Supporting Information for

Air Pollution and Suicide in Rural and Urban America: Evidence from Wildfire Smoke

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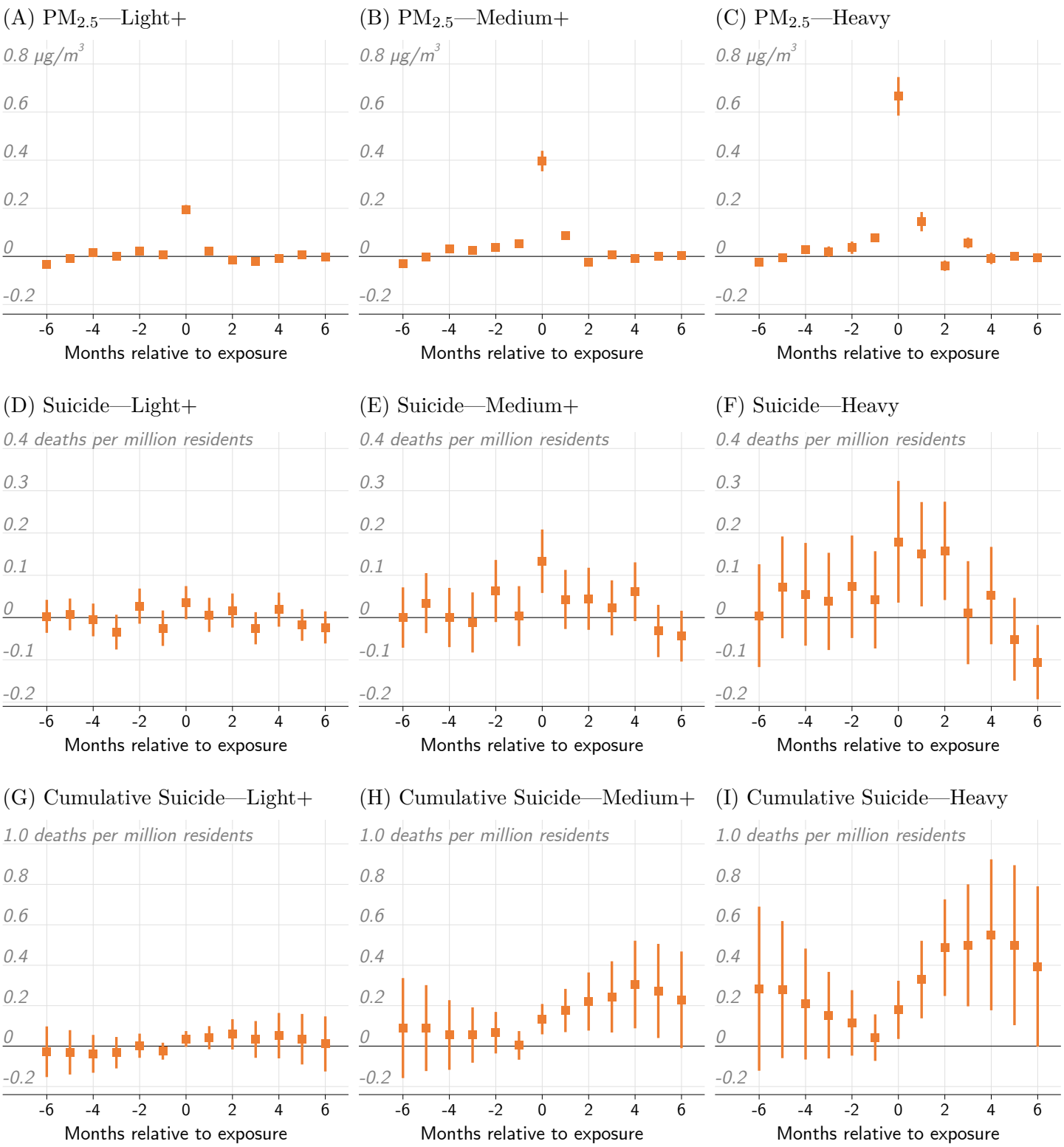
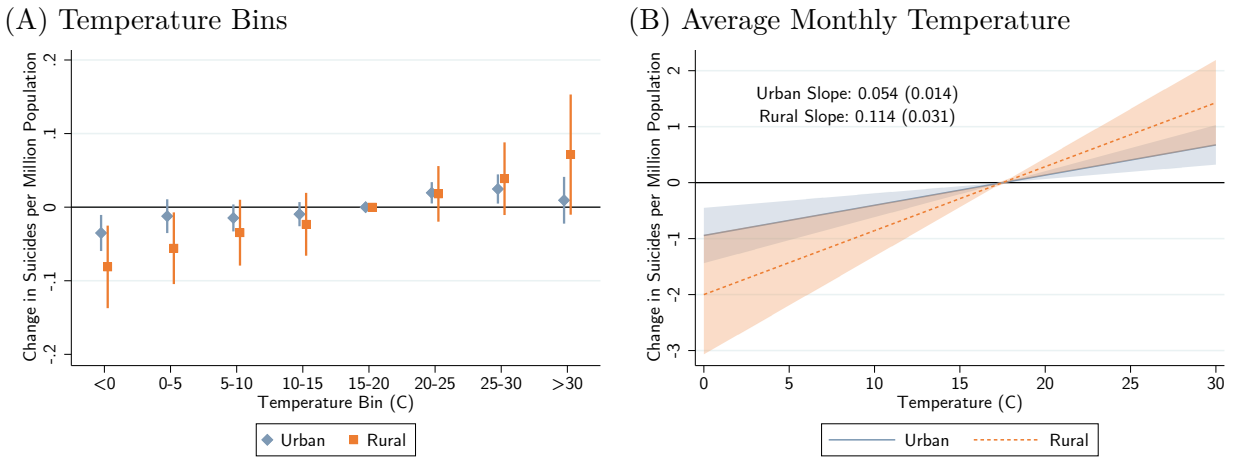
Figure S1



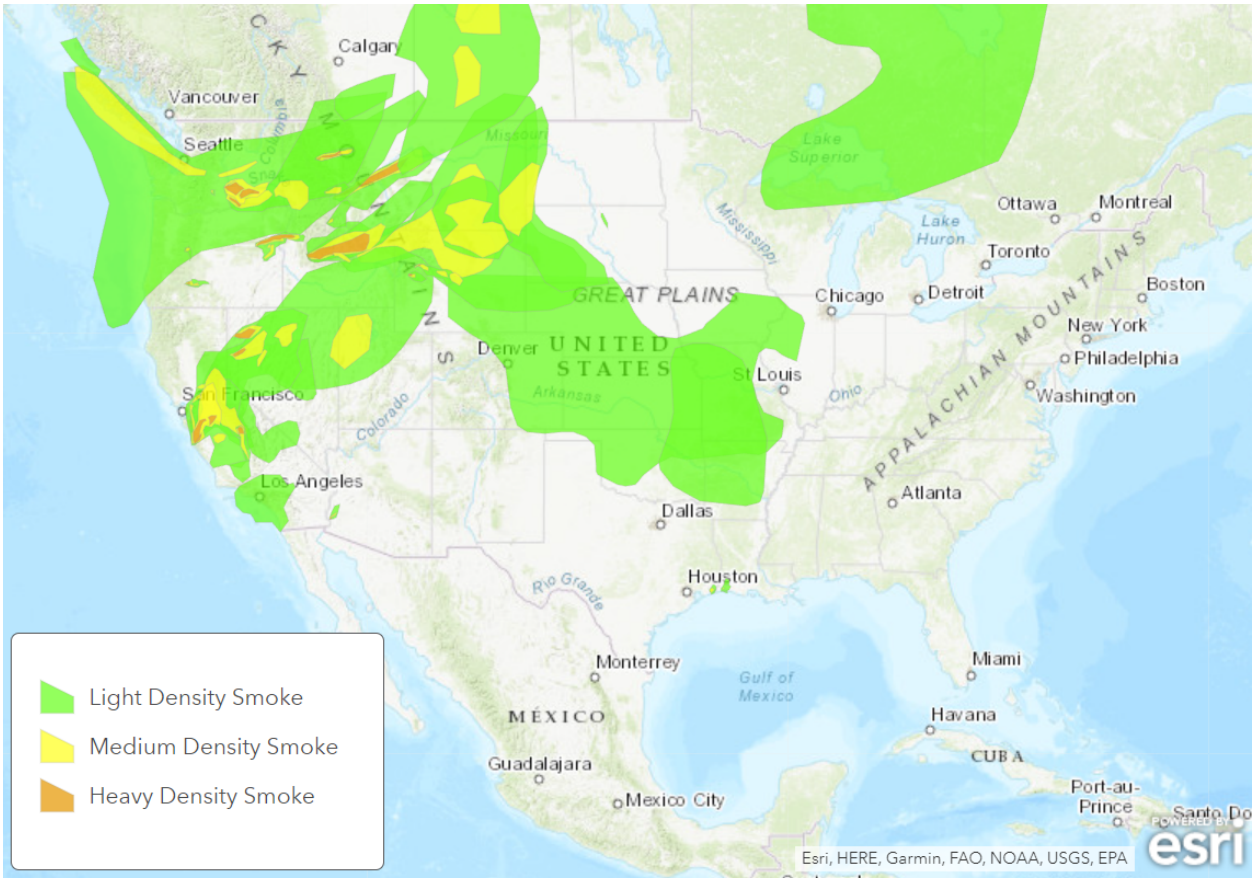
Dynamic effects of smoke exposure on $PM_{2.5}$ concentrations and suicide rates. Markers and lines indicate the point and 95% confidence interval estimates of the indicated relationships respectively. Each column relies on a different definition of a smoke day. The middle column (panels B, E, and H) considers smoke days as those with medium or thicker smoke, consistent with the primary definition used throughout our analyses. All estimates include smoke day counts for each of the six months preceding and following the month of the considered outcomes in addition to the number of smoke days in the contemporaneous month, which is labeled as month zero in each figure. Cumulative graphs in panels G, H, and I report estimates of summed coefficients from panels D, E, and F, respectively. For the post-exposure period, sums begin at $t = 0$ and work forward. For the pre-exposure period, sums begin at $t = -1$ and work backward.

Figure S2



Effects of ambient temperature on monthly suicide rates. (A) The effect of temperature (binned) on monthly suicide rates, separately for urban and rural counties. Estimates are derived from a version of Eq. (1) that includes a series of seven indicators for the number of days within 5°C temperature bins representing the mean daily temperature (15–20°C omitted as the reference bin). Mean daily temperature is the mean of the daily maximum and minimum. Each estimate represents the marginal effect of an additional day in a given temperature bin on suicide rates, relative to a day in the reference bin. The number of medium or thicker smoke days is included in the model as a control. (B) The effect of temperature (linear) on monthly suicide rates, separately for urban and rural counties. Estimates are derived from a version of Eq. (1) that includes the monthly average of mean daily temperatures. The plot shows the estimated difference in the monthly suicide rate between a month with a given average temperature and a month with an average temperature of 17.5°C. The number of medium or thicker smoke days is included in the model as a control.

Figure S3



Example smoke density map. Figure depicts smoke plume densities for a single day (July 31, 2016) for illustrative purposes. The data is provided by the NOAA Office of Satellite and Product Operations as part of the Hazard Mapping System Fire and Smoke Product, available: https://www.ospo.noaa.gov/Products/land/hms.html#data, accessed November 11, 2022.

Table S1*A*: First Stage, Reduced Form, and IV Estimates: Satellite-Based $PM_{2.5}$ Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Independent	First Stage			Reduced Form			IV (Light+)	IV (Med+)	IV (Heavy)
	var. mean	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	Suicide Rate	Suicide Rate	Suicide Rate	Suicide Rate	Suicide Rate	Suicide Rate
A. All Counties										
Light+ smoke	2.28	0.19***			0.011					
		(0.0050)			(0.0076)					
Medium+ smoke	0.58		0.36***			0.031*				
			(0.012)			(0.016)				
Heavy smoke	0.17			0.54***			0.015			
				(0.028)			(0.029)			
$PM_{2.5}$ (satellite)	8.31							0.059	0.086**	0.029
								(0.040)	(0.044)	(0.053)
First-stage F stat.								1,386	918	360
Dep. var. mean		8.3	8.3	8.3	11.0	11.0	11.0	11.0	11.0	11.0
Observations		484,848	484,848	484,848	484,848	484,848	484,848	484,848	484,848	484,848
B. Urban Counties										
Light+ smoke	2.16	0.18***			0.0010					
		(0.0060)			(0.0084)					
Medium+ smoke	0.55		0.33***			–0.0023				
			(0.013)			(0.017)				
Heavy smoke	0.16			0.47***			–0.037			
				(0.031)			(0.031)			
$PM_{2.5}$ (satellite)	8.49							0.0057	–0.0070	–0.078
								(0.046)	(0.052)	(0.068)
First-stage F stat.								904	671	235
Dep. var. mean		8.5	8.5	8.5	10.1	10.1	10.1	10.1	10.1	10.1
Observations		125,580	125,580	125,580	125,580	125,580	125,580	125,580	125,580	125,580
C. Rural Counties										
Light+ smoke	2.68	0.21***			0.039**					
		(0.0090)			(0.017)					
Medium+ smoke	0.69		0.41***			0.11***				
			(0.022)			(0.030)				
Heavy smoke	0.20			0.69***			0.14**			
				(0.041)			(0.053)			
$PM_{2.5}$ (satellite)	7.75							0.19**	0.27***	0.20**
								(0.083)	(0.076)	(0.078)
First-stage F stat.								522	342	278
Dep. var. mean		7.8	7.8	7.8	13.7	13.7	13.7	13.7	13.7	13.7
Observations		359,268	359,268	359,268	359,268	359,268	359,268	359,268	359,268	359,268

Notes: Analyses use the van Donkelaar satellite-based $PM_{2.5}$ sample. The three IV specifications use Light+, Medium+ and Heavy smoke, respectively, as instruments for $PM_{2.5}$. IV first-stage F statistics are the Kleibergen-Paap cluster-robust variant [38]. A */**/*** indicates significance at the 10/5/1% level.

Table S1*B*: First Stage, Reduced Form, and IV Estimates: EPA Monitor-Based $PM_{2.5}$ Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Independent	First Stage			Reduced Form			IV (Light+)	IV (Med+)	IV (Heavy)
	var. mean	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	Suicide Rate	Suicide Rate	Suicide Rate	Suicide Rate	Suicide Rate	Suicide Rate
A. All Counties										
Light+ smoke	2.20	0.22***			0.011					
		(0.0081)			(0.0082)					
Medium+ smoke	0.57		0.43***			0.023				
			(0.018)			(0.017)				
Heavy smoke	0.17			0.63***			0.0021			
				(0.042)			(0.030)			
$PM_{2.5}$ (monitor)	9.49							0.051	0.054	0.0033
								(0.036)	(0.039)	(0.049)
First-stage F stat.								759	559	222
Dep. var. mean		9.5	9.5	9.5	10.6	10.6	10.6	10.6	10.6	10.6
Observations		225,814	225,814	225,814	225,814	225,814	225,814	225,814	225,814	225,814
B. Urban Counties										
Light+ smoke	2.13	0.21***			–0.00040					
		(0.0092)			(0.0086)					
Medium+ smoke	0.54		0.39***			–0.0019				
			(0.019)			(0.018)				
Heavy smoke	0.16			0.55***			–0.031			
				(0.043)			(0.033)			
$PM_{2.5}$ (monitor)	9.62							–0.0019	–0.0049	–0.057
								(0.040)	(0.045)	(0.060)
First-stage F stat.								537	426	162
Dep. var. mean		9.6	9.6	9.6	10.0	10.0	10.0	10.0	10.0	10.0
Observations		102,451	102,451	102,451	102,451	102,451	102,451	102,451	102,451	102,451
C. Rural Counties										
Light+ smoke	2.60	0.28***			0.074***					
		(0.016)			(0.023)					
Medium+ smoke	0.70		0.55***			0.13***				
			(0.035)			(0.037)				
Heavy smoke	0.22			0.89***			0.13**			
				(0.067)			(0.064)			
$PM_{2.5}$ (monitor)	8.83							0.26***	0.24***	0.15**
								(0.082)	(0.067)	(0.069)
First-stage F stat.								312	257	178
Dep. var. mean		8.8	8.8	8.8	13.5	13.5	13.5	13.5	13.5	13.5
Observations		123,363	123,363	123,363	123,363	123,363	123,363	123,363	123,363	123,363

Notes: Analyses use the EPA monitor-based $PM_{2.5}$ sample. The three IV specifications use Light+, Medium+ and Heavy smoke, respectively, as instruments for $PM_{2.5}$. IV first-stage F statistics are the Kleibergen-Paap cluster-robust variant [38]. A */**/*** indicates significance at the 10/5/1% level.

Table S2: Alternative Specifications

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Suicide								Age-Adj. Suicide	MHRM
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	Poisson	OLS	OLS
A. All Counties										
Smoke days	0.024**	0.026**	0.023	0.031*	0.025	0.050**	0.038**	0.026*	0.033**	0.039*
	(0.011)	(0.013)	(0.015)	(0.016)	(0.016)	(0.023)	(0.018)	(0.014)	(0.016)	(0.022)
Mean death rate	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.1	11.0	24.1
Observations	484,848	484,848	484,848	484,848	484,068	484,068	484,068	484,848	484,848	484,848
B. Urban Counties										
Smoke days	–0.0045	–0.0012	–0.0094	–0.0023	–0.0056	–0.0015	0.00012	–0.0021	–0.0026	0.016
	(0.012)	(0.015)	(0.017)	(0.017)	(0.018)	(0.023)	(0.021)	(0.016)	(0.018)	(0.027)
Mean death rate	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.1	23.2
Observations	125,580	125,580	125,580	125,580	124,956	124,956	124,956	125,580	125,580	125,580
C. Rural Counties										
Smoke days	0.058**	0.084***	0.10***	0.11***	0.099***	0.18***	0.12***	0.10***	0.12***	0.097**
	(0.023)	(0.028)	(0.030)	(0.030)	(0.031)	(0.050)	(0.039)	(0.027)	(0.032)	(0.042)
Mean death rate	13.7	13.7	13.7	13.7	13.7	13.7	13.7	14.5	13.7	26.6
Observations	359,268	359,268	359,268	359,268	359,112	359,112	359,112	359,268	359,268	359,268
D. Specification Controls										
County	X	–	–	–	–	–	–	–	–	–
Year-Month	X	X	X	X	X	–	–	X	X	X
County-Month	–	X	X	X	X	X	X	X	X	X
State-Year	–	–	X	–	–	–	–	–	–	–
County-Year	–	–	–	X	X	–	X	X	X	X
State-Year-Month	–	–	–	–	–	X	–	–	–	–
Division-Year-Month	–	–	–	–	–	–	X	–	–	–
Weather	–	–	–	–	X	X	X	–	–	–

Notes: The coefficients for each column come from separate regressions. The outcomes for columns (1)–(8) are all-age monthly suicide deaths. The outcome for column (9) is the age-adjusted suicide rate, calculated as the weighted sum of suicide rates for every 5-year age group from age 5 through 85+, where the weights are the 2007 national population shares for each age group. The outcome for column (10) is a broader Mental Health-Related Mortality (MHRM) measure that in addition to suicide includes deaths from injuries of undetermined intent and certain accidents. For OLS regressions, deaths are measured as a rate per million residents. The Poisson specification uses the count of deaths by suicide as the outcome and the county's total population as the exposure variable. For comparison with the OLS estimates, Poisson estimates β are reported as the implied change in the suicide rate, calculated as $(\exp(\beta) - 1) \times$ [mean death rate]. Weather controls include indicators for mean daily temperature bins in increments of 3°C from < 0°C to > 33°C and indicators for quartiles of precipitation. A */**/*** indicates significance at the 10/5/1% level.

Table S3: Effect of one additional day of smoke on monthly suicide rates, by urban-rural category

	(1)	(2)	(3)	(4)	(5)	(6)
	Large central metropolitan	Large fringe metropolitan	Medium metropolitan	Small metropolitan	Micropolitan	Non-core
Smoke days	–0.016	–0.023	0.015	0.13***	0.13**	0.054
	(0.028)	(0.036)	(0.027)	(0.039)	(0.055)	(0.073)
Dep. var.	Suicide rate	Suicide rate	Suicide rate	Suicide rate	Suicide rate	Suicide rate
Dep. var. mean	9.0	10.0	11.9	13.0	13.7	14.7
Observations	10,608	57,408	57,564	55,380	99,372	204,516
Classification	Urban	Urban	Urban	Rural	Rural	Rural
Num. counties	68	368	369	355	637	1,311
Mean county pop.	1,337,296	200,635	166,224	77,935	41,679	14,426

Notes: Each column presents results from estimating the baseline regression on mutually exclusive and collectively exhaustive subsets of counties according to the six-level 2013 NCHS Urban-Rural Classification Scheme. Columns are ordered from the most urban category (large central metropolitan) to the most rural category (non-core). The last three rows of the table provide summary statistics for each category, including whether the group was classified as urban or rural for the primary analysis. A */**/*** indicates significance at the 10/5/1% level.

Table S4: Effect of one additional day of smoke on monthly suicide rates, by population subgroup

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Baseline	Sex		Age			Race		Education	
	Full Population	Male	Female	Age 0–24	Age 25–64	Age 65+	White/NH	NW/Hispanic	HS or less	College
A. All Counties										
Smoke days	0.031*	0.038	0.022	0.023	0.056**	–0.022	0.014	0.031	0.059	0.020
	(0.016)	(0.027)	(0.014)	(0.015)	(0.024)	(0.047)	(0.024)	(0.026)	(0.040)	(0.020)
Dep. var. mean	11.0	17.4	4.7	4.4	14.6	13.2	14.3	5.6	14.4	8.5
Observations	484,848	484,848	484,848	484,848	484,848	484,848	484,848	484,848	484,536	484,536
B. Urban Counties										
Smoke days	–0.0023	–0.022	0.016	0.0057	0.0068	–0.063	–0.033	0.024	0.0029	–0.0079
	(0.017)	(0.030)	(0.016)	(0.015)	(0.026)	(0.055)	(0.028)	(0.024)	(0.047)	(0.021)
Dep. var. mean	10.1	15.9	4.5	4.0	13.4	12.4	13.7	5.2	13.5	8.3
Observations	125,580	125,580	125,580	125,580	125,580	125,580	125,580	125,580	125,424	125,424
C. Rural Counties										
Smoke days	0.11***	0.19***	0.036	0.050	0.19***	0.078	0.14***	0.045	0.20***	0.081*
	(0.030)	(0.055)	(0.028)	(0.037)	(0.050)	(0.092)	(0.041)	(0.069)	(0.069)	(0.045)
Dep. var. mean	13.7	22.1	5.4	5.6	18.3	15.6	15.9	6.9	17.2	9.3
Observations	359,268	359,268	359,268	359,268	359,268	359,268	359,268	359,268	359,112	359,112

Notes: Coefficients for each population subgroup and county type are taken from separate regressions based on population subgroup-specific suicide rates per million residents in the indicated sample of counties. "White/NH" refers to individuals who are White and non-Hispanic, and "NW/Hispanic" is the converse (non-White or Hispanic). "HS or less" refers to individuals with a high school diploma or less, and "College" refers to individuals with some college credits or more. The education subgroups are based on the 25 and older population which has had the chance to complete their education. A */**/*** indicates significance at the 10/5/1% level.