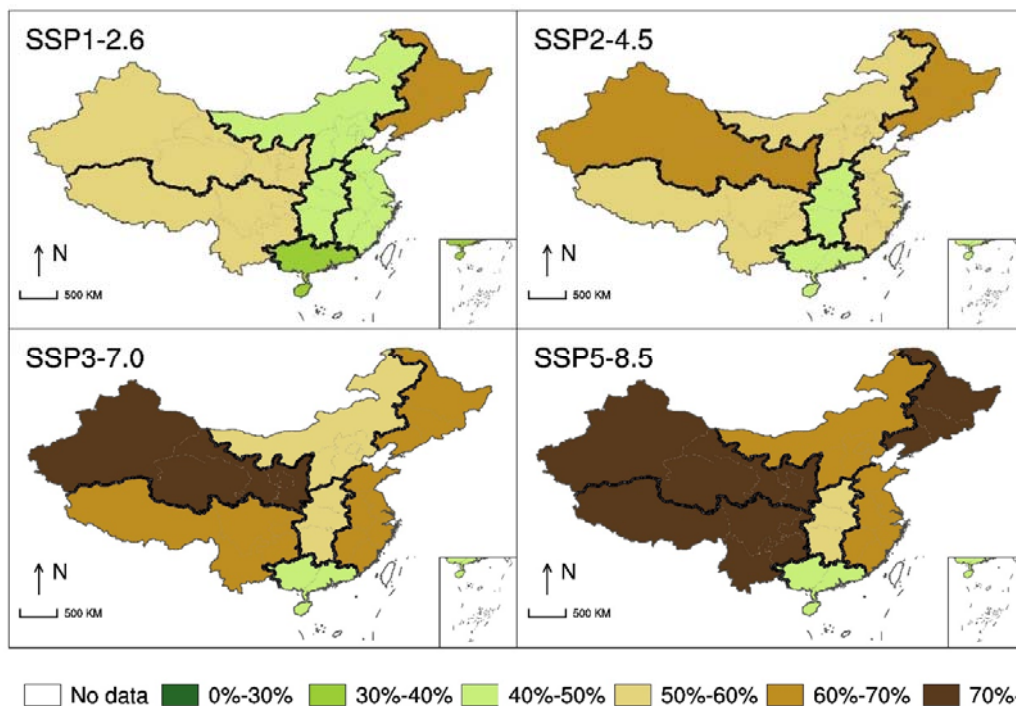
Supplementary Figure 4 Projected future human-induced warming and population. The first/third and second/fourth columns from the left are annual human-induced warming (units: °C) and population (units: 10^{-1} billion) for China and seven subregions from 2021 to 2100. Green blue, yellow, and red lines (shaded areas) indicate outcomes (model spreads with 95% CI) for SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5, respectively.



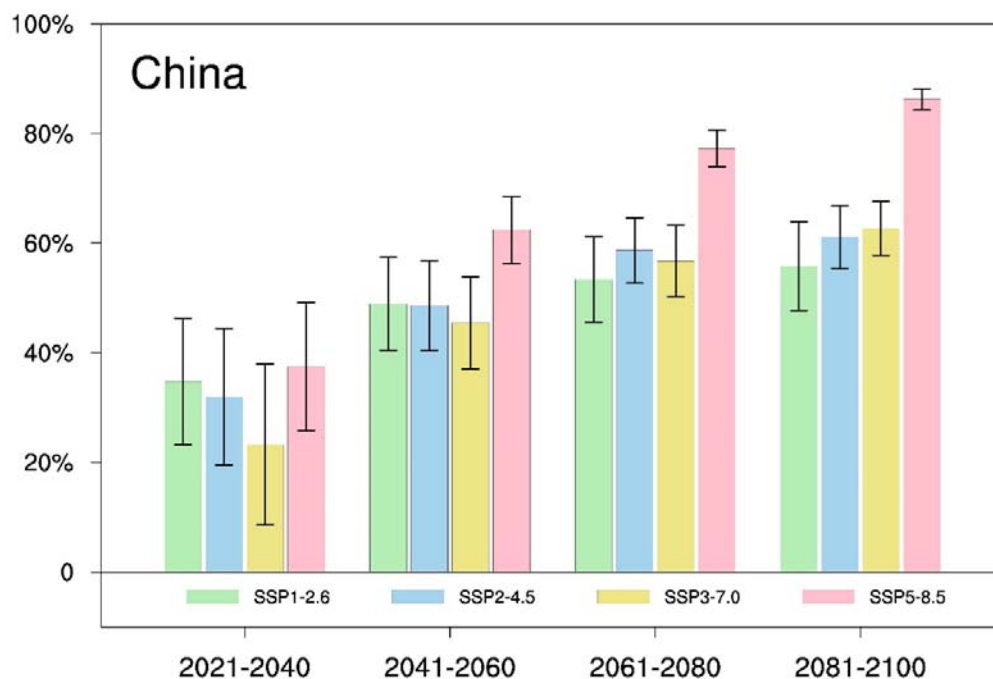
Supplementary Figure 5 Changing ratios of future phase-period heat-related deaths versus the present day. Results are averaged for every 20-year interval over 2021–2100. Green, blue, yellow, and red bars respectively indicate outcomes for SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5, where the dark (light) bars represent the outcomes of ALL (NAT). The 2020s, 2040s, 2060s, and 2080s cover the years 2021–2040, 2041–2060, 2061–2080, and 2081–2100, respectively.



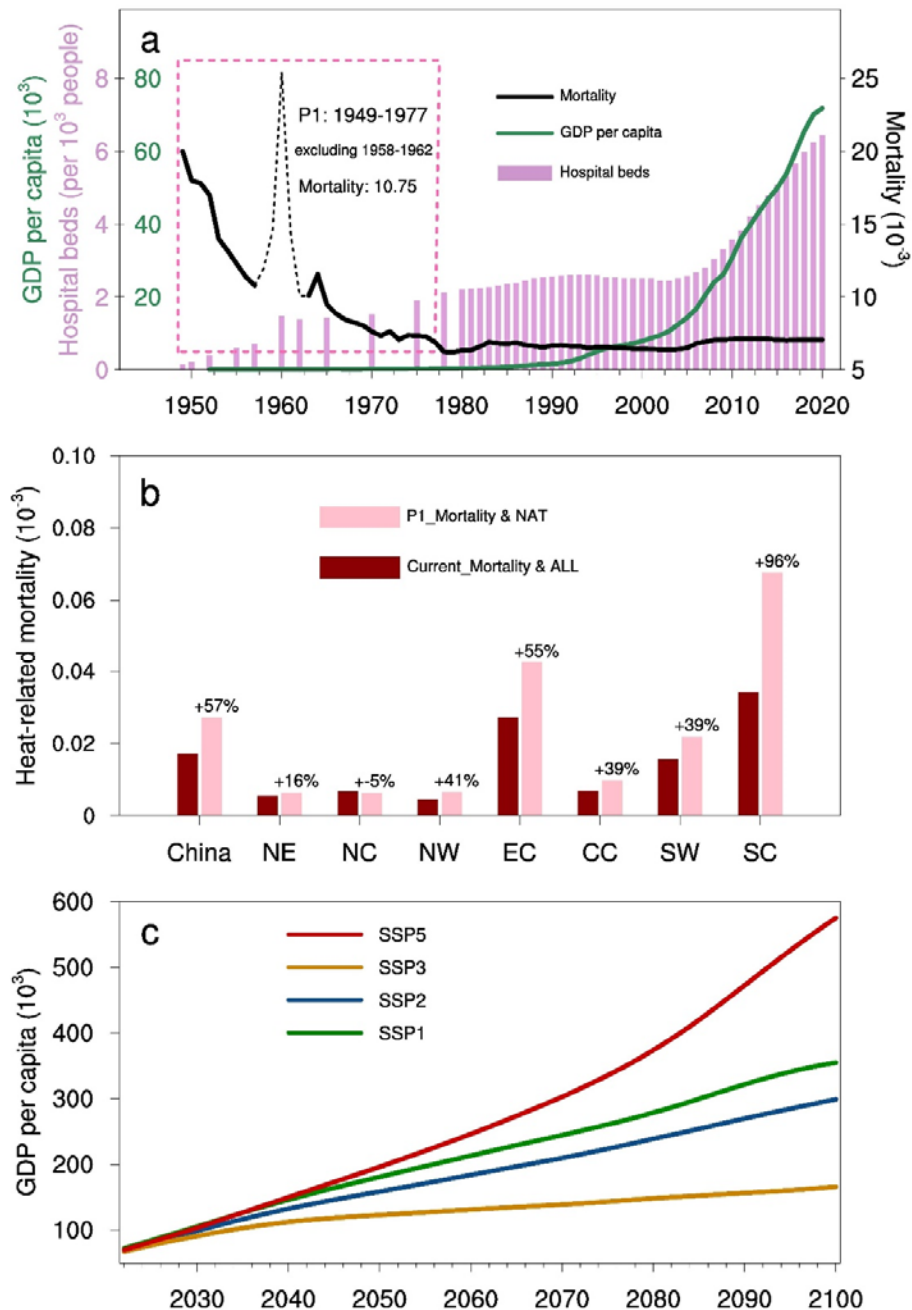
Supplementary Figure 6 Projected annual human-induced heat-related deaths for China and seven subregions. Green, blue, yellow, and red marker lines indicate outcomes averaged for every 20-year interval over 2021–2100 under SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5, respectively.



Supplementary Figure 7 Proportion of projected future heat-related mortality attributable to human-induced climate change across China. Outcomes are averaged over 2021–2100 for SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5. The thick black lines in the maps highlight the subregions.



Supplementary Figure 8 Projected future proportion of heat-related mortality attributable to human-induced climate change. Green, blue, yellow, and red bars indicate outcomes during 2021–2100 with a 20-year interval for SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5, respectively. The vertical black line across the top of each bar depicts the model spreads with 95% CI.



Supplementary Figure 9 Discussion of the potential relationship between economy and heat-related mortality. **a.** China's annual mortality (black line), GDP per capita (green line), and hospital beds (pink bars) from 1949 to 2020. The pink dashed frame refers to the period without significant economic development in China (P1, 1949–1977 excluding 1958–1962), with an average mortality of 10.75‰. **b.** Heat-related mortality of China and seven subregions simulated for the baseline period. Pink bars indicate the heat mortality calculated from death rates of the P1 period with the baseline temperature simulated by NAT, while red bars are the ALL simulated current heat mortality (the same as in Figure 1d). The number over the top of each bar depicts the increasing percentage of the pink bars relative to the red ones. **c.** Future projected annual GDP per capita of China from 2022 to 2100 under SSP1-2.6 (green), SSP2-4.5 (blue), SSP3-7.0 (yellow), and SSP5-8.5 (red).