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Supplemental Material

Independent and Combined Effects of Heatwaves and PM_{2.5} on Preterm Birth in Guangzhou, China: A Survival Analysis

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Table S1. Daily air pollutants and meteorological factors in the warm season (May-October) in Guangzhou, China, 2015-2017

Variables	Mean	SD	Max	75th	50th	25th	Min	Correlation				
								PM _{2.5}	PM ₁₀	NO ₂	SO ₂	O ₃
Air pollutants												
PM _{2.5} (µg/m ³)	29.8	14.7	117.0	38.0	26.0	19.0	5.0	1.00	0.90	0.52	0.35	0.49
PM ₁₀ (µg/m ³)	49.2	21.7	197.0	59.0	45.0	34.0	8.0		1.00	0.54	0.37	0.50
NO ₂ (µg/m ³)	38.6	17.1	139.0	49.0	36.0	27.0	2.0			1.00	0.23	0.10
SO ₂ (µg/m ³)	11.3	5.7	92.0	14.0	10.0	8.0	2.0				1.00	0.28
O ₃ (µg/m ³)	103.5	56.0	300.0	135.0	96.0	62.0	2.0					1.00
Meteorological factors								Maximum temperature		Mean temperature		Relative humidity
Maximum temperature (°C)	32.2	3.0	39.7	34.6	32.6	30.4	18.5	1.00		0.88		-0.26
Mean temperature (°C)	27.4	2.5	33.9	29.1	27.6	26.1	17.2			1.00		-0.23
Relative humidity (%)	81.4	9.5	100.0	88.0	82.0	75.0	39.0					1.00

Note: SD, standard deviation.

Table S2. Air pollutants and meteorological factors in the last gestational week before delivery

Variables	Mean	SD	Max	75th	50th	25th	Min	Correlation					
								PM _{2.5}	PM ₁₀	NO ₂	SO ₂	O ₃	
<i>Air pollutants</i>													
PM _{2.5} (µg/m ³)	30.5	9.4	85.4	35.7	29.6	23.5	8.6	1.00	0.89	0.45	0.26	0.53	
PM ₁₀ (µg/m ³)	49.6	13.4	151.6	56.6	47.6	40.3	19.6		1.00	0.43	0.32	0.55	
NO ₂ (µg/m ³)	39.9	13.0	97.3	47.7	39.1	30.7	8.1			1.00	0.05	0.04	
SO ₂ (µg/m ³)	11.4	5.0	59.1	13.1	10.6	8.4	2.1				1.00	0.28	
O ₃ (µg/m ³)	105.1	37.1	237.3	129.1	100.1	76.7	21.6					1.00	
<i>Meteorological factors</i>								Maximum temperature		Mean temperature		Relative humidity	
Maximum temperature (°C)	31.8	2.1	36.9	33.3	31.9	30.2	26.1	1.00		0.94		-0.25	
Mean temperature (°C)	27.3	1.8	32.0	28.7	27.4	26.0	21.0			1.00		-0.21	
Relative humidity (%)	81.9	6.1	97.9	86.4	82.4	78.0	54.1					1.00	

Note: SD, standard deviation.

Table S3. PM_{2.5} and mean temperature during different gestational time periods and the correlations

	Mean	SD	Correlation				
			PM _{2.5}			Mean temperature	
			Entire pregnancy	Weeks 20-28	The last gestational week before delivery	Entire pregnancy	The last gestational week before delivery
PM _{2.5} (µg/m ³)							
Entire pregnancy	38.9	4.9	1.00	0.70	-0.07	-0.28	0.11
Weeks 20-28	37.7	9.5		1.00	-0.20	-0.50	0.02
The last gestational week before delivery	30.5	9.4			1.00	0.34	-0.18
Mean temperature (°C)							
Entire pregnancy	20.9	1.4				1.00	-0.18
The last gestational week before delivery	27.3	1.8					1.00

Note: SD, standard deviation.

Table S4. PM_{2.5} in the last gestational week before delivery by heatwave exposure

Heatwaves	Participants without heatwave exposure (Mean ± SD, µg/m ³)	Participants with heatwave exposure (Mean ± SD, µg/m ³)	<i>t</i> (<i>P</i>)
33°C-D2	30.8 ± 8.2	30.2 ± 10.5	16.3 (<0.0001)
33°C-D3	30.3 ± 8.4	30.8 ± 10.9	-12.2 (<0.0001)
33°C-D4	30.4 ± 9.1	30.8 ± 10.4	-7.6 (<0.0001)
75 th -D2	30.1 ± 9.0	31.5 ± 10.3	-29.6 (<0.0001)
75 th -D3	30.2 ± 9.2	31.7 ± 10.3	-28.3 (<0.0001)
75 th -D4	30.4 ± 9.3	31.3 ± 10.3	-13.8 (<0.0001)
90 th -D2	30.2 ± 9.5	32.4 ± 8.9	-40.5 (<0.0001)
90 th -D3	30.4 ± 9.5	31.8 ± 8.6	-20.6 (<0.0001)
90 th -D4	30.5 ± 9.5	31.7 ± 8.7	-9.7 (<0.0001)
95 th -D2	30.4 ± 9.6	32.2 ± 7.4	-30.6 (<0.0001)
95 th -D3	30.5 ± 9.5	32.8 ± 7.0	-21.0 (<0.0001)
98 th -D2	30.4 ± 9.5	34.0 ± 6.8	-34.6 (<0.0001)

Note: SD, standard deviation; Heatwaves were defined by an absolute (33 °C) or percentile temperature threshold (75th, 90th, 95th, 98th percentiles, corresponding to 34.6 °C, 35.7 °C, 36.4 °C, and 37 °C, respectively), and by the number of consecutive days above the threshold (2–4 days, indicated by D2, D3, or D4); *t* (*P*): differences in the last week's PM_{2.5} exposure between the participants with and without heatwave exposure were examined with independent sample t-tests, and corresponding *t* and *P* values were calculated.

Table S5. Hazard ratios of preterm birth associated with PM_{2.5} exposure in the last gestational week in Guangzhou, China, 2015-2017

Adjusted heatwave	Overall PTB ^a		Overall PTB ^b		PTB at weeks 28-34 ^b		PTB at weeks 35-36 ^b	
	Unadjusted HR	95%CI	Adjusted HR	95%CI	HR	95%CI	HR	95%CI
33°C-D2	1.13	0.97, 1.30	1.14	0.99, 1.32	1.07	0.96, 1.21	1.12	0.95, 1.32
33°C-D3	1.13	0.98, 1.30	1.14	0.99, 1.32	1.07	0.95, 1.21	1.12	0.95, 1.33
33°C-D4	1.12	0.98, 1.30	1.14	0.99, 1.31	1.07	0.95, 1.21	1.12	0.95, 1.32
75 th -D2	1.12	0.97, 1.30	1.14	0.99, 1.31	1.07	0.94, 1.21	1.12	0.95, 1.32
75 th -D3	1.12	0.96, 1.29	1.13	0.98, 1.31	1.06	0.94, 1.20	1.11	0.95, 1.31
75 th -D4	1.12	0.97, 1.29	1.14	0.99, 1.31	1.07	0.95, 1.21	1.12	0.95, 1.31
90 th -D2	1.11	0.95, 1.29	1.13	0.97, 1.30	1.07	0.94, 1.21	1.11	0.94, 1.30
90 th -D3	1.12	0.96, 1.30	1.14	0.98, 1.31	1.07	0.95, 1.22	1.11	0.95, 1.31
90 th -D4	1.12	0.97, 1.30	1.14	0.99, 1.32	1.08	0.96, 1.21	1.12	0.95, 1.32
95 th -D2	1.11	0.96, 1.29	1.13	0.98, 1.31	1.06	0.94, 1.21	1.11	0.94, 1.31
95 th -D3	1.12	0.97, 1.30	1.14	0.99, 1.32	1.08	0.96, 1.21	1.12	0.95, 1.32
98 th -D2	1.12	0.97, 1.29	1.14	0.99, 1.31	1.07	0.96, 1.20	1.12	0.95, 1.31

Note: PTB, preterm birth; HR, hazard ratio; CI, confidence interval; Heatwaves were defined by an absolute (33 °C) or percentile temperature threshold (75th, 90th, 95th, 98th percentiles, corresponding to 34.6 °C, 35.7 °C, 36.4 °C, and 37 °C, respectively), and by the number of consecutive days above the threshold (2–4 days, indicated by D2, D3, or D4); Each HR was calculated for per 10 µg/m³ increment in PM_{2.5}.

^a Unadjusted model included heatwave exposure in the last gestational week before delivery, gestational temperature and PM_{2.5} exposures; residency districts of the participants were fitted as a random effect.

^b Adjusted model additionally included maternal age, parity, month of birth, and relative humidity in the last gestational week before delivery.

Table S6. Hazard ratios of overall preterm birth associated with heatwave exposure in the last gestational week before delivery with adjustment for PM_{2.5} exposures during weeks 20-28

Heatwaves	HR	95%CI
33°C-D2	1.49	1.34, 1.65
33°C-D3	1.44	1.30, 1.58
33°C-D4	1.52	1.36, 1.70
75 th -D2	1.61	1.47, 1.76
75 th -D3	1.63	1.45, 1.83
75 th -D4	2.01	1.74, 2.32
90 th -D2	2.03	1.64, 2.50
90 th -D3	1.93	1.59, 2.34
90 th -D4	2.27	1.71, 3.01
95 th -D2	1.98	1.80, 2.18
95 th -D3	2.77	1.93, 3.98
98 th -D2	2.75	2.07, 3.66

Note: PTB, preterm birth; HR, hazard ratio; CI, confidence interval; Heatwaves were defined by an absolute (33 °C) or percentile temperature threshold (75th, 90th, 95th, 98th percentiles, corresponding to 34.6 °C, 35.7 °C, 36.4 °C, and 37 °C, respectively), and by the number of consecutive days above the threshold (2–4 days, indicated by D2, D3, or D4). Models included gestational temperature PM_{2.5} exposures during weeks 20-28 and the last week PM_{2.5} exposures, maternal age, parity, month of birth, and relative humidity in the last gestational week before delivery; residency districts of the participants were fitted as a random effect.

Table S7. Hazard ratios of preterm birth associated with heatwave exposure in the last gestational week before delivery, stratified by delivery method

Heatwaves	Vaginal births		Cesarean births	
	HR	95%CI	HR	95%CI
33°C-D2	1.02	0.92, 1.13	1.04	0.93, 1.16
33°C-D3	1.02	0.94, 1.11	1.02	0.89, 1.18
33°C-D4	1.08	1.02, 1.14	1.11	0.96, 1.27
75 th -D2	1.16	1.05, 1.27	1.12	1.00, 1.26
75 th -D3	1.22	1.13, 1.33	1.16	1.00, 1.35
75 th -D4	1.39	1.26, 1.53	1.31	1.07, 1.62
90 th -D2	1.37	1.21, 1.54	1.35	1.13, 1.61
90 th -D3	1.36	1.15, 1.62	1.33	1.04, 1.71
90 th -D4	1.45	1.12, 1.88	1.29	0.98, 1.69
95 th -D2	1.41	1.24, 1.61	1.54	1.34, 1.76
95 th -D3	1.91	1.30, 2.82	1.87	1.48, 2.36
98 th -D2	1.92	1.28, 2.89	1.79	1.38, 2.32

Note: PTB, preterm birth; HR, hazard ratio; CI, confidence interval; Heatwaves were defined by an absolute (33 °C) or percentile temperature threshold (75th, 90th, 95th, 98th percentiles, corresponding to 34.6 °C, 35.7 °C, 36.4 °C, and 37 °C, respectively), and by the number of consecutive days above the threshold (2–4 days, indicated by D2, D3, or D4).

Models included gestational temperature, gestational and the last week PM_{2.5} exposures, maternal age, parity, month of birth, and relative humidity in the last gestational week before delivery; residency districts of the participants were fitted as a random effect.

Table S8. Hazard ratios of preterm birth associated with PM_{2.5} exposures in the last gestational week before delivery

		HR	95%CI
Delivery method ^a	Vaginal delivery	1.12	0.97, 1.31
	Cesarean delivery	1.17	1.02, 1.33
Overall PTB (PM _{2.5} exposures during weeks 20-28 was adjusted) ^b		1.08	0.98, 1.19

Note: PTB, preterm birth; HR, hazard ratio; CI, confidence interval. Each HR was calculated for per 10 µg/m³ increment in PM_{2.5}.

^a Models included heatwave exposure in the last gestational week before delivery, gestational temperature and PM_{2.5} exposures, maternal age, parity, month of birth, and relative humidity in the last gestational week before delivery; residency districts of the participants were fitted as a random effect.

^b PM_{2.5} exposures during weeks 20-28 was adjusted instead of gestational PM_{2.5} exposures. Other adjusted covariates were the same as models a.

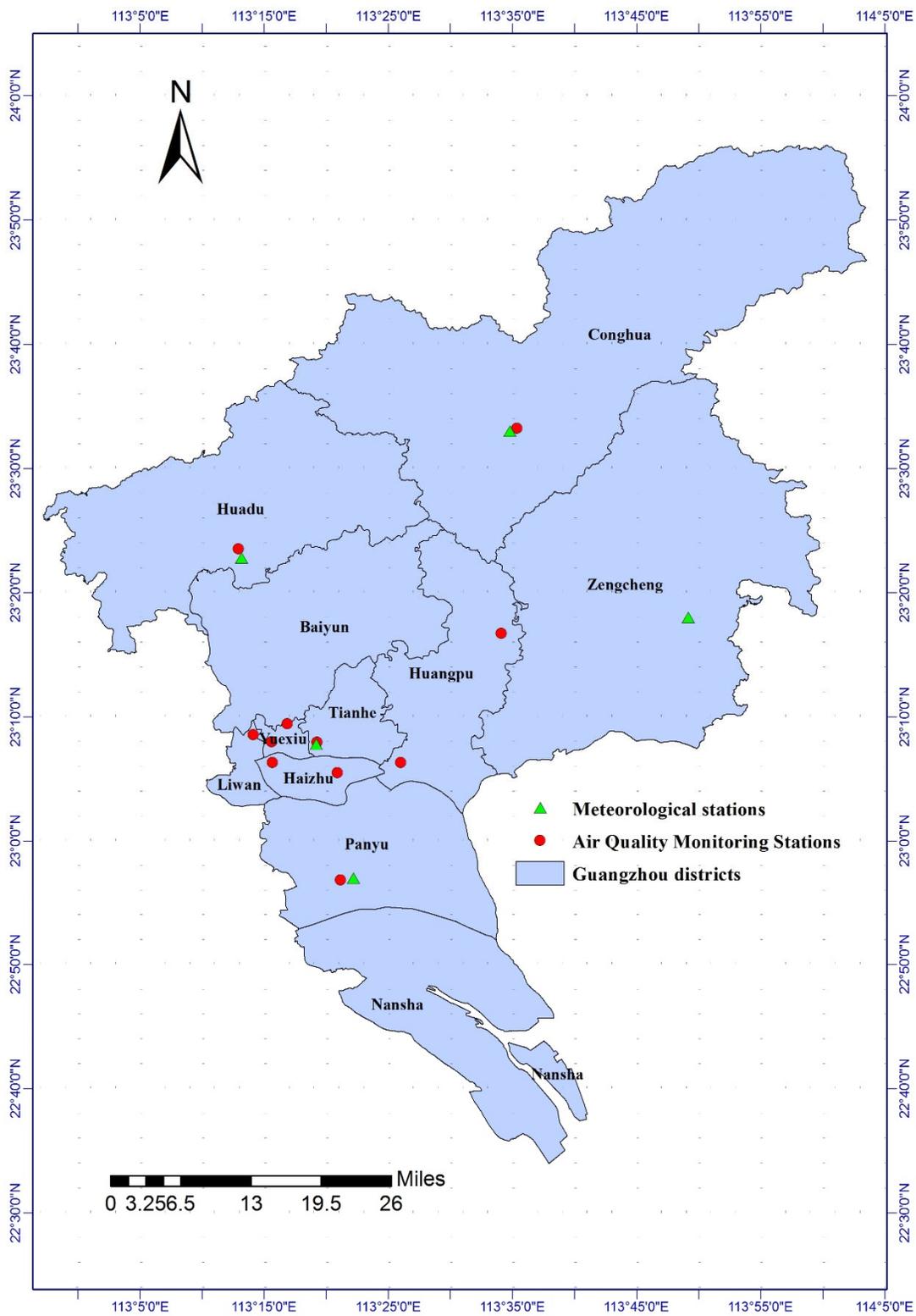


Figure S1. Locations of meteorological and air quality monitoring stations