Supplementary material

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Table S.1 Baseline and excess age-standardized death rates during the heatwave by settlement categories, including Moscow and Saint Petersburg

Region	Age-standardized death rates (per 1,000)			
	Observed	Expected	Excess	Relative increase
Moscow	12,8	7,6 (CI: 7,5 – 7,8)	5,1 (CI: 5 – 5,3)	67,1% (CI: 63,4% – 70,7%)
Saint Petersburg	11,0	9 (CI: 8,8 – 9,2)	2 (CI: 1,8 – 2,2)	22,5% (CI: 20% – 25,3%)
Other 1,000,000+	15,2	10,4 (CI: 10 – 10,8)	4,8 (CI: 4,5 – 5,2)	46,6% (CI: 41,5% – 51,8%)
500,000 - 999,999	14,4	10 (CI: 9,6 – 10,5)	4,4 (CI: 3,9 – 4,8)	43,6% (CI: 37,7% – 49,8%)
250,000 - 499,999	13,6	10,6 (CI: 10,1 – 11,1)	3 (CI: 2,5 – 3,5)	28,8% (CI: 22,7% – 35,2%)
100,000 - 249,999	14,4	11 (CI: 10,5 – 11,5)	3,4 (CI: 2,8 – 3,9)	30,5% (CI: 24,3% – 37,2%)
fewer than 100,000	14,5	12 (CI: 11,5 – 12,6)	2,5 (CI: 2 – 3)	20,7% (CI: 15,6% – 26%)
Rural area	13,7	11,8 (CI: 11,3 – 12,3)	2 (CI: 1,5 – 2,5)	16,8% (CI: 11,9% – 22%)

Note: The two largest cities are presented individually.

Table S.2 Age-standardized death rates during the heatwave and population sizes by regions and economic district in European Russia

Region	Age-standardized death rates (per 1,000)				Population, thousands (2010 census)
	Observed	Expected	Excess	Relative increase	
Cenral-Black Earth	15.2	11 (CI: 10.5 – 11.5)	4.2 (CI: 3.7 – 4.7)	38.5% (CI: 32.4% – 44.9%)	7266.7
Belgorod	13.0	10.2 (CI: 9.7 – 10.7)	2.8 (CI: 2.2 – 3.3)	27.1% (CI: 20.7% – 33.7%)	1532.1
Voronezh	15.2	10.9 (CI: 10.5 – 11.3)	4.3 (CI: 3.9 – 4.7)	39.7% (CI: 34.5% – 45.1%)	2334.9
Kursk	15.3	11.7 (CI: 11.2 – 12.2)	3.6 (CI: 3 – 4.1)	30.6% (CI: 24.7% – 36.9%)	1130.4
Lipetsk	17.4	11.6 (CI: 11.1 – 12.2)	5.8 (CI: 5.2 – 6.3)	49.5% (CI: 42.3% – 57.1%)	1174.6
Tambov	16.0	10.8 (CI: 10.4 – 11.4)	5.1 (CI: 4.6 – 5.6)	47.4% (CI: 40.5% – 54.4%)	1094.7
Central	14.3	10.3 (CI: 10 – 10.7)	3.9 (CI: 3.6 – 4.3)	38% (CI: 33.6% – 42.6%)	31124.5
Bryansk	14.4	11.4 (CI: 10.9 – 11.9)	3 (CI: 2.5 – 3.5)	26.3% (CI: 20.9% – 31.8%)	1281.0
Vladimir	15.8	12.7 (CI: 12.2 – 13.2)	3.1 (CI: 2.5 – 3.6)	24.3% (CI: 19.2% – 29.4%)	1445.5
Ivanovo	14.7	12 (CI: 11.5 – 12.6)	2.7 (CI: 2.2 – 3.3)	22.7% (CI: 17.2% – 28.4%)	1064.0
Tver	15.9	12.9 (CI: 12.4 – 13.3)	3 (CI: 2.5 – 3.4)	23.3% (CI: 18.9% – 27.7%)	1357.8

Region	Age-standardized death rates (per 1,000)				Population, thousands (2010 census)
	Observed	Expected	Excess	Relative increase	
Kaluga	14.1	11.5 (CI: 11 – 12.1)	2.6 (CI: 2 – 3.2)	22.4% (CI: 16.6% – 28.8%)	1012.1
Kostroma	14.5	12.1 (CI: 11.5 – 12.7)	2.4 (CI: 1.8 – 3)	20% (CI: 14.2% – 26.3%)	669.7
Moscow	12.8	7.6 (CI: 7.5 – 7.8)	5.1 (CI: 5 – 5.3)	67.1% (CI: 63.4% – 70.7%)	11461.7
Moscow Oblast	15.1	11.7 (CI: 11.4 – 12)	3.4 (CI: 3.1 – 3.7)	28.8% (CI: 25.7% – 32.1%)	7065.3
Oryol	15.5	11.3 (CI: 10.7 – 11.8)	4.2 (CI: 3.7 – 4.8)	37.5% (CI: 30.9% – 44.5%)	789.4
Ryazan	16.7	11.7 (CI: 11.2 – 12.2)	5 (CI: 4.5 – 5.5)	42.4% (CI: 36.5% – 48.9%)	1156.9
Smolensk	14.5	12.5 (CI: 12 – 13.1)	2 (CI: 1.5 – 2.6)	16.1% (CI: 11.3% – 21.3%)	988.0
Tula	15.5	12.3 (CI: 11.8 – 12.7)	3.3 (CI: 2.8 – 3.7)	26.6% (CI: 21.9% – 31.4%)	1557.5
Yaroslavl	14.5	11.3 (CI: 10.9 – 11.8)	3.1 (CI: 2.7 – 3.6)	27.7% (CI: 22.4% – 33.3%)	1275.6
North	13.8	12.3 (CI: 11.7 – 12.9)	1.6 (CI: 0.9 – 2.2)	12.8% (CI: 7.3% – 18.5%)	4784.4
Arkhangelsk	12.6	11.7 (CI: 11.1 – 12.3)	0.9 (CI: 0.3 – 1.5)	7.7% (CI: 2.4% – 13.3%)	1231.2
Vologda	15.2	12.1 (CI: 11.6 – 12.6)	3.1 (CI: 2.6 – 3.7)	26.1% (CI: 20.6% – 31.7%)	1204.8
Murmansk	12.8	12.2 (CI: 11.6 – 12.9)	0.6 (CI: –0.1 – 1.2)	4.7% (CI: -0.7% – 10.4%)	797.0
Karelia	14.6	12.9 (CI: 12.2 – 13.5)	1.7 (CI: 1 – 2.4)	13.4% (CI: 7.7% – 19.3%)	645.7
Komi	14.0	12.9 (CI: 12.2 – 13.6)	1.1 (CI: 0.4 – 1.8)	8.8% (CI: 3.1% – 14.5%)	905.7
North Caucasus	11.6	10.1 (CI: 9.6 – 10.7)	1.5 (CI: 0.9 – 2)	14.7% (CI: 8.8% – 20.9%)	19338.6
Krasnodar	11.9	10 (CI: 9.7 – 10.3)	1.9 (CI: 1.5 – 2.2)	18.8% (CI: 14.9% – 22.8%)	5222.2
Stavropol	11.2	10.3 (CI: 9.9 – 10.7)	0.9 (CI: 0.5 – 1.3)	8.3% (CI: 4.3% – 12.6%)	2781.7
Ingushetia	7.6	7.6 (CI: 6.6 – 8.7)	0 (CI: –1.1 – 1)	0.2% (CI: -12.6% – 15.9%)	413.2
Rostov	13.9	11 (CI: 10.6 – 11.5)	2.9 (CI: 2.5 – 3.3)	26.5% (CI: 21.4% – 31.5%)	4280.0
Adygea	11.9	10.9 (CI: 10.1 – 11.7)	1 (CI: 0.1 – 1.7)	8.9% (CI: 1.3% – 17%)	439.9
Dagestan	9.8	9.8 (CI: 9.1 – 10.7)	0 (CI: –0.8 – 0.8)	0.1% (CI: -7.8% – 8.6%)	2891.5
Kabardino-Balkar	10.0	9.7 (CI: 9 – 10.3)	0.3 (CI: –0.3 – 1)	3.3% (CI: -3% – 10.9%)	859.7
North Ossetia-Alania	9.3	9 (CI: 8.5 – 9.6)	0.3 (CI: –0.3 – 0.9)	3.7% (CI: -2.7% – 10.3%)	712.2
Karachay-Cherkess	9.9	9.1 (CI: 8.3 – 9.9)	0.9 (CI: 0.1 – 1.6)	9.7% (CI: 0.7% – 19.5%)	475.6
Chechen	11.4	9.4 (CI: 8.5 – 10.3)	2.1 (CI: 1.1 – 2.9)	21.9% (CI: 11.2% – 34%)	1262.6

Region	Age-standardized death rates (per 1,000)				Population, thousands (2010 census)
	Observed	Expected	Excess	Relative increase	
Northeast	12.2	10.5 (CI: 10.1 – 10.8)	1.8 (CI: 1.4 – 2.1)	16.7% (CI: 13.1% – 20.7%)	8831.1
Kaliningrad	12.1	11.1 (CI: 10.6 – 11.7)	0.9 (CI: 0.4 – 1.5)	8.5% (CI: 3.1% – 13.8%)	940.3
Saint Petersburg	11.0	9 (CI: 8.8 – 9.2)	2 (CI: 1.8 – 2.2)	22.5% (CI: 20% – 25.3%)	4866.1
Leningrad Oblast	13.1	12 (CI: 11.6 – 12.4)	1.1 (CI: 0.7 – 1.5)	9.3% (CI: 5.8% – 13.1%)	1711.8
Novgorod	16.1	13.9 (CI: 13.2 – 14.6)	2.2 (CI: 1.5 – 2.9)	15.7% (CI: 10.3% – 21.9%)	636.3
Pskov	15.4	13.3 (CI: 12.6 – 13.9)	2.2 (CI: 1.5 – 2.8)	16.5% (CI: 10.9% – 22.5%)	676.6
Ural (European part only)	13.4	11.9 (CI: 11.5 – 12.4)	1.5 (CI: 1 – 2)	12.7% (CI: 8.5% – 17.1%)	10271.1
Orenburg	13.7	12.2 (CI: 11.6 – 12.7)	1.6 (CI: 1 – 2.1)	12.8% (CI: 8.1% – 17.9%)	2036.8
Perm	13.2	12.5 (CI: 12 – 12.9)	0.7 (CI: 0.3 – 1.1)	5.7% (CI: 2% – 9.6%)	2641.2
Bashkortostan	13.2	11.6 (CI: 11.1 – 12)	1.6 (CI: 1.2 – 2)	14% (CI: 9.8% – 18.4%)	4070.4
Udmurt	14.2	11.6 (CI: 11.2 – 12.1)	2.5 (CI: 2.1 – 3)	21.9% (CI: 17.2% – 26.9%)	1522.8
Volga	15.6	11.1 (CI: 10.6 – 11.6)	4.5 (CI: 4 – 5)	40.4% (CI: 34.3% – 47%)	16126.7
Astrakhan	13.3	11 (CI: 10.4 – 11.7)	2.3 (CI: 1.6 – 2.9)	20.7% (CI: 13.8% – 27.8%)	1010.5
Volgograd	15.7	11.2 (CI: 10.7 – 11.7)	4.5 (CI: 3.9 – 5)	40.1% (CI: 33.6% – 47.1%)	2610.9
Samara	16.9	11.7 (CI: 11.2 – 12.1)	5.2 (CI: 4.7 – 5.7)	44.7% (CI: 39% – 50.9%)	3218.2
Penza	14.7	10.6 (CI: 10.1 – 11)	4.1 (CI: 3.7 – 4.6)	39% (CI: 33.4% – 45%)	1388.3
Saratov	17.2	11.3 (CI: 10.8 – 11.8)	5.9 (CI: 5.4 – 6.3)	51.8% (CI: 45.5% – 58.7%)	2527.4
Ulyanovsk	15.5	11 (CI: 10.5 – 11.5)	4.6 (CI: 4 – 5.1)	41.6% (CI: 35.2% – 48.2%)	1296.1
Kalmykia	14.1	10.8 (CI: 9.9 – 11.8)	3.3 (CI: 2.3 – 4.3)	30.7% (CI: 19.3% – 43.3%)	289.3
Tatarstan	14.5	10.7 (CI: 10.3 – 11.2)	3.7 (CI: 3.3 – 4.2)	34.9% (CI: 29.4% – 40.7%)	3786.0
Volga-Vyatka	16.2	12 (CI: 11.5 – 12.5)	4.2 (CI: 3.7 – 4.7)	34.6% (CI: 29.2% – 40.5%)	7450.0
Nizhny Novgorod	17.1	12.5 (CI: 12.1 – 12.9)	4.6 (CI: 4.2 – 5)	36.8% (CI: 32.4% – 41.7%)	3317.3
Kirov	13.4	11.9 (CI: 11.4 – 12.4)	1.5 (CI: 1 – 2)	12.7% (CI: 7.9% – 17.6%)	1345.8
Mari El	17.6	12.1 (CI: 11.5 – 12.7)	5.4 (CI: 4.8 – 6.1)	44.9% (CI: 37.9% – 52.7%)	697.5
Mordovia	15.1	11.1 (CI: 10.5 – 11.7)	4 (CI: 3.4 – 4.6)	36.4% (CI: 29.2% – 44%)	836.3
Chuvash	16.7	11.4 (CI: 10.9 – 12)	5.2 (CI: 4.6 – 5.8)	45.7% (CI: 38.5% – 53.2%)	1253.2

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Table S.3 Summary of regression models for the logarithm of increase in death rate as a dependent variable associated with thermal stress by settlement categories

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(Intercept)	1.148 [1.119, 1.177]	0.906 [0.882, 0.930]	0.843 [0.813, 0.874]	0.919 [0.895, 0.944]	0.859 [0.828, 0.890]	0.952 [0.929, 0.975]	0.912 [0.886, 0.938]	0.950 [0.925, 0.975]	0.896 [0.863, 0.929]	0.993 [0.968, 1.019]	0.977 [0.946, 1.009]
Settlement categories (Rural area is a reference):											
Over 1,000,000	1.213 [1.132, 1.299]	1.186 [1.122, 1.254]	1.208 [1.137, 1.283]	1.188 [1.123, 1.257]	1.210 [1.139, 1.286]	1.187 [1.124, 1.254]	1.210 [1.140, 1.285]	1.197 [1.130, 1.268]	1.222 [1.148, 1.301]	1.208 [1.138, 1.282]	1.236 [1.157, 1.319]
500,000 - 999,999	1.195 [1.134, 1.259]	1.176 [1.127, 1.226]	1.191 [1.138, 1.246]	1.178 [1.130, 1.229]	1.194 [1.141, 1.250]	1.147 [1.100, 1.195]	1.160 [1.109, 1.214]	1.191 [1.140, 1.244]	1.210 [1.154, 1.268]	1.203 [1.150, 1.258]	1.224 [1.165, 1.285]
250,000 - 499,999	1.084 [1.038, 1.133]	1.079 [1.041, 1.117]	1.088 [1.047, 1.130]	1.078 [1.041, 1.117]	1.087 [1.047, 1.130]	1.090 [1.053, 1.128]	1.101 [1.060, 1.143]	1.076 [1.038, 1.116]	1.085 [1.043, 1.129]	1.076 [1.036, 1.117]	1.086 [1.042, 1.132]
100,000 - 249,999	1.082 [1.038, 1.129]	1.091 [1.055, 1.129]	1.107 [1.067, 1.149]	1.092 [1.056, 1.130]	1.108 [1.068, 1.150]	1.080 [1.044, 1.116]	1.092 [1.053, 1.133]	1.093 [1.055, 1.132]	1.109 [1.068, 1.152]	1.091 [1.052, 1.131]	1.106 [1.062, 1.150]
<100,000	1.040 [1.004, 1.077]	1.040 [1.010, 1.070]	1.041 [1.009, 1.073]	1.040 [1.010, 1.070]	1.041 [1.009, 1.074]	1.040 [1.011, 1.069]	1.041 [1.009, 1.073]	1.040 [1.009, 1.071]	1.041 [1.008, 1.075]	1.040 [1.008, 1.072]	1.041 [1.007, 1.076]
Thermal stress indicators:											
t2m anomalies		1.042 [1.038, 1.045]	1.035 [1.032, 1.039]								
t2m anomalies, one-week lag			1.016 [1.011, 1.021]								
PET anomalies				1.031 [1.029, 1.034]	1.027 [1.024, 1.030]						
PET anomalies, one-week lag					1.013 [1.009, 1.017]						
HI anomalies						1.104 [1.097, 1.112]	1.093 [1.083, 1.103]				
HI anomalies, one-week lag							1.026 [1.017, 1.036]				
UTCI anomalies								1.029 [1.027, 1.032]	1.026 [1.023, 1.029]		
UTCI anomalies, one-week lag									1.011 [1.007, 1.015]		
HUM anomalies										1.059 [1.053, 1.064]	1.056 [1.050, 1.062]
HUM anomalies, one-week lag											1.009 [1.001, 1.017]
Num. Obs.	1295	1295	1110	1295	1110	1295	1110	1295	1110	1295	1110
AIC	48.3	-507.0	-426.3	-486.1	-416.3	-555.5	-450.0	-412.7	-347.6	-339.9	-249.3
BIC	84.5	-465.7	-381.2	-444.8	-371.2	-514.2	-404.9	-371.3	-302.5	-298.6	-204.2
Adj. R-squared	0.051	0.383	0.425	0.373	0.420	0.406	0.438	0.336	0.383	0.298	0.326
logLik	-17.170	261.496	222.150	251.060	217.158	285.772	234.010	214.333	182.793	177.970	133.656

Note: The model coefficients are presented in an exponentiated form for interpretability and clarity, along with 95% confidence intervals.

Table S.4 Summary of regression models for the logarithm of increase in death rate as a dependent variable associated with thermal stress and air pollution, by settlement categories

	(1)	(2)	(3)	(4)	(5)
(Intercept)	1.148 [1.119, 1.177]	0.952 [0.929, 0.975]	0.951 [0.929, 0.974]	0.951 [0.929, 0.974]	0.951 [0.929, 0.974]
Settlement categories (Rural area is a reference):					
Over 1,000,000	1.213 [1.132, 1.299]	1.187 [1.124, 1.254]	1.187 [1.124, 1.254]	1.187 [1.124, 1.254]	1.187 [1.124, 1.254]
500,000 - 999,999	1.195 [1.134, 1.259]	1.147 [1.100, 1.195]	1.147 [1.101, 1.195]	1.147 [1.101, 1.195]	1.147 [1.101, 1.195]
250,000 - 499,999	1.084 [1.038, 1.133]	1.090 [1.053, 1.128]	1.090 [1.053, 1.128]	1.090 [1.053, 1.128]	1.090 [1.053, 1.128]
100,000 - 249,999	1.082 [1.038, 1.129]	1.080 [1.044, 1.116]	1.080 [1.044, 1.116]	1.080 [1.044, 1.116]	1.080 [1.044, 1.116]
<100,000	1.040 [1.004, 1.077]	1.040 [1.011, 1.069]	1.040 [1.011, 1.069]	1.040 [1.011, 1.069]	1.040 [1.011, 1.069]
Thermal stress indicators:					
HI (Heat Index) anomalies		1.104 [1.097, 1.112]	1.102 [1.094, 1.111]	1.103 [1.094, 1.111]	1.103 [1.094, 1.112]
Air pollution:					
PM1, µg/m^3			1.000 [1.000, 1.000]		
PM2.5, µg/m^3				1.000 [1.000, 1.000]	
PM10, µg/m^3					1.000 [1.000, 1.000]
Num. Obs.	1295	1295	1295	1295	1295
AIC	48.3	-555.5	-554.6	-554.1	-554.0
BIC	84.5	-514.2	-508.1	-507.6	-507.5
Adj. R-squared	0.051	0.406	0.406	0.406	0.406
logLik	-17.170	285.772	286.294	286.066	286.018

Notes: The model coefficients are presented in an exponentiated form for interpretability and clarity, along with 95% confidence intervals.
In models (2–10) HI anomalies were incorporated as an indicator of thermal stress chosen as the best-performing indicator from the previous set of models.

(table continues on next page)

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Table S.4 (continued)

	(6)	(7)	(8)	(9)	(10)
(Intercept)	0.952 [0.929, 0.974]	0.950 [0.928, 0.973]	0.986 [0.924, 1.051]	0.952 [0.929, 0.975]	0.951 [0.928, 0.975]
Settlement categories (Rural area is a reference):					
Over 1,000,000	1.187 [1.124, 1.254]	1.184 [1.121, 1.251]	1.188 [1.125, 1.255]	1.187 [1.124, 1.254]	1.186 [1.122, 1.253]
500,000 - 999,999	1.147 [1.100, 1.195]	1.146 [1.100, 1.195]	1.146 [1.099, 1.194]	1.147 [1.100, 1.195]	1.147 [1.100, 1.195]
250,000 - 499,999	1.090 [1.053, 1.128]	1.090 [1.053, 1.129]	1.090 [1.053, 1.128]	1.090 [1.053, 1.128]	1.090 [1.053, 1.128]
100,000 - 249,999	1.080 [1.044, 1.116]	1.080 [1.044, 1.116]	1.080 [1.044, 1.116]	1.080 [1.045, 1.116]	1.080 [1.044, 1.116]
<100,000	1.040 [1.011, 1.069]	1.040 [1.011, 1.069]	1.040 [1.011, 1.069]	1.040 [1.011, 1.069]	1.040 [1.011, 1.069]
Thermal stress indicators:					
HI (Heat Index) anomalies	1.105 [1.097, 1.113]	1.102 [1.094, 1.111]	1.107 [1.098, 1.115]	1.104 [1.096, 1.112]	1.104 [1.096, 1.112]
Air pollution:					
CO, ppbv	1.000 [1.000, 1.000]				
NO_2, ppbv		1.001 [0.999, 1.003]			
HCHO, ppbv				1.000 [0.999, 1.001]	
O_3, ppbv			0.999 [0.997, 1.001]		
SO_2, ppbv					1.001 [0.995, 1.007]
Num. Obs.	1295	1295	1295	1295	1295
AIC	-553.9	-555.0	-554.9	-553.6	-553.6
BIC	-507.4	-508.5	-508.4	-507.1	-507.1
Adj. R-squared	0.406	0.406	0.406	0.406	0.406
logLik	285.930	286.512	286.440	285.803	285.801

Notes: The model coefficients are presented in an exponentiated form for interpretability and clarity, along with 95% confidence intervals.
In models (2–10) HI anomalies were incorporated as an indicator of thermal stress chosen as the best-performing indicator from the previous set of models.

Table S.5 Summary of regression models for the logarithm of increase in death rate as a dependent variable associated with thermal stress and air pollution by settlement categories, including one-week lag for thermal stress

	(1)	(2)	(3)	(4)	(5)
(Intercept)	1.148 [1.119, 1.177]	0.912 [0.886, 0.938]	0.911 [0.886, 0.938]	0.911 [0.886, 0.938]	0.911 [0.886, 0.938]
Settlement categories (Rural area is a reference):					
Over 1,000,000	1.213 [1.132, 1.299]	1.210 [1.140, 1.285]	1.210 [1.140, 1.285]	1.210 [1.140, 1.285]	1.210 [1.140, 1.285]
500,000 - 999,999	1.195 [1.134, 1.259]	1.160 [1.109, 1.214]	1.160 [1.109, 1.213]	1.159 [1.108, 1.213]	1.159 [1.108, 1.213]
250,000 - 499,999	1.084 [1.038, 1.133]	1.101 [1.060, 1.143]	1.101 [1.060, 1.143]	1.100 [1.060, 1.143]	1.100 [1.060, 1.143]
100,000 - 249,999	1.082 [1.038, 1.129]	1.092 [1.053, 1.133]	1.092 [1.053, 1.133]	1.092 [1.053, 1.133]	1.092 [1.053, 1.133]
<100,000	1.040 [1.004, 1.077]	1.041 [1.009, 1.073]	1.041 [1.009, 1.073]	1.041 [1.009, 1.073]	1.041 [1.009, 1.073]
Thermal stress indicators:					
HI anomalies		1.093 [1.083, 1.103]	1.094 [1.084, 1.104]	1.094 [1.084, 1.104]	1.094 [1.084, 1.104]
HI anomalies, one-week lag		1.026 [1.017, 1.036]	1.027 [1.017, 1.037]	1.027 [1.017, 1.037]	1.027 [1.017, 1.037]
Air pollution:					
PM1, 10 µg/m^3			0.999 [0.997, 1.002]		
PM2.5, 10 µg/m^3				0.999 [0.997, 1.001]	
PM10, 10 µg/m^3					0.999 [0.998, 1.001]
Num. Obs.	1295	1110	1110	1110	1110
AIC	48.3	-450.0	-448.3	-448.6	-448.7
BIC	84.5	-404.9	-398.2	-398.5	-398.6
Adj. R-squared	0.051	0.438	0.438	0.438	0.438
logLik	-17.170	234.010	234.162	234.314	234.351

Notes: The model coefficients are presented in an exponentiated form for interpretability and clarity, along with 95% confidence intervals.
In models (2–10) HI anomalies were incorporated as an indicator of thermal stress and chosen as the best-performing indicator from the previous set of models.

(table continues on next page)

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Table S.5 (continued)

	(6)	(7)	(8)	(9)	(10)
(Intercept)	0.910 [0.885, 0.937]	0.912 [0.886, 0.938]	0.977 [0.914, 1.045]	0.912 [0.886, 0.938]	0.913 [0.887, 0.940]
Settlement categories (Rural area is a reference):					
Over 1,000,000	1.210 [1.140, 1.284]	1.210 [1.139, 1.284]	1.212 [1.142, 1.286]	1.210 [1.140, 1.285]	1.214 [1.143, 1.289]
500,000 - 999,999	1.160 [1.109, 1.214]	1.160 [1.109, 1.214]	1.157 [1.107, 1.211]	1.160 [1.109, 1.214]	1.160 [1.109, 1.213]
250,000 - 499,999	1.100 [1.059, 1.142]	1.101 [1.060, 1.143]	1.101 [1.061, 1.143]	1.100 [1.060, 1.143]	1.100 [1.059, 1.142]
100,000 - 249,999	1.092 [1.053, 1.132]	1.092 [1.053, 1.133]	1.092 [1.053, 1.132]	1.092 [1.053, 1.133]	1.093 [1.054, 1.133]
<100,000	1.041 [1.009, 1.073]	1.041 [1.009, 1.073]	1.041 [1.009, 1.073]	1.041 [1.009, 1.073]	1.041 [1.009, 1.073]
Thermal stress indicators:					
HI (Heat Index) anomalies	1.094 [1.084, 1.104]	1.092 [1.083, 1.102]	1.097 [1.086, 1.107]	1.094 [1.084, 1.104]	1.094 [1.084, 1.103]
HI anomalies, one-week lag	1.027 [1.018, 1.037]	1.026 [1.016, 1.036]	1.028 [1.018, 1.038]	1.027 [1.017, 1.037]	1.027 [1.017, 1.037]
Air pollution:					
CO, ppbv	1.000 [1.000, 1.000]				
NO_2, ppbv		1.000 [0.998, 1.002]			
HCHO, ppbv				1.000 [0.999, 1.001]	
O_3, ppbv			0.998 [0.996, 1.000]		
SO_2, ppbv					0.998 [0.992, 1.004]
Num. Obs.	1110	1110	1110	1110	1110
AIC	-450.3	-448.1	-453.0	-448.6	-448.6
BIC	-400.2	-398.0	-402.9	-398.4	-398.5
Adj. R-squared	0.439	0.438	0.440	0.438	0.438
logLik	235.151	234.060	236.519	234.280	234.294

Notes: The model coefficients are presented in an exponentiated form for interpretability and clarity, along with 95% confidence intervals.
In models (2–10) HI anomalies were incorporated as an indicator of thermal stress chosen as the best-performing indicator from the previous set of models.

Table S.6 Summary of regression models for the logarithm of increase in death rate as a dependent variable associated with the interaction between thermal stress and settlement categories

	(1)	(2)	(3)	(4)	(5)	(6)
(Intercept)	1.148 [1.119, 1.177]	0.976 [0.940, 1.014]	0.984 [0.949, 1.021]	1.018 [0.988, 1.050]	1.005 [0.970, 1.042]	1.038 [1.004, 1.072]
Settlement categories (Rural area is a reference):						
Over 1,000,000	1.213 [1.132, 1.299]	0.911 [0.810, 1.025]	0.946 [0.845, 1.060]	0.959 [0.873, 1.053]	0.986 [0.886, 1.097]	1.086 [0.995, 1.185]
500,000 - 999,999	1.195 [1.134, 1.259]	0.970 [0.894, 1.053]	0.992 [0.916, 1.074]	0.935 [0.869, 1.006]	1.027 [0.953, 1.108]	1.061 [0.992, 1.134]
250,000 - 499,999	1.084 [1.038, 1.133]	0.987 [0.924, 1.055]	0.997 [0.934, 1.064]	0.999 [0.949, 1.053]	1.018 [0.956, 1.083]	1.027 [0.969, 1.088]
100,000 - 249,999	1.082 [1.038, 1.129]	0.958 [0.900, 1.021]	0.972 [0.914, 1.034]	0.951 [0.902, 1.002]	0.989 [0.932, 1.049]	1.013 [0.960, 1.069]
<100,000	1.040 [1.004, 1.077]	0.979 [0.928, 1.032]	0.982 [0.933, 1.035]	0.990 [0.948, 1.034]	0.991 [0.943, 1.042]	1.006 [0.960, 1.053]
Interactions with thermal stress:						
Over 1,000,000		1.073 [1.056, 1.090]	1.053 [1.040, 1.065]	1.184 [1.143, 1.226]	1.050 [1.037, 1.062]	1.084 [1.060, 1.110]
500,000 - 999,999		1.061 [1.051, 1.072]	1.046 [1.037, 1.054]	1.172 [1.143, 1.201]	1.043 [1.035, 1.052]	1.095 [1.075, 1.115]
250,000 - 499,999		1.044 [1.036, 1.052]	1.033 [1.027, 1.039]	1.116 [1.096, 1.135]	1.029 [1.023, 1.036]	1.060 [1.045, 1.075]
100,000 - 249,999		1.052 [1.044, 1.060]	1.039 [1.033, 1.045]	1.139 [1.119, 1.159]	1.036 [1.030, 1.043]	1.072 [1.058, 1.086]
<100,000		1.039 [1.033, 1.045]	1.030 [1.025, 1.034]	1.093 [1.080, 1.107]	1.028 [1.023, 1.032]	1.054 [1.044, 1.065]
Rural area		1.028 [1.023, 1.034]	1.022 [1.017, 1.026]	1.065 [1.052, 1.079]	1.020 [1.016, 1.025]	1.041 [1.031, 1.051]
Num. Obs.	1295	1295	1295	1295	1295	1295
AIC	48.3	-507.0	-486.1	-555.5	-412.7	-339.9
BIC	84.5	-465.7	-444.8	-514.2	-371.3	-298.6
Adj. R-squared	0.051	0.383	0.373	0.406	0.336	0.298
logLik	-17.170	261.496	251.060	285.772	214.333	177.970

Notes: The model coefficients are presented in an exponentiated form for interpretability and clarity, along with 95% confidence intervals.
In Model (2) t2m anomalies were incorporated as an indicator of thermal stress.
In Model (3) PET anomalies were incorporated as an indicator of thermal stress.
In Model (4) HI anomalies were incorporated as an indicator of thermal stress.
In Model (5) UTCI anomalies were incorporated as an indicator of thermal stress.
In Model (6) HUM anomalies were incorporated as an indicator of thermal stress.

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Table S.7 Summary of regression models for the logarithm of increase in death rate as a dependent variable associated with the interaction between thermal stress and settlement categories and air pollution as an independent variable

	(1)	(2)	(3)	(4)	(5)
(Intercept)	1.148 [1.119, 1.177]	1.018 [0.988, 1.050]	1.018 [0.988, 1.050]	1.018 [0.987, 1.050]	1.018 [0.987, 1.050]
Settlement categories (Rural area is a reference):					
Over 1,000,000	1.213 [1.132, 1.299]	0.959 [0.873, 1.053]	0.959 [0.873, 1.053]	0.959 [0.873, 1.053]	0.959 [0.873, 1.053]
500,000 - 999,999	1.195 [1.134, 1.259]	0.935 [0.869, 1.006]	0.935 [0.870, 1.006]	0.935 [0.869, 1.006]	0.935 [0.869, 1.006]
250,000 - 499,999	1.084 [1.038, 1.133]	0.999 [0.949, 1.053]	0.999 [0.948, 1.052]	0.999 [0.948, 1.052]	0.999 [0.948, 1.053]
100,000 - 249,999	1.082 [1.038, 1.129]	0.951 [0.902, 1.002]	0.951 [0.902, 1.002]	0.951 [0.902, 1.002]	0.951 [0.902, 1.002]
<100,000	1.040 [1.004, 1.077]	0.990 [0.948, 1.034]	0.990 [0.948, 1.034]	0.990 [0.948, 1.034]	0.990 [0.948, 1.034]
Interactions with thermal stress (Heat Index):					
Over 1,000,000		1.184 [1.143, 1.226]	1.182 [1.141, 1.224]	1.182 [1.141, 1.224]	1.182 [1.141, 1.225]
500,000 - 999,999		1.172 [1.143, 1.201]	1.170 [1.141, 1.199]	1.170 [1.142, 1.200]	1.170 [1.142, 1.200]
250,000 - 499,999		1.116 [1.096, 1.135]	1.114 [1.095, 1.134]	1.115 [1.095, 1.134]	1.115 [1.095, 1.135]
100,000 - 249,999		1.139 [1.119, 1.159]	1.137 [1.117, 1.158]	1.138 [1.118, 1.158]	1.138 [1.118, 1.159]
<100,000		1.093 [1.080, 1.107]	1.092 [1.077, 1.106]	1.092 [1.078, 1.106]	1.092 [1.078, 1.106]
Rural area		1.065 [1.052, 1.079]	1.064 [1.050, 1.078]	1.064 [1.050, 1.078]	1.064 [1.051, 1.078]
Air pollution:					
PM1, µg/m^3			1.000 [1.000, 1.000]		
PM2.5, µg/m^3				1.000 [1.000, 1.000]	
PM10, µg/m^3					1.000 [1.000, 1.000]
Num. Obs.	1295	1295	1295	1295	1295
AIC	48.3	-628.1	-627.0	-626.6	-626.5
BIC	84.5	-560.9	-554.7	-554.2	-554.1
Adj. R-squared	0.051	0.442	0.443	0.443	0.443
logLik	-17.170	327.039	327.503	327.276	327.232

Notes: The model coefficients are presented in an exponentiated form for interpretability and clarity, along with 95% confidence intervals.
In models (2–10) HI anomalies were incorporated as an indicator of thermal stress chosen as the best-performing indicator from the previous set of models.

(table continues on next page)

Table S.7 (continued)

	(6)	(7)	(8)	(9)	(10)
(Intercept)	1.018 [0.987, 1.050]	1.017 [0.986, 1.049]	1.055 [0.988, 1.127]	1.018 [0.988, 1.050]	1.018 [0.987, 1.050]
Settlement categories (Rural area is a reference):					
Over 1,000,000	0.959 [0.873, 1.053]	0.957 [0.871, 1.051]	0.959 [0.873, 1.053]	0.959 [0.873, 1.053]	0.958 [0.872, 1.053]
500,000 - 999,999	0.959 [0.873, 1.053]	0.957 [0.871, 1.051]	0.959 [0.873, 1.053]	0.959 [0.873, 1.053]	0.958 [0.872, 1.053]
250,000 - 499,999	0.959 [0.873, 1.053]	0.957 [0.871, 1.051]	0.959 [0.873, 1.053]	0.959 [0.873, 1.053]	0.958 [0.872, 1.053]
100,000 - 249,999	0.959 [0.873, 1.053]	0.957 [0.871, 1.051]	0.959 [0.873, 1.053]	0.959 [0.873, 1.053]	0.958 [0.872, 1.053]
<100,000	0.959 [0.873, 1.053]	0.957 [0.871, 1.051]	0.959 [0.873, 1.053]	0.959 [0.873, 1.053]	0.958 [0.872, 1.053]
Interactions with thermal stress (Heat Index):					
Over 1,000,000	1.185 [1.144, 1.227]	1.182 [1.141, 1.224]	1.186 [1.145, 1.229]	1.183 [1.143, 1.226]	1.183 [1.143, 1.226]
500,000 - 999,999	1.173 [1.145, 1.203]	1.169 [1.140, 1.198]	1.174 [1.145, 1.203]	1.172 [1.143, 1.201]	1.172 [1.143, 1.201]
250,000 - 499,999	1.116 [1.097, 1.136]	1.115 [1.095, 1.134]	1.118 [1.098, 1.138]	1.116 [1.096, 1.135]	1.116 [1.096, 1.135]
100,000 - 249,999	1.140 [1.120, 1.160]	1.138 [1.117, 1.158]	1.142 [1.121, 1.162]	1.139 [1.119, 1.159]	1.139 [1.119, 1.159]
<100,000	1.094 [1.080, 1.108]	1.092 [1.078, 1.106]	1.095 [1.081, 1.110]	1.093 [1.079, 1.107]	1.093 [1.079, 1.107]
Rural area	1.066 [1.053, 1.080]	1.064 [1.050, 1.078]	1.068 [1.054, 1.082]	1.065 [1.052, 1.079]	1.065 [1.052, 1.079]
Air pollution:					
CO, ppbv	1.000 [1.000, 1.000]				
NO_2, ppbv		1.001 [0.999, 1.003]			
HCHO, ppbv			0.999 [0.997, 1.001]		
O_3, ppbv				1.000 [0.999, 1.001]	
SO_2, ppbv					1.000 [0.995, 1.006]
Num. Obs.	1295	1295	1295	1295	1295
AIC	-626.6	-627.2	-627.5	-626.1	-626.1
BIC	-554.3	-554.9	-555.2	-553.8	-553.8
Adj. R-squared	0.443	0.443	0.443	0.442	0.442
logLik	327.303	327.614	327.765	327.047	327.053

Notes: The model coefficients are presented in an exponentiated form for interpretability and clarity, along with 95% confidence intervals.
In models (2–10) HI anomalies were incorporated as an indicator of thermal stress chosen as the best-performing indicator from the previous set of models.

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