

## Extreme Heat and Cognitive Decline

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**Supplementary Appendix 1.**

$$\begin{aligned} \text{Cognitive function}_{ij} = & \gamma_{00} + \gamma_{10} \text{Age}_{ij} + \gamma_{20} \text{Age}_{ij}^2 + \\ & \gamma_{01} \text{Heat}_i + \gamma_{02} \text{Group}_i + \gamma_{03} (\text{Heat}_i \times \text{Group}_i) + \beta_{yx} X_{ij} + \beta_{yz} Z_i + \\ & \gamma_{11} \text{Heat}_i \text{Age}_{ij} + \gamma_{12} \text{Group}_i \text{Age}_{ij} + \gamma_{13} (\text{Heat}_i \times \text{Group}_i) \text{Age}_{ij} + \\ & \beta_{yxt} X_{ij} \text{Age}_{ij} + \beta_{yzt} Z_i \text{Age}_{ij} + \zeta_{0i} + \zeta_{1i} \text{Age}_{ij} + \varepsilon_{ij} \end{aligned}$$

where subscripts  $j$  represents measurement occasion (survey wave) and  $i$  represents individual. Cognitive function $_{ij}$  is the value of cognitive scores for individual  $i$  at occasion  $j$ .  $\gamma_{00}$  is the average intercept,  $\gamma_{10}$  and  $\gamma_{20}$  are the average effects for the linear and quadratic terms of age.  $\gamma_{01}$ ,  $\gamma_{02}$ , and  $\gamma_{03}$  represent the effects of extreme heat exposure, a subgroup (i.e., race/ethnicity, neighbourhood socioeconomic status), and their interactions on the intercept.  $\gamma_{11}$ ,  $\gamma_{12}$ , and  $\gamma_{13}$  are the effects of extreme heat exposure, a subgroup, and their interactions with the linear term of age.  $X_{ij}$  is a vector of time-varying covariates (living arrangement and household wealth) for the individual  $i$  at observation  $j$ , while  $Z_i$  is a vector of time-constant covariates (sex, education, region of residence, urbanicity, and years of follow-up) for the individual  $i$ .  $\beta_{yx}$  and  $\beta_{yz}$  denote vectors of coefficients for the effects of covariates  $X_{ij}$  and  $Z_i$  on the intercept.  $\beta_{yxt}$  and  $\beta_{yzt}$  are vectors of coefficients for the effects of covariates  $X_{ij}$  and  $Z_i$  on the rate of change with age.  $\zeta_{0i}$  and  $\zeta_{1i}$  are a random intercept and linear slope of age.  $\varepsilon_{ij}$  is the occasion-specific error term.

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**Supplementary Table 1.** Differences in Extreme Heat Exposure Across Subgroups

	% High exposure	Group comparison
<i>Race/ethnicity</i>		
White	16.9	vs. Black ( $p < .001$ )
<b>Black</b>	<b>32.5</b>	vs. Hispanic ( $p < .001$ )
Hispanic	11.0	vs. White ( $p = .01$ )
<i>Neighborhood SES</i>		
Average	18.9	vs. Disadvantaged ( $p = .36$ )
<b>Disadvantaged</b>	<b>22.1</b>	vs. Affluent ( $p = 0.01$ )
Affluent	11.7	vs. Average ( $p = 0.005$ )

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**Supplementary Table 2.** Growth Curve Models of the Associations between Extreme Heat Exposure and Cognitive Function

Trajectories, U.S. Health and Retirement Study, 2006-2018

	Model 1: Average association				Model 2: Racial/ethnic interaction				Model 3: Neighbourhood SES interaction			
	Intercept		Rate of change		Intercept		Rate of change		Intercept		Rate of change	
	b	p value	b	p value	b	p value	b	p value	b	p value	b	p value
<i>Fixed effects</i>												
Age (centred at age 65)	-0.12	<0.001			-0.12	<0.001			-0.12	<0.001		
Age squared	-0.01	<0.001			-0.01	<0.001			-0.01	<0.001		
Heat	-0.03	0.83	0.002	0.85	-0.04	0.77	0.01	0.23	-0.06	0.70	0.01	0.29
<b>Heat × Non-Hispanic Black<sup>a</sup></b>					-0.04	0.91	<b>-0.08</b>	<b>&lt;0.001</b>				
Heat × Hispanic <sup>a</sup>					0.15	0.78	0.003	0.93				
<b>Heat × Disadvantaged neighbourhood<sup>b</sup></b>									0.14	0.66	<b>-0.07</b>	<b>0.002</b>
Heat × Affluent neighbourhood <sup>c</sup>									0.04	0.91	-0.00	0.98
Female	0.99	<0.001	-0.02	0.01	0.99	<0.001	-0.02	0.01	0.99	<0.001	-0.02	0.006
Race/ethnicity (ref: White)												
Black	-2.41	<0.001	-0.02	0.03	-2.41	<0.001	0.00	0.99	-2.41	<0.001	-0.02	0.03
Hispanic	-1.99	<0.001	-0.002	0.85	-2.01	<0.001	-0.002	0.87	-1.99	<0.001	-0.01	0.64
Neighbourhood SES (ref: average)												
Disadvantaged neighbourhood	-0.61	<0.001	0.01	0.29	-0.60	<0.001	0.01	0.32	-0.64	<0.001	0.03	0.02
Affluent neighbourhood	0.65	<0.001	-0.01	0.12	0.65	<0.001	-0.01	0.13	0.65	<0.001	-0.01	0.17
Living alone, not married/partnered	-0.01	0.86	0.01	0.03	-0.01	0.88	0.01	0.02	-0.01	0.87	0.01	0.03
≥ Some college education	2.05	<0.001	-0.01	0.08	2.05	<0.001	-0.01	0.07	2.05	<0.001	-0.01	0.07
Household wealth	0.02	<0.001	0.002	<0.001	0.02	<0.001	0.002	<0.001	0.02	<0.001	0.002	<0.001
Region of residence (ref: Northeast)												
Midwest	-0.04	0.79	0.002	0.86	-0.04	0.79	0.001	0.89	-0.04	0.79	0.001	0.88
South	-0.20	0.17	0.002	0.79	-0.19	0.17	0.001	0.89	-0.19	0.18	0.001	0.88
West	-0.13	0.41	-0.004	0.69	-0.12	0.42	-0.004	0.74	-0.12	0.42	-0.01	0.65
Urbanicity	0.20	0.05	0.01	0.30	0.20	0.06	0.007	0.35	0.20	0.06	0.01	0.33

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## Length of follow-up (ref: 2 years)

4 years	0.19	0.41	-0.01	0.78	0.19	0.42	-0.004	0.81	0.19	0.42	-0.004	0.80
6 years	0.02	0.94	-0.004	0.82	0.01	0.95	-0.004	0.82	0.02	0.95	-0.003	0.87
8 years	0.59	0.01	-0.03	0.07	0.59	0.006	-0.03	0.07	0.58	0.01	-0.03	0.08
10 years	0.45	0.03	-0.01	0.42	0.45	0.03	-0.01	0.43	0.45	0.03	-0.01	0.44
12 years	1.10	<0.001	0.05	<0.001	1.10	<0.001	0.05	<0.001	1.10	<0.001	0.05	<0.001
<i>Random effects</i>	Variance		95% CI		Variance		95% CI		Variance		95% CI	
Intercept	6.62		6.23, 7.04		6.62		6.22, 7.03		6.62		6.23, 7.04	
Linear slope	0.01		0.007, 0.011		0.01		0.007, 0.010		0.01		0.007, 0.010	
Residual	6.49		6.32, 6.66		6.49		6.32, 6.66		6.49		6.33, 6.66	

Note. <sup>a</sup> Reference group = non-Hispanic White; <sup>b</sup> Reference group = average neighbourhood.

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**Supplementary Table 3.** Interaction Models with Both Race and Neighbourhood Interactions

	Intercept		Rate of change	
	b	p value	b	p value
Age (centred at age 65)	-0.12	<0.001		
Age squared	-0.01	<0.001		
Heat	-0.06	0.71	0.02	0.15
<b>Heat × Non-Hispanic Black<sup>a</sup></b>	-0.08	0.81	<b>-0.06</b>	<b>0.007</b>
Heat × Hispanic <sup>a</sup>	0.07	0.90	0.02	0.53
<b>Heat × Disadvantaged neighbourhood<sup>b</sup></b>	0.16	0.65	<b>-0.05</b>	<b>0.03</b>
Heat × Affluent neighbourhood <sup>b</sup>	0.03	0.93	-0.002	0.93
Female	0.99	<0.001	-0.02	0.01
Race/ethnicity (ref: White)				
Black	-2.40	<0.001	-0.05	0.69
Hispanic	-2.00	<0.001	-0.01	0.59
Neighbourhood SES (ref: average)				
Disadvantaged neighbourhood	-0.64	<0.001	0.02	0.06
Affluent neighbourhood	0.65	<0.001	-0.01	0.17
Living alone, not married/partnered	-0.01	0.88	0.01	0.02
≥ Some college education	2.05	<0.001	-0.01	0.06
Household wealth	0.02	<0.001	0.002	<0.001
Region of residence (ref: Northeast)				
Midwest	-0.04	0.79	0.001	0.91
South	-0.19	0.18	0.001	0.92
West	-0.12	0.43	-0.004	0.72
Urbanicity	0.20	0.06	0.01	0.37
Length of follow-up (ref: 2 years)				
4 years	0.19	0.42	-0.004	0.81
6 years	0.01	0.96	-0.003	0.86
8 years	0.58	0.006	-0.03	0.08
10 years	0.45	0.03	-0.01	0.44
12 years	1.10	<0.001	0.05	<0.001

Note. <sup>a</sup> Reference group = non-Hispanic White; <sup>b</sup> Reference group = average neighbourhood.

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**Supplementary Table 4.** Growth Curve Models of the Associations between Extreme Heat Exposure and Cognitive Function Trajectories, U.S. Health and Retirement Study, 2006-2018, Continuous Measure of Extreme Heat Exposure

	Model 1: Average association				Model 2: Racial/ethnic interaction				Model 3: Neighbourhood SES interaction			
	Intercept		Rate of change		Intercept		Rate of change		Intercept		Rate of change	
	b	p value	b	p value	b	p value	b	p value	b	p value	b	p value
Fixed Effects												
Age (centred at age 65)	-0.13	<0.001			-0.13	<0.001			-0.13	<0.001		
Age squared	-0.01	<0.001			-0.01	<0.001			-0.01	<0.001		
Heat	0.03	0.25	-0.002	0.20	0.02	0.51	-0.001	0.69	0.02	0.53	-0.001	0.51
<b>Heat × Non-Hispanic Black<sup>a</sup></b>					-0.02	0.71	<b>-0.01</b>	<b>0.001</b>				
Heat × Hispanic <sup>a</sup>					0.12	0.11	-0.001	0.85				
<b>Heat × Disadvantaged neighbourhood<sup>b</sup></b>									0.08	0.12	<b>-0.01</b>	<b>0.02</b>
Heat × Affluent neighbourhood <sup>c</sup>									-0.01	0.80	0.003	0.34

*Note.* <sup>a</sup> Reference group = non-Hispanic White; <sup>b</sup> Reference group = average neighbourhood; All models were adjusted for race/ethnicity, neighbourhood socioeconomic status, sex, living arrangement, education, household wealth, region of residence, urbanicity, and years of follow-up.

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**Supplementary Table 5.** Growth Curve Models of the Associations between Extreme Heat Exposure and Cognitive FunctionTrajectories Moderated by Subgroups, U.S. Health and Retirement Study, 2006-2018, 99<sup>th</sup> Threshold for Extreme Heat

	Model 1: Average association				Model 2: Racial/ethnic interaction				Model 3: Neighbourhood SES interaction			
	Intercept		Rate of change		Intercept		Rate of change		Intercept		Rate of change	
	b	p value	b	p value	b	p value	b	p value	b	p value	b	p value
Fixed Effects												
Age (centred at age 65)	-0.12	<0.001			-0.12	<0.001			-0.12	<0.001		
Age squared	-0.01	<0.001			-0.01	<0.001			-0.01	<0.001		
Heat	0.02	0.84	-0.002	0.81	0.02	0.88	0.01	0.40	0.02	0.88	0.01	0.27
<b>Heat × Non-Hispanic Black<sup>a</sup></b>					-0.17	0.59	<b>-0.09</b>	<b>&lt;0.001</b>				
Heat × Hispanic <sup>a</sup>					0.28	0.63	0.003	0.93				
<b>Heat × Disadvantaged neighbourhood<sup>b</sup></b>									0.01	0.98	<b>-0.08</b>	<b>&lt;0.001</b>
Heat × Affluent neighbourhood <sup>c</sup>									-0.01	0.97	0.01	0.81

*Note.* <sup>a</sup> Reference group = non-Hispanic White; <sup>b</sup> Reference group = average neighbourhood; All models were adjusted for race/ethnicity, neighbourhood socioeconomic status, sex, living arrangement, education, household wealth, region of residence, urbanicity, and years of follow-up.

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**Supplementary Table 6.** Growth Curve Models of the Associations between Extreme Heat Exposure and Cognitive Function

Trajectories Moderated by Subgroups, U.S. Health and Retirement Study, 2006-2018, Completers

	Model 1: Average association				Model 2: Racial/ethnic interaction				Model 3: Neighbourhood SES interaction			
	Intercept		Rate of change		Intercept		Rate of change		Intercept		Rate of change	
	b	p value	b	p value	b	p value	b	p value	b	p value	b	p value
Fixed Effects												
Age (centred at age 65)	-0.08	<0.001			-0.08	<0.001			-0.08	<0.001		
Age squared	-0.004	<0.001			-0.004	<0.001			-0.004	<0.001		
Heat	0.14	0.39	-0.01	0.57	0.20	0.29	0.004	0.74	0.22	0.22	0.002	0.85
<b>Heat × Non-Hispanic Black<sup>a</sup></b>					-0.31	0.43	<b>-0.07</b>	<b>0.01</b>				
Heat × Hispanic <sup>a</sup>					-0.24	0.70	-0.01	0.72				
<b>Heat × Disadvantaged neighbourhood<sup>b</sup></b>									-0.63	0.19	<b>-0.07</b>	<b>0.03</b>
Heat × Affluent neighbourhood <sup>c</sup>									-0.03	0.96	-0.01	0.87

*Note.* <sup>a</sup> Reference group = non-Hispanic White; <sup>b</sup> Reference group = average neighbourhood; All models were adjusted for race/ethnicity, neighbourhood socioeconomic status, sex, living arrangement, education, household wealth, region of residence, urbanicity, and years of follow-up.



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**Supplementary Table 7.** Growth Curve Models of the Associations between Extreme Heat Exposure and Cognitive Function

Trajectories Stratified by Race/ethnicity, U.S. Health and Retirement Study, 2006-2018

	Stratified Model 1: Whites				Stratified Model 2: Black				Stratified Model 3: Hispanic			
	Intercept		Rate of change		Intercept		Rate of change		Intercept		Rate of change	
Fixed Effects	b	p value	b	p value	b	p value	b	p value	b	p value	b	p value
Age (centred at age 65)	-0.12	<0.001			-0.14	0.001			-0.21	<0.001		
Age squared	-0.01	<0.001			-0.004	<0.001			-0.01	<0.001		
Heat	-0.09	0.55	0.01	0.19	<b>0.19</b>	<b>0.54</b>	<b>-0.06</b>	<b>0.004</b>	-0.13	0.81	-0.004	0.90
Female	1.14	<0.001	-0.02	<0.001	0.74	0.002	0.01	0.66	-0.57	0.01	0.01	0.53
Neighbourhood SES (ref: average)												
Disadvantaged neighbourhood	-0.19	0.39	0.01	0.36	-0.37	0.12	-0.01	0.68	-1.62	<0.001	0.01	0.66
Affluent neighbourhood	0.68	<0.001	-0.01	0.21	0.79	0.12	-0.02	0.45	1.15	0.003	-0.03	0.42
Living alone, not married/partnered	-0.05	0.62	0.02	0.03	0.19	0.28	-0.001	0.93	-0.002	0.99	0.02	0.31
≥ Some college education	1.90	<0.001	-0.01	0.13	3.21	<0.001	-0.03	0.13	2.13	<0.001	0.02	0.38
Household wealth	0.02	<0.001	0.002	<0.001	0.02	0.08	0.001	0.16	0.03	0.006	0.001	0.19
Region of residence (ref: Northeast)												
Midwest	-0.13	0.38	0.01	0.52	0.27	0.50	-0.05	0.046	1.98	0.006	-0.11	0.01
South	-0.20	0.21	0.003	0.79	-0.57	0.13	-0.01	0.67	1.22	0.01	-0.01	0.69
West	-0.22	0.18	0.002	0.86	-0.11	0.80	-0.03	0.45	1.12	0.01	-0.04	0.26
Urbanicity	0.16	0.17	0.003	0.74	0.29	0.42	0.06	0.004	0.60	0.24	0.02	0.50
Length of follow-up (ref: 2 years)												
4 years	0.33	0.21	-0.01	0.64	-0.07	0.90	-0.03	0.43	-0.87	0.26	0.10	0.11
6 years	-0.03	0.93	-0.001	0.97	0.26	0.66	-0.07	0.12	-0.38	0.56	0.08	0.09
8 years	0.54	0.02	-0.03	0.08	1.07	0.10	-0.04	0.39	-0.01	0.99	0.04	0.45
10 years	0.43	0.06	-0.02	0.26	1.19	0.048	0.01	0.84	-0.27	0.66	0.03	0.42
12 years	1.15	<0.001	0.04	0.001	1.23	0.008	0.04	0.26	0.26	0.63	0.13	<0.001

**Supplementary Table 8.** Growth Curve Models of the Associations between Extreme Heat Exposure and Cognitive Function

Trajectories Moderated by Subgroups, U.S. Health and Retirement Study, 2006-2018, Persistent Extreme Heat Exposure

	Model 1: Average association				Model 2: Racial/ethnic interaction				Model 3: Neighbourhood SES interaction			
	Intercept		Rate of change		Intercept		Rate of change		Intercept		Rate of change	
	b	p value	b	p value	b	p value	b	p value	b	p value	b	p value
Fixed Effects												
Age (centred at age 65)	-0.13	<0.001			-0.13	<0.001			-0.13	<0.001		
Age squared	-0.01	<0.001			-0.01	<0.001			-0.01	<0.001		
Heat	0.02	0.43	<b>-0.01</b>	<b>0.007</b>	0.02	0.48	-0.004	0.08	0.02	0.55	<b>-0.01</b>	<b>0.04</b>
<b>Heat × Non-Hispanic Black<sup>a</sup></b>					-0.01	0.94	<b>-0.02</b>	<b>&lt;0.001</b>				
Heat × Hispanic <sup>a</sup>					-0.02	0.86	0.01	0.37				
<b>Heat × Disadvantaged neighbourhood<sup>b</sup></b>									-0.03	0.75	-0.01	0.27
Heat × Affluent neighbourhood <sup>c</sup>									0.04	0.56	0.001	0.77

*Note.* <sup>a</sup> Reference group = non-Hispanic White; <sup>b</sup> Reference group = average neighbourhood; All models were adjusted for race/ethnicity, neighbourhood socioeconomic status, sex, living arrangement, education, household wealth, region of residence, urbanicity, and years of follow-up. Persistent exposure to extreme heat was measured with a score representing the proportion of each HRS participant's follow-up period spent in census tracts with high heat exposure. This score, ranging from 0 to 10, a score of 1 signifies that 10% of the follow-up period was spent in such conditions, while a score of 10 indicates a consistent, or 100%, exposure to extreme heat throughout the follow-up period.