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SUPPLEMENTARY INFORMATION

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Higher temperatures increase suicide rates in the United States and Mexico

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Supplementary Information for Burke et al, "Higher temperatures increase suicide risk in US and Mexico"

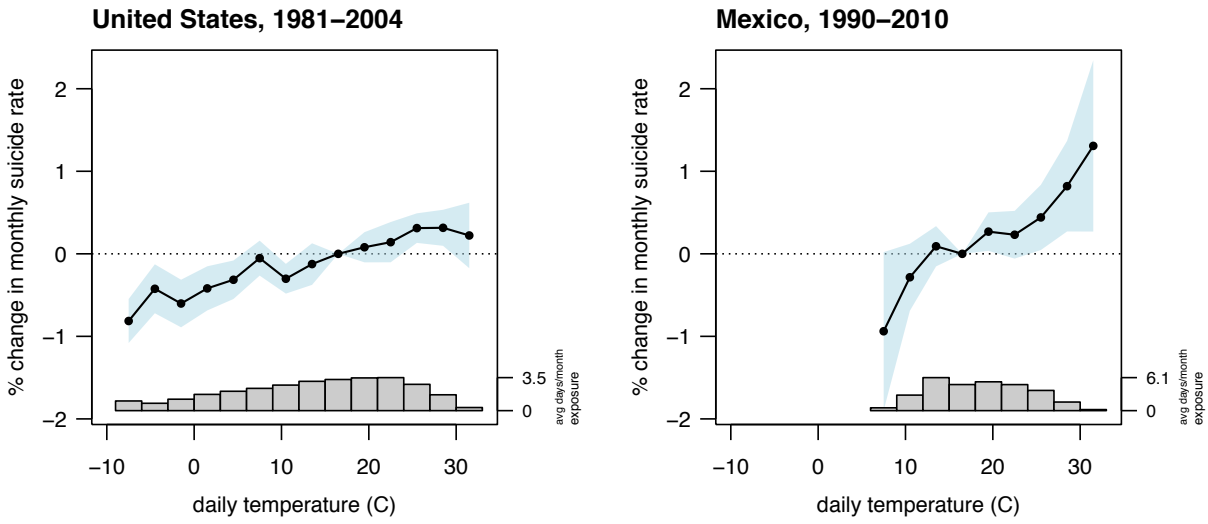

Figure S1: **Effects of daily temperature on monthly suicide rate.** Connected black markers are the change in monthly suicides rates in US (left; 1981-2004) and Mexico (right; 1990-2010) caused by altering the temperature of a single day in that month (blue shaded area is 95% CI). Effects are the relative change in monthly suicides due to changing a day's average temperature from 15-18°C to an alternative average temperature (left vertical axis). Estimates are net of all constant differences between locations, all within-location seasonal (monthly) variations, and all nationally coherent annual changes in rates. Grey histograms display the distribution of individual days in each sample (right vertical axis).

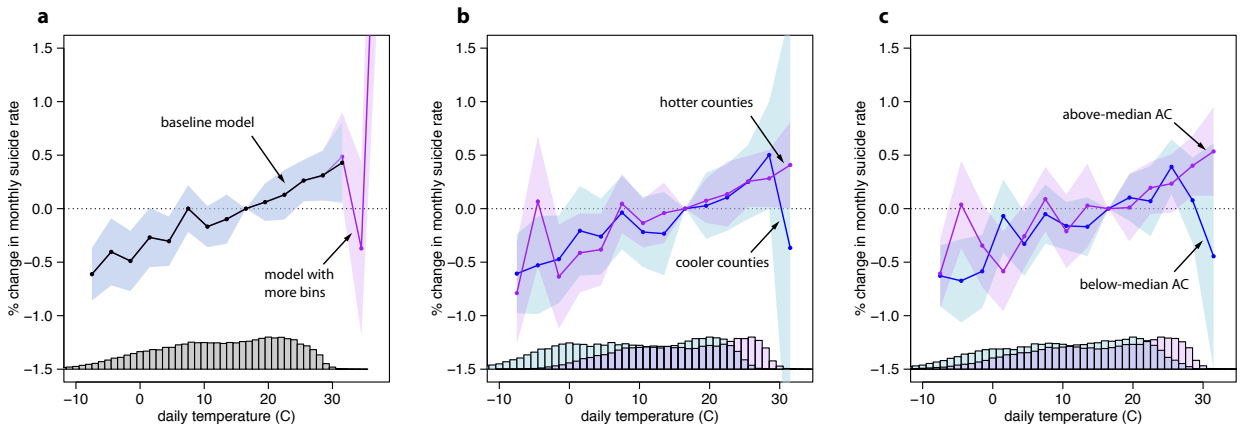

Figure S2: **Robustness and heterogeneity in the binned model for the US. a**, Baseline binned model (black, as in Figure S1a) assigns all daily exposure >30°C into one bin. Estimates from a model that instead splits exposure above 30°C exposure into 30-33°C, 33-36°C, and >36°C bins (purple line) has identical estimates below 30°C but noisy estimates above 33°C, given the very low number of days in our sample with daily average temperatures above 33°C (as shown in the histogram at bottom). **b**, the effect of daily temperature exposure on suicide as a function of county average temperatures, with blue (purple) showing counties with below (above) median temperature. Estimates in cooler counties are noisy in the >30°C bin given the minimal exposure in those counties to hot temperatures, as shown in the histograms at bottom. **c**, as in **b** but for above- and below-average air-conditioning (AC) penetration. Counties with lower AC penetration, which tend to be cooler in our sample and thus have low current exposure to extreme heat, again have noisy estimates for the >30°C bin. As in Figure S1, all estimates refer to the 1981-2004 period for which we have daily temperature data.

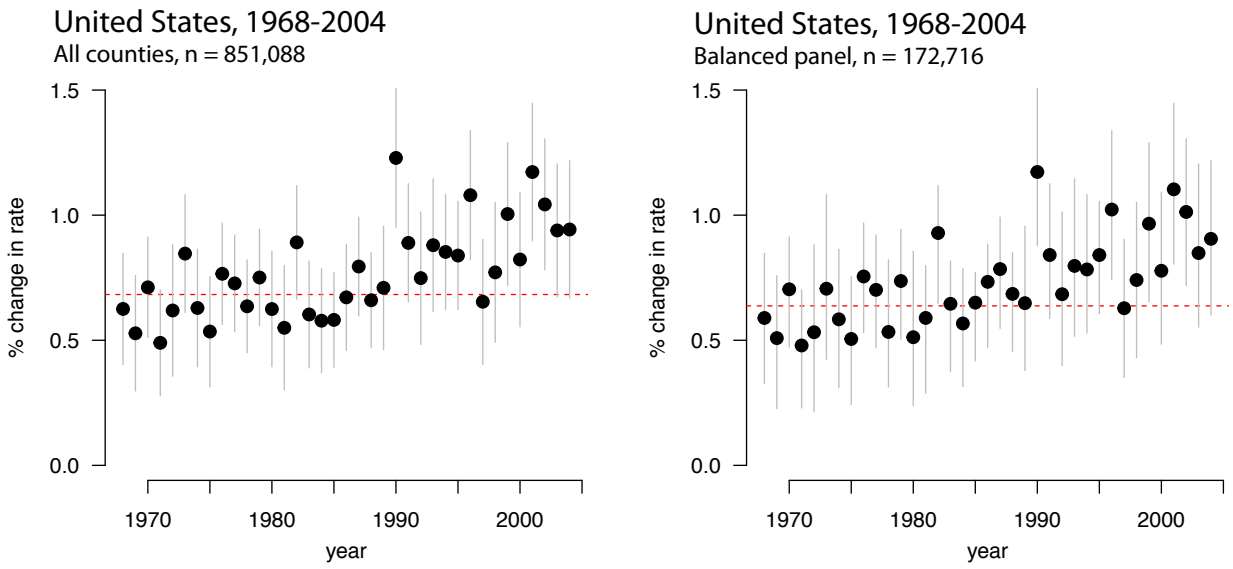

Figure S3: **Robustness of effects of temperature on monthly suicide rate over time in the US.** Left plot: As in Figure 2A. Right plot: sample restricted to a balanced panel of counties reporting data in every year.

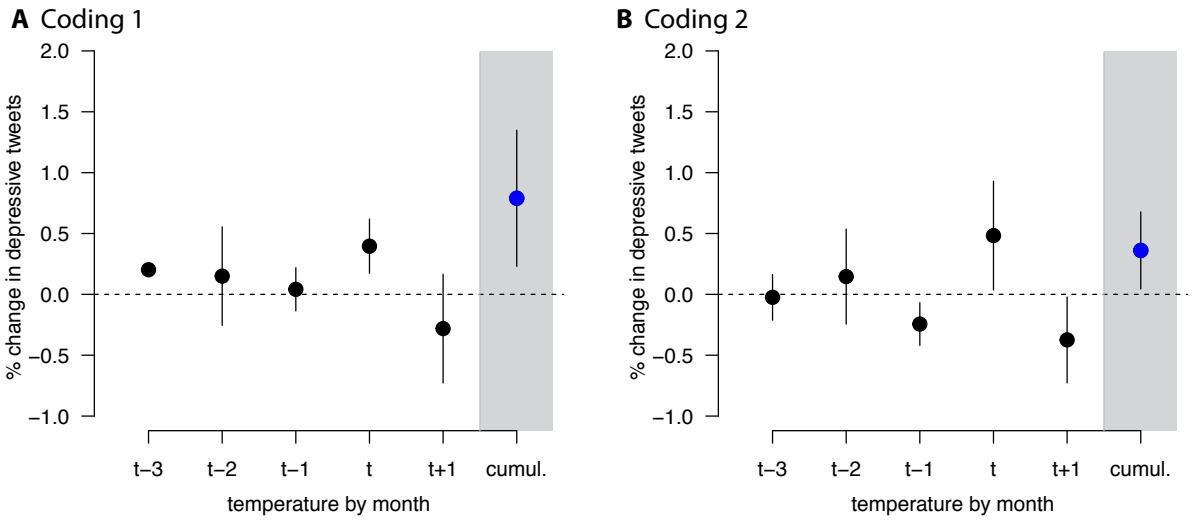

Figure S4: **Effect of temperature in earlier and later months on depressive tweets in the current month.** Black markers are changes in the rate of depressive tweets in month t as a function of a 1°C increase in previous, current, and future months, for both codings of depressive tweets. Blue markers show the cumulative effect ($\sum_{t-3}^{t} \beta_t$) of current and previous-month temperature exposure. See Methods for full description.

Table S1: **Estimates of the linear effect of temperature on suicide rate in the US are robust to different statistical specifications.** All models include county-month fixed effects (i.e. 12 dummy variables for each county) as indicated in the FE1 row, and include time fixed effects as indicated in the FE2 row, with 'S'=state, 'Yr'=year, 'Mo'=month. Some models also contain linear time trends, and are weighted by county population, as indicated in the bottom rows. The outcome variable is the monthly suicide rate (models 1-5; mean = 1.03 suicides per 100,000 people), the log of the monthly suicide rate (model 6), or the inverse hyperbolic sine-transformed monthly suicide rate (model 7). Temperature is measured in °C , precip in meters. Standard errors are shown in parenthesis, clustered at the county level. Models 1-5 are analogous to lines 1-5 shown in Figure 1A.

	Dependent variable:						
	suicide rate					log(rate)	ihs(rate)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
temp. (°C)	0.007***	0.008***	0.006***	0.006***	0.005***	0.005***	0.004***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.0005)
prec. (m)	−0.035	0.014	−0.059**	−0.038	−0.048	−0.011	−0.016
	(0.024)	(0.073)	(0.029)	(0.024)	(0.032)	(0.032)	(0.016)
FE1	C x Mo	C x Mo	C x Mo	C x Mo	C x Mo	C x Mo	C x Mo
FE2	S x Yr	S x Yr	Yr	Yr	Yr x Mo	S x Yr	S x Yr
Time trends	N	N	N	Y	N	N	N
Pop. weights	Y	N	Y	Y	Y	Y	Y
Observations	851,088	851,088	851,088	851,088	851,088	280,486	851,088
R^2	0.175	0.128	0.166	0.172	0.167	0.512	0.232

Note: *p<0.1; **p<0.05; ***p<0.01

Table S2: **Estimates of the linear effect of temperature on suicide rate in Mexico are robust to different statistical specifications.** All models include Municipality fixed effects as indicated in the FE1 row, state-month fixed effects (i.e. 12 dummies for each state) as indicated in the FE2 row, and include time fixed effects as indicated in the FE3 row, with 'S'=state, 'Yr'=year, 'Mo'=month. Some models also contain linear time trends, and are weighted by municipality population, as indicated in the bottom rows. The outcome variable is the monthly suicide rate (models 1-5; mean = 0.22 suicides per 100,000 people), the log of the monthly suicide rate (model 6), or the inverse hyperbolic sine-transformed monthly suicide rate (model 7). Temperature is measured in °C , precip in meters. Standard errors are shown in parenthesis, clustered at the county level. Models 1-5 are analogous to lines 1-5 shown in Figure 1B.

	Dependent variable:						
	suicide rate					log(rate)	ihs(rate)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
temp. (C)	0.006^{***}	0.007^{**}	0.005^{***}	0.005^{***}	0.005^{**}	0.008^{*}	0.005^{***}
	(0.001)	(0.003)	(0.002)	(0.002)	(0.002)	(0.004)	(0.001)
prec. (m)	0.011	0.009	−0.015	−0.010	−0.025	0.076	0.007
	(0.020)	(0.046)	(0.027)	(0.027)	(0.028)	(0.055)	(0.013)
FE1	Mun.	Mun.	Mun.	Mun.	Mun.	Mun.	Mun.
FE2	S x Mo	S x Mo	S x Mo	S x Mo	S x Mo	S x Mo	S x Mo
FE3	S x Yr	S x Yr	Yr	Yr	Yr x Mo	S x Yr	S x Yr
Time trends	N	N	N	Y	N	N	N
Pop. weights	Y	N	Y	Y	Y	Y	Y
Observations	611,366	611,366	611,366	611,366	611,366	40,701	611,366
R^2	0.168	0.018	0.164	0.166	0.164	0.736	0.298

Note: *p<0.1; **p<0.05; ***p<0.01

Table S3: **Estimates of the linear effect of temperature on suicide rate are robust to different ways of clustering the standard errors.** Top panel is United States, bottom panel is Mexico. Columns show estimates under different clustering schemes: (1) county, (2) county + state-by-year, (3) county + year, (4) state.

	United States:			
	(1)	(2)	(3)	(4)
temp. (C)	0.0067^{***}	0.0067^{***}	0.0067^{***}	0.0067^{***}
	(0.0008)	(0.0008)	(0.0011)	(0.0007)
prec. (m)	-0.0347	-0.0347	-0.0347	-0.0347
	(0.0242)	(0.0238)	(0.0236)	(0.0300)
Clustering	County	County + State-Yr	County + Yr	State
Observations	851,088	851,088	851,088	851,088
R^2	0.1754	0.1754	0.1754	0.1754

	Mexico:			
	(1)	(2)	(3)	(4)
temp. (C)	0.0063^{***}	0.0063^{***}	0.0063^{***}	0.0063^{***}
	(0.0014)	(0.0015)	(0.0014)	(0.0017)
prec. (m)	0.0108	0.0108	0.0108	0.0108
	(0.0203)	(0.0137)	(0.0172)	(0.0144)
Clustering	Mun.	Mun. + State-Yr	Mun. + Yr	State
Observations	611,366	611,366	611,366	611,366
R^2	0.1684	0.1684	0.1684	0.1684

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table S4: **Heterogeneous effect of temperature on suicide rate in the US**. Covariates include county income in each year (in $1000 USD), county average temperature averaged across all years (in °C), and state-level AC penetration in each year (defined as percent of households with residential AC, derived from Barreca et al[30]). Covariates are all de-meaned to ease interpretation. All regressions include county-month FE and state-year FE and are weighted by county population.

	Dependent variable:			
	suicide rate			
	(1)	(2)	(3)	(4)
temp	0.0068^{***}	0.0065^{***}	0.0067^{***}	0.0065^{***}
	(0.0008)	(0.0008)	(0.0008)	(0.0008)
temp*income	0.0001^{***}			-0.000003
	(0.00003)			(0.00004)
temp*avgtemp		-0.0001		-0.0002
		(0.0002)		(0.0002)
temp*AC			0.0037^{***}	0.0037^{*}
			(0.0012)	(0.0020)
Observations	806,448	806,448	806,448	806,448
R^2	0.1756	0.1755	0.1755	0.1756
Note:				*p<0.1; **p<0.05; ***p<0.01