

SUPPLEMENTARY MATERIALS

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SUPPLEMENTARY TEXT

Methods

Main Specification

Our main specification was a multilevel dynamic panel regression model with fixed effects for county (Stata command "xtpmg, dfe"(28-30)):

(1)

$$y_{i,t} = \sum_{k=1}^3 \alpha_k y_{i,t-k} + \beta Tax_{s,t-1} + \delta X_{i,t-1} + \mu_i + \varepsilon_{it}$$

Where y_{it} is estimated life expectancy at birth of county i within state s during year t , Tax_{st} is the cigarette tax rate in 2016 dollars of state s in year t , and $X_{i,t}$ is a vector of time-varying county-year covariates on population demographics, educational attainment, and income as specified in the main text. We clustered standard errors at the state-level using the non-parametric, cluster-robust “sandwich” estimator (Stata option “vce(cluster)”) to account for serial correlation in life expectancy over time within counties, intra-cluster correlation in life expectancy across counties within states, and loss of degrees-of-freedom from imputation of covariates(34).

In additional analyses, we replaced $y_{i,t}$ in Equation 1 with county annual smoking prevalence, to assess whether the observed association between cigarette taxes and life expectancy was plausibly related to changes in smoking prevalence.

Derivation of error correction model through decomposition of Equation 1

Equation 1, which describes an autoregressive distributive lag model(29), can be rewritten as an error correction model (as in reference 29) that separates the short-term and long-term dynamics of changes in tax rates and life expectancy. All coefficients (e.g. cointegrating coefficients, error

correction terms, and first differences of time-varying covariates) reported in the manuscript, tables, and figures correspond to the following error correction model:

(2)

$$\Delta y_{i,s,t} = \phi_{i,s}(y_{i,t-1} - \theta'_{i,s} X_{i,s,t}) + \sum_{j=1}^{p-1} \alpha^*_{ij} \Delta y_{i,t-j} + \sum_{j=1}^{q-1} \beta_{ij} \Delta Tax_{s,t-j} + \sum_{j=1}^{q-1} \delta^{*'}_{ij} \Delta X_{i,t-j} + \mu_i + \varepsilon_{it}$$

where:

(3)

$$\phi_{is} = - \left(1 - \sum_{j=1}^p \alpha_{isj} \right), \theta_i = \frac{\sum_{j=1}^p \delta_{isj} + \sum_{j=1}^{q-1} \beta_{ij}}{1 - \sum_k \alpha_{isk}}, \alpha^*_{isj} = - \sum_{m=j+1}^p \alpha_{ism}$$

(4)

$$\text{for } j = 1, 2, \dots, p-1$$

and

(5)

$$\delta^*_{i,s,j} = - \sum_{m=j+1}^p \delta_{i,s,m} \quad \text{for } j = 1, 2, \dots, p-1$$

We chose a reduced-form error-correction specification (all explanatory variables are lagged) that estimates the net association of cigarette taxes and life-expectancy after accounting for the effect of contemporaneous structural relationships(31-33). We selected the optimal lag order for life expectancy based on the mean of the distribution of optimal lags for each county (Stata command “ardl, aic”).

After rewriting the model, of particular interest is ϕ_{is} , the error-correction speed. If $\phi_{is} = 0$, then there is no long-term relationship between the state level taxes and life expectancy. Furthermore, as shown in Equation (2), the expected sign of the error term is negative, since $\sum_{j=1}^p \alpha_{isj} < 1$. Finally, θ'_{is} is the vector of long-run relationships between the independent variables and life expectancy. We used the fixed effect version of this model, in which the slope coefficients are assumed to be the same for all counties/states, while the intercepts are allowed to differ. This version of the model also assumes that the speed of adjustment coefficient and the short-run coefficients to be equal among units of observation. Blackbourne and Frank (29) and Baltagi, Griffin, and Xiong (30) show that there is risk of bias from the endogeneity between the error term and the lagged dependent variable. We ran Hausman tests between the fixed effects model and the mean group estimator, which allows all the parameters to vary among units (states/counties), and showed that the simultaneous equation bias is minimal, which justifies our use of the fixed effects model in contrast with the mean group (MG) and pooled mean group (PMG) that are also proposed by Blackbourne and Frank (29).

Testing of Model Assumptions

Further testing and sensitivity analyses were performed to avoid spurious associations between life expectancy (or, in mediator analysis, smoking prevalence) and cigarette taxes, given they are non-stationary variables(13, 14). We confirmed there is a cointegrating relationship that ties the stochastic trends of life expectancy (or smoking prevalence) and cigarette taxes together – such that they cannot wander away from each other for an extended period of time – using a Johansen co-integration test of whether there is a linear combination of life expectancy (or smoking prevalence) and cigarette taxes that is stationary. The Johansen procedure uses a likelihood-based approach to determine the maximum possible number of cointegrating relationships in the data. (Stata command “vecrank”(35, 40)). The panel co-integration test developed by

Westerlund(36, 41), which tests whether there is a statistically significant adjustment from disequilibrium back to the hypothesized long-run equilibrium, was used to check the results. We additionally checked whether the model's residuals were normal and stationary, to ensure assumptions for a cointegrating regression model coefficient interpretation were fulfilled.

Secondary Analyses

In additional analyses, we replaced the dependent variable (life expectancy) with county annual smoking prevalence, to assess whether the observed association between cigarette taxes and life expectancy was plausibly related to changes in smoking prevalence. To further assess the plausibility that the associations we observed reflected causal relationships, we examined the relationship between smoking prevalence and life expectancy and between cigarette taxes and county mortality rates by cause of death.

Sensitivity Analyses

We first examined whether the selection of lag order qualitatively influenced our results. Second, we fit a generalized method of moments dynamic panel estimator developed by Blundell and Bond(37), which relaxes the assumption of strongly exogenous covariates and was designed for small-T, large-N datasets. Third, we restricted analysis to the 43 out of 51 (counting the District of Columbia) states where there is no local government taxation of tobacco(38). Fourth, we included state-year workplace, bar and restaurant smoking restrictions from The National Adult Tobacco Survey(39) as time-varying covariates in the main analysis. Fifth, we repeated the analysis using annual life expectancy estimates for the 100 most populated U.S. community zones derived from official death records. Sixth, we conducted a falsification test of the association between future, not-yet-announced cigarette taxes (5 years in the future) and current life expectancy and current smoking prevalence.

Supplementary Tables and Figures

Table S1. Co-integration Tests

Panel A. Unit root tests to ensure aggregate variables are stationary at the same level (stata command “dfuller”)

<i>Levels</i>	<u>Overall</u> <i>Evaluate average across all counties</i> P-Value	<u>By County</u> <i>Evaluate each county separately</i> % of P-Values < 0.05
Life Expectancy	0.833	0% (mean 0.629)
Smoking Prevalence	0.967	0% (mean 0.999)
Cigarette Taxes	0.715	3% (mean 0.665)
<i>Differences</i>		
Life Expectancy	0.045	97% (mean 0.006)
Smoking Prevalence	0.044	100% (mean 0.044)
Cigarette Taxes	0.004	86% (mean 0.017)

Notes: H0: Series has a unit-root; H1: Series is stationary.

Panel B. Determining the number of cointegrating equations between dependent variables and cigarette taxes averaged by year, using the Johansen Test

B1. Dependent Variable Averaged by Year

Rank	Trace Statistic	5% critical value	1% critical value
<i>Life Expectancy</i>			
Rank = 0	26.06***	15.41	20.04
Rank = 1	0.22	3.76	6.65
<i>Smoking Prevalence</i>			
Rank = 0	20.74***	15.41	20.04
Rank = 1	3.49	3.76	6.65

B2. Dependent Variable Averaged by State-Year

	% states with maximum rank = 1 by 5% critical value
<i>Life Expectancy</i>	79.59%
<i>Smoking Prevalence</i>	68.29%

B3. Dependent Variable at County-Year Level

Westerlund panel cointegration tests (with leads)						
	<u>Life Expectancy</u>			<u>Smoking Prevalence</u>		
	Value	Z-Value	P-Value	Value	Z-Value	P-Value
Pt	-19.824	-9.541	< 0.001	-15.992	5.789	< 0.001
Pa	-9.310	-8.171	< 0.001	-6.529	3.662	< 0.001

Notes: H0: $a_i = 0$ for all i (no cointegrating relationship at all); H1: $a_i < 0$ for all i , where a_i is an estimate of the speed of error-correction towards the long run equilibrium. The Pa and Pt test statistics pool information over all the cross-sectional units to test H0: $a_i = 0$ for all i vs H1: $a_i < 0$ for all i . Rejection of H0 should therefore be taken as evidence of cointegration for the panel as a whole.

Panel C. Testing for stationarity of residuals of regression of dependent variables on cigarette tax

Harris-Tzavalis unit-root test for fixed T panels				
	<u>Life Expectancy</u>		<u>Smoking Prevalence</u>	
	Statistic	P-Value	Statistic	P-Value
rho	0.791	<0.001	0.827	0.0289

Notes: H0: All panels contain unit roots ($\rho_i = \rho$ for all i); H1: Some panels are stationary ($\rho < 1$)

Table S2. Formulating the Error-correction-model in Logs**Panel A.** Elasticity of Life Expectancy to \$1 Changes in Cigarette Tax

	Log Life Expectancy	Log Smoking Prevalence
Log Cigarette Tax (Long Run) (\$/pack)	0.01*** (0.00)	-0.10*** (0.01)
Speed of adjustment	-0.08*** (0.01)	-0.16*** (0.02)
Lag 1 of Log Life Expectancy (years)	-0.16*** (0.02)	0.03 (0.02)
Lag 2 of Log Life Expectancy (years)	0.03*** (0.01)	0.13*** (0.02)
Lag 3 of Log Life Expectancy (years)	-0.01 (0.01)	0.08*** (0.02)
Δ Log Cigarette tax _t (Short run) (\$/pack)	-0.00 (0.00)	0.01*** (0.00)
Share female (%)	0.01 (0.01)	0.06 (0.09)
Share under 18 (%)	0.00 (0.00)	-0.14** (0.06)
Share over 65 (%)	0.00* (0.00)	-0.11** (0.04)
Share black (%)	-0.03*** (0.01)	0.22** (0.11)
Share Hispanic (%)	-0.00*** (0.00)	-0.51 (0.47)
Share completing high school (%)	0.01** (0.00)	2.62** (1.17)
Income per capita (\$)	0.00*** (0.00)	0.00 (0.00)
Constant	0.34*** (0.04)	0.49*** (0.06)

Cluster-robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: Changes in the natural log of life expectancy (and smoking prevalence) from the main regression analysis with adjustment for the natural log of state-year cigarette taxes, county-year income per capita, share female, share Black, share over 65, share under 18, and share with high school, and fixed effects for county. 95% confidence intervals reflect Huber-White robust standard errors clustered at the state level. Positive values represent increases in life expectancy. Cigarette tax dollars are inflation-adjusted to 2016 year dollars. Speed of adjustment to the long-

term equilibrium, or the error correction speed, is a direct estimate of the speed at which county life expectancy returns to equilibrium after any disturbance from long-run cointegrating relationship.

Panel B. Testing for stationarity of log model residuals (Harris-Tzavalis unit-root test for fixed T panels, 1999)

		<u>Life Expectancy</u>		<u>Smoking Prevalence</u>	
		Statistic	P-Value	Statistic	P-Value
rho	P	-0.1419	<0.001	0.6907	<0.001

Notes: H0: All panels contain unit roots ($\rho_i = \rho$ for all i); H1: Some panels are stationary ($\rho < 1$)

Table S3. Association of Cigarette Tax and County-level Life Expectancy by Income Quintile*Panel A.* Association of Cigarette Tax and County-level Life Expectancy by Income Quintile

	Life Expectancy (years)				
	Income Q1	Income Q2	Income Q3	Income Q4	Income Q5
Cigarette Tax (Long Run) (\$/pack)	1.44*** (0.35)	1.27*** (0.18)	1.09*** (0.18)	0.79*** (0.27)	0.55** (0.28)
Speed of adjustment	-0.10*** (0.02)	-0.11*** (0.01)	-0.09*** (0.01)	-0.07*** (0.01)	-0.05*** (0.01)
Lag 1 of Life Expectancy (years)	-0.14*** (0.02)	-0.15*** (0.02)	-0.15*** (0.03)	-0.13*** (0.02)	-0.13*** (0.03)
Lag 2 of Life Expectancy (years)	0.04*** (0.01)	0.05*** (0.02)	0.03 (0.02)	0.04*** (0.02)	0.07*** (0.02)
Lag 3 of Life Expectancy (years)	-0.03*** (0.01)	-0.00 (0.02)	0.01 (0.02)	0.03* (0.02)	0.02 (0.02)
Δ Cigarette tax _t (Short run) (\$/pack)	-0.01 (0.05)	-0.03 (0.04)	-0.03 (0.03)	-0.01 (0.02)	-0.00 (0.03)
Share female (%)	0.44 (1.52)	2.96*** (1.06)	0.26 (0.72)	-1.54 (1.07)	-0.49 (0.59)
Share under 18 (%)	0.39 (0.63)	0.00 (0.44)	0.27 (0.27)	0.04 (0.30)	-0.59** (0.24)
Share over 65 (%)	1.16** (0.46)	0.50 (0.43)	0.32 (0.39)	0.24 (0.17)	-0.12 (0.19)
Share black (%)	-2.73** (1.29)	-2.12*** (0.80)	-2.40* (1.42)	-2.95 (2.09)	-1.40 (1.49)
Share Hispanic (%)	10.87** (4.46)	21.23*** (5.19)	-0.09*** (0.01)	-0.11*** (0.01)	-0.16*** (0.02)
Share completing high school (%)	26.44*** (2.70)	0.00 (0.00)	0.35*** (0.09)	-0.05 (0.16)	0.61*** (0.17)
Income per capita (\$)	0.00*** (0.00)	0.00** (0.00)	0.00* (0.00)	0.00* (0.00)	0.00*** (0.00)
Constant	6.79*** (1.28)	8.38*** (1.06)	7.10*** (0.84)	5.91*** (0.78)	4.07*** (0.54)
Observations	11913	11932	11951	11932	11932

Cluster-robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: Changes in life expectancy from the main regression analysis with adjustment for county-year income per capita, share female, share Black, share over 65, share under 18, and share with high school, and fixed effects for county. Huber-White robust standard errors clustered at the state level. Positive values represent increases in life expectancy. Cigarette tax dollars are inflation-adjusted to 2016 year dollars. Speed of adjustment to the long-term equilibrium, or the error correction speed, is a direct estimate of the speed at which county life expectancy returns to equilibrium after any disturbance from long run cointegrating relationship.

Panel B. Testing for a Linear Trend in the Association of Cigarette Tax and County-level Life Expectancy by Income Quintile

	Coefficient	Standard Error	95% Confidence Interval
Income Quintile	-0.23***	0.14	(-0.28, -0.18)
Constant	1.73***	0.46	(1.59, 1.88)

Notes: Results of a weighted linear regression of the estimated long-run association of cigarette tax and county-level life expectancy by income quintile (from Panel A) against income quintile, using the inverse of the variance of the estimated coefficient for the weights.

Table S4. Association of Cigarette Tax and County-level Life Expectancy across Rural vs. Urban Counties

	Life Expectancy (years)	
	Rural	Urban
Cigarette Tax (Long Run) (\$/pack)	1.05*** (0.16)	0.92*** (0.26)
Speed of adjustment	-0.08*** (0.01)	-0.07*** (0.01)
Lag 1 of Life Expectancy (years)	-0.06*** (0.01)	-0.20*** (0.01)
Lag 2 of Life Expectancy (years)	0.08*** (0.01)	0.02 (0.01)
Lag 3 of Life Expectancy (years)	-0.02* (0.01)	0.01 (0.01)
Δ Cigarette tax _t (Short run) (\$/pack)	-0.02 (0.03)	-0.00 (0.02)
Share female (%)	0.32 (0.72)	0.89 (0.97)
Share under 18 (%)	0.22 (0.20)	-1.14** (0.51)
Share over 65 (%)	0.04 (0.13)	1.07*** (0.34)
Share black (%)	-2.69** (1.12)	-1.75* (1.01)
Share Hispanic (%)	-0.09*** (0.01)	-0.13*** (0.05)
Share completing high school (%)	0.71*** (0.16)	-0.01 (0.10)
Income per capita (\$)	0.00*** (0.00)	0.00*** (0.00)
Constant	5.79*** (0.64)	5.10*** (0.81)
Observations	31,962	27,968

Cluster-robust errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: Changes in life expectancy from the main regression analysis with adjustment for county-year income per capita, share female, share Black, share over 65, share under 18, and share with high school, and fixed effects for county. Huber-White robust standard errors clustered at the state level. Positive values represent increases in life expectancy. Cigarette tax dollars are inflation-adjusted to 2016 year dollars. Speed of adjustment to the long-term equilibrium, or the

error correction speed, is a direct estimate of the speed at which county life expectancy returns to equilibrium after any disturbance from long run cointegrating relationship.

Table S5. Association of Cigarette Tax and Smoking Prevalence

	Smoking Prevalence (%)		
	Overall	Male	Female
Cigarette Tax (Long Run) (\$/pack)	-3.09*** (0.35)	-3.30*** (0.41)	-2.39*** (0.19)
Speed of adjustment	-0.21*** (0.02)	-0.20*** (0.02)	-0.30*** (0.02)
Lag 1 of Smoking Prevalence (%)	0.05** (0.03)	0.04 (0.03)	0.14*** (0.01)
Lag 2 of Smoking Prevalence (%)	0.15*** (0.02)	0.11*** (0.02)	0.19*** (0.01)
Lag 3 of Smoking Prevalence (%)	0.10*** (0.03)	0.06*** (0.02)	0.13*** (0.02)
Δ Cigarette tax _t (Short run) (\$/pack)	0.42*** (0.09)	0.44*** (0.10)	0.49*** (0.09)
Share female (%)	0.70 (2.63)	0.78 (3.46)	-0.01 (2.34)
Share under 18 (%)	-2.46 (1.50)	-1.94 (1.67)	-3.30 (2.02)
Share over 65 (%)	-3.37*** (1.27)	-3.30** (1.37)	-4.41*** (1.69)
Share black (%)	5.01 (3.18)	9.03** (4.20)	3.79 (2.60)
Share Hispanic (%)	-10.85 (10.93)	-15.45 (10.94)	-1.48 (13.18)
Share completing high school (%)	60.22** (26.97)	12.42 (60.66)	126.22*** (19.24)
Income per capita (\$)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Constant	5.39*** (0.49)	5.83*** (0.62)	6.98*** (0.42)
Observations	52,462	52,462	52,462

Cluster-robust errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: Changes in smoking prevalence from the main regression analysis with adjustment for county-year income per capita, share female, share Black, share over 65, share under 18, and share with high school, and fixed effects for county. 95% confidence intervals reflect Huber-White robust standard errors clustered at the state level. Negative values represent reductions in smoking prevalence. Cigarette tax dollars are inflation-adjusted to 2016 year dollars. Speed of adjustment to the long-term equilibrium, or the error correction speed, is a direct estimate of the

speed at which county smoking prevalence returns to equilibrium after any disturbance from long run cointegrating relationship.

Table S6. Association of Cigarette Tax and County-level Smoking Prevalence (%) by Income Quintile

	Smoking Prevalence (%)				
	Income Q1	Income Q2	Income Q3	Income Q4	Income Q5
Cigarette Tax (Long Run) (\$/pack)	-3.51***	-4.00***	-3.78***	-2.54***	-2.69***
	(0.73)	(0.63)	(0.40)	(0.33)	(0.36)
Speed of adjustment	-0.31***	-0.22***	-0.18***	-0.20***	-0.17***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
Lag 1 of Smoking Prevalence (%)	0.05	0.03	0.05**	0.08***	0.03
	(0.04)	(0.04)	(0.03)	(0.02)	(0.02)
Lag 2 of Smoking Prevalence (%)	0.18***	0.14***	0.10***	0.11***	0.13***
	(0.05)	(0.03)	(0.02)	(0.03)	(0.03)
Lag 3 of Smoking Prevalence (%)	0.11*	0.09**	0.10***	0.12***	0.08**
	(0.06)	(0.03)	(0.03)	(0.03)	(0.03)
Δ Cigarette tax _t (Short run) (\$/pack)	0.65***	0.61***	0.51***	0.37***	0.20**
	(0.22)	(0.15)	(0.09)	(0.09)	(0.08)
Share female (%)	-0.54	0.76	-1.67	5.50*	0.33
	(5.13)	(3.65)	(4.93)	(3.34)	(3.34)
Share under 18 (%)	1.22	-1.16	-4.74**	-2.84	-3.72
	(3.51)	(2.02)	(2.42)	(2.12)	(3.49)
Share over 65 (%)	-0.76	-2.44	-4.89*	-3.21*	-2.68*
	(2.28)	(1.81)	(2.90)	(1.91)	(1.44)
Share black (%)	7.82*	4.85	5.67	18.75	-24.68
	(4.26)	(4.38)	(7.69)	(17.09)	(18.77)
Share Hispanic (%)	2.77	-26.07	-20.55*	-3.24	1.08
	(18.93)	(33.43)	(11.99)	(13.11)	(14.40)
Share completing high school (%)	-2.21	0.00	0.00	371.83***	82.33***
	(60.48)	(0.00)	(0.00)	(52.33)	(25.83)
Income per capita (\$)	0.00**	0.00	0.00	0.00	0.00**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	9.54***	6.47***	5.01***	3.33***	3.70***
	(0.82)	(0.56)	(0.48)	(0.47)	(0.66)
Observations	10,421	10,567	10,510	10,476	10,488

Clustered-standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: Changes in smoking prevalence from the main regression analysis with adjustment for county-year income per capita, share female, share Black, share over 65, share under 18, and share with high school, and fixed effects for county. 95% confidence intervals reflect Huber-White robust standard errors clustered at the state level. Negative values represent reductions in smoking prevalence. Cigarette tax dollars are inflation-adjusted to 2016 year dollars. Speed of adjustment to the long-term equilibrium, or the error correction speed, is a direct estimate of the speed at which county smoking prevalence returns to equilibrium after any disturbance from long run cointegrating relationship.

Table S7. Association of Cigarette Tax and Smoking prevalence (%) by urban/rural status*Panel A.* Including All States

	Smoking Prevalence (%)	
	Rural	Urban
Cigarette Tax (Long Run) (\$/pack)	-2.71*** (0.35)	-3.47*** (0.43)
Speed of adjustment	-0.25*** (0.01)	-0.17*** (0.02)
Lag 1 of Smoking Prevalence (%)	0.06** (0.02)	0.06* (0.03)
Lag 2 of Smoking Prevalence (%)	0.16*** (0.02)	0.14*** (0.03)
Lag 3 of Smoking Prevalence (%)	0.12*** (0.03)	0.09** (0.03)
Δ Cigarette tax _t (Short run) (\$/pack)	0.43*** (0.10)	0.40*** (0.09)
Share female (%)	2.69 (2.62)	-3.57 (3.68)
Share under 18 (%)	-3.88** (1.80)	0.90 (1.89)
Share over 65 (%)	-3.05* (1.66)	-4.27** (2.11)
Share black (%)	9.21** (3.61)	0.10 (3.62)
Share Hispanic (%)	-10.45 (11.67)	-13.60 (14.29)
Share completing high school (%)	59.07 (37.66)	0.00 (0.00)
Income per capita (\$)	0.00* (0.00)	0.00 (0.00)
Constant	6.60*** (0.43)	4.66*** (0.58)
Observations	28,101	24,361

Cluster-robust errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: Changes in smoking prevalence from the main regression analysis with adjustment for county-year income per capita, share female, share Black, share over 65, share under 18, and share with high school, and fixed effects for county. 95% confidence intervals reflect Huber-White robust standard errors clustered at the state level. Negative values represent reductions in

smoking prevalence. Cigarette tax dollars are inflation-adjusted to 2016 year dollars. Speed of adjustment to the long-term equilibrium, or the error correction speed, is a direct estimate of the speed at which county smoking prevalence returns to equilibrium after any disturbance from long run cointegrating relationship.

Panel B. Removing States where Local Cigarette Taxes were in Effect

	Smoking Prevalence (%)	
	Rural	Urban
Cigarette Tax (Long Run) (\$/pack)	-2.71*** (0.39)	-3.74*** (0.47)
Speed of adjustment	-0.24*** (0.02)	-0.16*** (0.02)
Lag 1 of Smoking Prevalence (%)	0.06** (0.03)	0.04 (0.04)
Lag 2 of Smoking Prevalence (%)	0.16*** (0.02)	0.14*** (0.03)
Lag 3 of Smoking Prevalence (%)	0.11*** (0.03)	0.06* (0.04)
Δ Cigarette tax _t (Short run) (\$/pack)	0.39*** (0.10)	0.35*** (0.07)
Share female (%)	2.85 (2.96)	-3.66 (3.59)
Share under 18 (%)	-4.45** (2.06)	0.57 (2.14)
Share over 65 (%)	-3.27* (1.87)	-4.34* (2.34)
Share black (%)	11.26*** (3.50)	-0.79 (3.64)
Share Hispanic (%)	-14.20 (11.61)	-8.89 (15.54)
Share completing high school (%)	34.24 (37.88)	0.00 (0.00)
Income per capita (\$)	0.00 (0.00)	0.00 (0.00)
Constant	6.61*** (0.48)	4.40*** (0.66)
Observations	24,395	18,921

The following states were removed because they allow for local preemption of cigarette taxes: AL, AK, CO, IL, LA, NY, OH, PA, VA. Changes in smoking prevalence from the main regression analysis with adjustment for county-year income per capita, share female, share Black, share over 65, share under 18, and share with high school, and fixed effects for county. 95% confidence intervals reflect Huber-White robust standard errors clustered at the state level.

Negative values represent reductions in smoking prevalence. Cigarette tax dollars are inflation-adjusted to 2016 year dollars. Speed of adjustment to the long-term equilibrium, or the error correction speed, is a direct estimate of the speed at which county smoking prevalence returns to equilibrium after any disturbance from long run cointegrating relationship.

Table S8. Null Hypothesis Rejections for Mortality Rate Changes By Cause Of Death

	Coefficient	Std. Error	T-Stat	P-Value
<i>CVD Related Causes of Death</i>				
Peripheral vascular disease	-0.09	0.01	-6.21	5.23E-10
Ischemic stroke	-3.01	0.84	-3.57	0.000353
Cerebrovascular disease	-3.98	1.15	-3.47	0.000516
Hemorrhagic stroke	-1.04	0.35	-3.02	0.002497
Endocarditis	-0.08	0.03	-2.90	0.003677
Ischemic heart disease	-9.33	3.42	-2.73	0.006316
Rheumatic heart disease	-0.16	0.07	-2.35	0.018639
Hypertensive heart disease	0.58	0.26	2.22	0.02638
Aortic aneurysm	-0.22	0.11	-2.04	0.041691
Atrial fibrillation and flutter	-0.11	0.07	-1.64	0.101172
Other cardiovascular and circulatory diseases	-0.15	0.12	-1.28	0.201232
Cardiomyopathy and myocarditis	-0.16	0.17	-0.97	0.333526
<i>Cancer-related Causes of Death</i>				
Non-melanoma skin cancer	0.05	0.01	5.44	5.45E-08
Leukemia	-0.20	0.04	-5.36	8.13E-08
Chronic lymphoid leukemia	-0.11	0.02	-4.41	1.02E-05
Acute lymphoid leukemia	-0.05	0.01	-4.37	1.23E-05
Ovarian cancer	-1.63	0.41	-4.00	6.44E-05
Non-Hodgkin lymphoma	-0.26	0.07	-3.95	7.73E-05
Other neoplasms	0.19	0.05	3.95	7.86E-05
Larynx cancer	-0.76	0.19	-3.92	8.93E-05
Colon and rectum cancer	-0.82	0.23	-3.61	0.000305
Tracheal, bronchus, and lung cancer	-2.77	0.83	-3.34	0.000839
Other pharynx cancer	0.08	0.03	2.92	0.003556
Hodgkin lymphoma	-0.03	0.01	-2.90	0.003676
Pancreatic cancer	-0.11	0.04	-2.73	0.006338
Brain and nervous system cancer	0.13	0.05	2.67	0.007679
Esophageal cancer	-0.18	0.07	-2.34	0.019091
Stomach cancer	-0.23	0.10	-2.32	0.02032
Multiple myeloma	-0.09	0.04	-2.24	0.025295
Testicular cancer	0.01	0.00	2.18	0.02927
Bladder cancer	-0.03	0.02	-1.62	0.104186
Breast cancer	-0.27	0.17	-1.62	0.105191
Uterine cancer	-0.02	0.01	-1.57	0.116519
Gallbladder and biliary tract cancer	-0.05	0.03	-1.56	0.119932
Nasopharynx cancer	0.00	0.00	-1.54	0.124416
Prostate cancer	-0.17	0.12	-1.46	0.14352
Malignant skin melanoma	-0.03	0.02	-1.11	0.268482

Liver cancer	0.06	0.06	0.99	0.321587
Thyroid cancer	0.00	0.00	-0.83	0.407982
Cervical cancer	-0.01	0.02	-0.67	0.500631
Acute myeloid leukemia	0.01	0.02	0.62	0.53414
Lip and oral cavity cancer	0.01	0.02	0.46	0.643074
Chronic myeloid leukemia	0.00	0.01	0.39	0.699233
Kidney cancer	-0.02	0.06	-0.35	0.726751
<i>Respiratory Disease Related Causes of Death</i>				
Other pneumoconiosis	-0.01	0.00	-4.74	2.12E-06
Pneumoconiosis	-0.21	0.06	-3.35	0.000801
Silicosis	-0.01	0.00	-3.11	0.001893
Chronic obstructive pulmonary disease	-1.82	0.74	-2.47	0.01345
Asbestosis	-0.03	0.01	-2.11	0.034679
Mesothelioma	0.05	0.03	1.69	0.09156
Other chronic respiratory diseases	-0.01	0.01	-1.54	0.124122
Interstitial lung disease and pulmonary sarcoidosis	0.03	0.02	1.39	0.165975
Asthma	-0.03	0.03	-1.04	0.298756
Coal workers pneumoconiosis	-0.01	0.02	-0.72	0.470554
<i>Injury Related Causes of Death</i>				
Self-harm	3.40	0.95	3.58	0.000348
Interpersonal violence	-0.23	0.10	-2.32	0.02058
Alcohol use disorders	0.01	0.05	0.21	0.831246
Drug use disorders	-0.01	0.52	-0.03	0.978364

Notes: Lists of the conditions for which the null hypothesis of no effect was rejected are in bold, organized by major cause of death category. We used the adaptive Holm step-down procedure for multiple test adjustment by major cause of death category (cardiovascular, cancer, respiratory conditions, and injury related). The conservative assumption was made that the tests between major types of disease were independent, and a Bonferroni adjustment was used to adjust the overall significance level of 0.05 over all tests performed for all 58 conditions. For each major cause of death category the Bonferroni adjusted significance level was $0.05/4 = 0.0125$ over all the tests in that category. The analysis used the SAS multtest procedure.

Table S9. Sensitivity Analysis: Association of Cigarette Tax and County-level Life Expectancy using Lag Orders of 1 – 5 years

	Life Expectancy (years) using Lag Order of 1 to 5				
Cigarette Tax (Long Run) (\$/pack)	1.07*** (0.19)	1.30*** (0.23)	1.00*** (0.20)	0.66*** (0.17)	0.30** (0.12)
Speed of adjustment	-0.06*** (0.01)	-0.06*** (0.01)	-0.07*** (0.01)	-0.08*** (0.01)	-0.12*** (0.01)
Lag 1 of Life Expectancy (years)	-0.14*** (0.01)	-0.18*** (0.01)	-0.14*** (0.01)	-0.17*** (0.01)	-0.22*** (0.01)
Lag 2 of Life Expectancy (years)		-0.02*** (0.01)	0.05*** (0.01)	0.10*** (0.01)	0.09*** (0.01)
Lag 3 of Life Expectancy (years)			-0.00 (0.01)	0.07*** (0.01)	0.16*** (0.01)
Lag 4 of Life Expectancy (years)				-0.18*** (0.01)	-0.03** (0.01)
Lag 5 of Life Expectancy (years)					-0.14*** (0.01)
Δ Cigarette tax _t (Short run) (\$/pack)	-0.01 (0.02)	-0.01 (0.03)	-0.01 (0.03)	-0.02 (0.02)	-0.03 (0.02)
Share female (%)	0.62 (0.63)	0.45 (0.67)	0.46 (0.64)	0.48 (0.61)	0.67 (0.52)
Share under 18 (%)	-0.10 (0.27)	-0.22 (0.30)	-0.11 (0.27)	-0.12 (0.21)	-0.01 (0.19)
Share over 65 (%)	0.29** (0.15)	0.24 (0.15)	0.32** (0.14)	0.34*** (0.13)	0.36*** (0.11)
Share black (%)	-2.32*** (0.64)	-2.50*** (0.77)	-2.40*** (0.73)	-2.21*** (0.65)	-2.21*** (0.47)
Share Hispanic (%)	-0.10*** (0.02)	-0.09*** (0.02)	-0.10*** (0.02)	-0.13*** (0.02)	-0.12*** (0.01)
Share completing high school (%)	0.63*** (0.18)	0.66** (0.32)	0.46* (0.24)	-0.04 (0.14)	-0.22** (0.10)
Income per capita (\$)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)	0.00*** (0.00)
Constant	4.84*** (0.68)	4.33*** (0.71)	5.44*** (0.69)	6.42*** (0.64)	9.07*** (0.56)

Cluster-robust errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: Changes in life expectancy from the main regression analysis with adjustment for county-year income per capita, share female, share Black, share over 65, share under 18, and share with high school, and fixed effects for county. Huber-White robust standard errors clustered at the

state level. Positive values represent increases in life expectancy. Cigarette tax dollars are inflation-adjusted to 2016 year dollars. Speed of adjustment to the long-term equilibrium, or the error correction speed, is a direct estimate of the speed at which county life expectancy returns to equilibrium after any disturbance from long run cointegrating relationship.

Table S10. Dynamic instrumental variables panel model

System GMM Estimator	
	Life Expectancy (years)
Cigarette Tax (Long Run)	0.30** (0.14)
Lag 1 of Life Expectancy	0.49*** (0.06)
Lag 2 of Life Expectancy	0.05 (0.05)
Lag 3 of Life Expectancy	0.03 (0.05)
Lag 4 of Life Expectancy	-0.30*** (0.05)
Cigarette Tax (Short Run)	0.14*** (0.05)
Time trend	0.10** (0.04)
Share female (%)	-33.83 (24.48)
Share under 18 (%)	-8.37** (3.21)
Share over 65 (%)	-3.36 (7.12)
Share Black (%)	13.14 (21.58)
Share Hispanic (%)	1.07 (2.65)
Share Completing High School (%)	-6.20 (6.43)
Income per Capita (\$)	-0.00 (0.00)
Observations	43,377

Cluster-robust errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: We implemented the regression: “xtabond2 leBoth L(1/4).leBoth cigtax t ifemale iunder18 iover65 iblack ihisp iHS incomepc_d, noleveleq ivstyle(cigtax t, passthru) gmmstyle(L(1/4).leBoth, lag(1 3)) gmmstyle(ifemale iunder18 iover65 iblack ihisp iHS incomepc_d) pca cluster(state_fips) small twostep robust”, which fits a dynamic panel model based Blundell and Bond (37), which relaxes the assumption of strongly exogenous covariates by using lags (of order 2 and greater) as instrumental variables and which was designed for small-T, large-N datasets. We take cigarette taxes as strongly exogenous and the other time-varying covariates are considered predetermined (meaning are potentially correlated with past errors). The key assumptions of the model were met: (1) the Arellano-Bond test for autocorrelation, which would indicate that lags of the dependent variable are endogenous: we reject the null of AR(1) residuals ($P < 0.001$); we cannot reject the null AR(2) residuals ($P = 0.101$); and (2) tests of whether the instruments, as a group, appear exogenous: we reject the null of overidentified restrictions (Hansen J statistic P value = 0.361). We report the finite-sample corrected standard errors based on the two-step covariance matrix.

Table S11. Correlation of residuals and time-varying covariates

	Share Female (%)	Share Under 18	Share Over 65	Share Black	Share Hispani c	Share Completing High School	Income per capita
Residuals of main ECM	-0.01	0.06	0.06	0.05	0.01	-0.11	-0.03

Table S12. Sensitivity Analysis: Association of Cigarette Tax and County-level Life Expectancy after Removing States where Local Cigarette Taxes are in Effect

	Life Expectancy (years)		
	Overall	Males	Females
Cigarette Tax (Long Run) (\$/pack)	1.08*** (0.17)	1.31*** (0.19)	0.83*** (0.13)
Speed of adjustment	-0.08*** (0.01)	-0.07*** (0.01)	-0.10*** (0.01)
Lag 1 of Life Expectancy (years)	-0.13*** (0.02)	-0.27*** (0.01)	-0.15*** (0.02)
Lag 2 of Life Expectancy (years)	0.06*** (0.01)	-0.08*** (0.01)	0.11*** (0.01)
Lag 3 of Life Expectancy (years)	-0.01 (0.01)	-0.05*** (0.01)	0.09*** (0.01)
Δ Cigarette tax _t (Short run) (\$/pack)	-0.01 (0.03)	-0.02 (0.03)	-0.01 (0.02)
Share female (%)	0.69 (0.72)	-0.41 (0.85)	0.26 (0.48)
Share under 18 (%)	-0.08 (0.33)	-0.15 (0.42)	0.22 (0.32)
Share over 65 (%)	0.32** (0.15)	0.30* (0.18)	0.50*** (0.18)
Share black (%)	-2.55*** (0.87)	-2.72** (1.18)	-1.80*** (0.65)
Share Hispanic (%)	10.63*** (3.36)	6.86** (2.70)	12.26*** (3.49)
Share completing high school (%)	10.27** (5.05)	8.22*** (1.25)	5.27* (2.75)
Income per capita (\$)	0.00*** (0.00)	-0.00* (0.00)	0.00*** (0.00)
Constant	5.76***	5.51***	8.12***

Cluster-robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: The following states were removed because they allow for local preemption of cigarette taxes: AL, AK, CO, IL, LA, NY, OH, PA, VA. Changes in life expectancy from the main regression analysis with adjustment for county-year income per capita, share female, share Black, share over 65, share under 18, and share with high school, and fixed effects for county. Huber-White robust standard errors clustered at the state level. Positive values represent increases in life expectancy. Cigarette tax dollars are inflation-adjusted to 2016 year dollars. Speed of adjustment to the long-term equilibrium, or the error correction speed, is a direct

estimate of the speed at which county life expectancy returns to equilibrium after any disturbance from long run cointegrating relationship.

Table S13. Sensitivity Analysis: Legal Restrictions on Smoking*Panel A.* Correlation between Cigarettes Taxes per Pack of 20 and Smoking Restrictions

County-Year Smoking Restriction	State-Year Cigarette Tax
Bar restriction	0.27
Restaurant restriction	0.22
Workplace restriction	0.21

Panel B. R² from a Linear Regression of Cigarette Taxes and Smoking Restrictions

County-Year Variables	State-Year Cigarette Tax
Bar restriction	0.72*** (0.04)
Restaurant restriction	-0.15*** (0.03)
Workplace restriction	0.29*** (0.03)
Constant	0.70*** (0.01)
R-squared	0.07
Observations	50,192

Cluster-robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Panel C. Sensitivity analysis: main error-correction-model with annual state-level smoking restrictions included as time-varying covariates

	Life Expectancy (years)
Cigarette Tax (Long Run) (\$/pack)	0.97*** (0.20)
Speed of adjustment	-0.07*** (0.01)
Lag 1 of Life Expectancy (years)	-0.14*** (0.01)
Lag 2 of Life Expectancy (years)	0.05*** (0.01)
Lag 3 of Life Expectancy (years)	-0.01 (0.01)
Δ Cigarette tax _t (Short run) (\$/pack)	-0.01 (0.02)
Share female (%)	0.52 (0.62)
Share under 18 (%)	-0.15 (0.28)
Share over 65 (%)	0.32** (0.14)
Share black (%)	-2.49*** (0.74)
Share Hispanic (%)	-0.10*** (0.02)
Share completing high school (%)	0.43 (0.26)
Income per capita (\$)	0.00*** (0.00)
Worksite ban	-0.00 (0.02)
Restaurant ban	0.03 (0.04)
Bar ban	0.05 (0.04)
Constant	5.40*** (0.68)

Cluster-robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table S14. Assessing Plausibility of a Causal Interpretation for the Observed Long-run Association of Cigarette Tax and County-level Life Expectancy*Panel A.* Smoking Prevalence as a Mediator: Long-run Association of County-level Smoking Prevalence and County-level Life Expectancy

	Life Expectancy (Years)
Smoking Prevalence (Long Run) (%)	-0.79*** (0.13)
Speed of adjustment	-0.04*** (0.01)
Lag 1 of Life Expectancy (years)	-0.28*** (0.02)
Lag 2 of Life Expectancy (years)	-0.20*** (0.01)
Lag 3 of Life Expectancy (years)	-0.12*** (0.01)
Δ Smoking Prevalence (Short run) (%)	-0.08*** (0.02)
Share female (%)	0.55 (0.58)
Share under 18 (%)	0.08 (0.26)
Share over 65 (%)	0.29* (0.15)
Share black (%)	-0.60 (1.01)
Share Hispanic (%)	7.06*** (2.10)
Share completing high school (%)	46.07*** (15.83)
Income per capita (\$)	-0.00 (0.00)
Constant	4.17*** (1.18)
Observations	52,462

Cluster-robust errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: Changes in life expectancy from the main regression analysis with adjustment for county-year smoking prevalence, county-year income per capita, share female, share Black, share over 65, share under 18, and share with high school, and fixed effects for county. 95% confidence

intervals reflect Huber-White robust standard errors clustered at the state level. Positive values represent increases in life expectancy. Cigarette tax dollars are inflation-adjusted to 2016 year dollars. Speed of adjustment to the long-term equilibrium, or the error correction speed, is a direct estimate of the speed at which county life expectancy returns to equilibrium after any disturbance from long-run cointegrating relationship.

Panel B. Placebo Test of Association between Future Cigarette Taxes (t+5), Current life expectancy(t), and Current Smoking Prevalence(t)

	Life Expectancy (t) (Years)	Smoking Prevalence (t) (%)
Cigarette Tax (t+5) (\$/pack)	0.09 (0.06)	0.03 (0.16)
Share female (%)	0.69 (0.60)	-0.11 (2.63)
Share under 18 (%)	-3.72*** (0.92)	-4.78* (2.44)
Share over 65 (%)	2.08*** (0.76)	-10.16*** (2.10)
Share black (%)	-2.69** (1.03)	-6.07 (4.51)
Share Hispanic (%)	3.60* (1.96)	-22.99*** (4.15)
Share completing high school (%)	-2.11*** (0.77)	-3.65 (2.27)
Income per capita (\$)	0.00*** (0.00)	-0.00 (0.00)
Observations	36,602	36,602

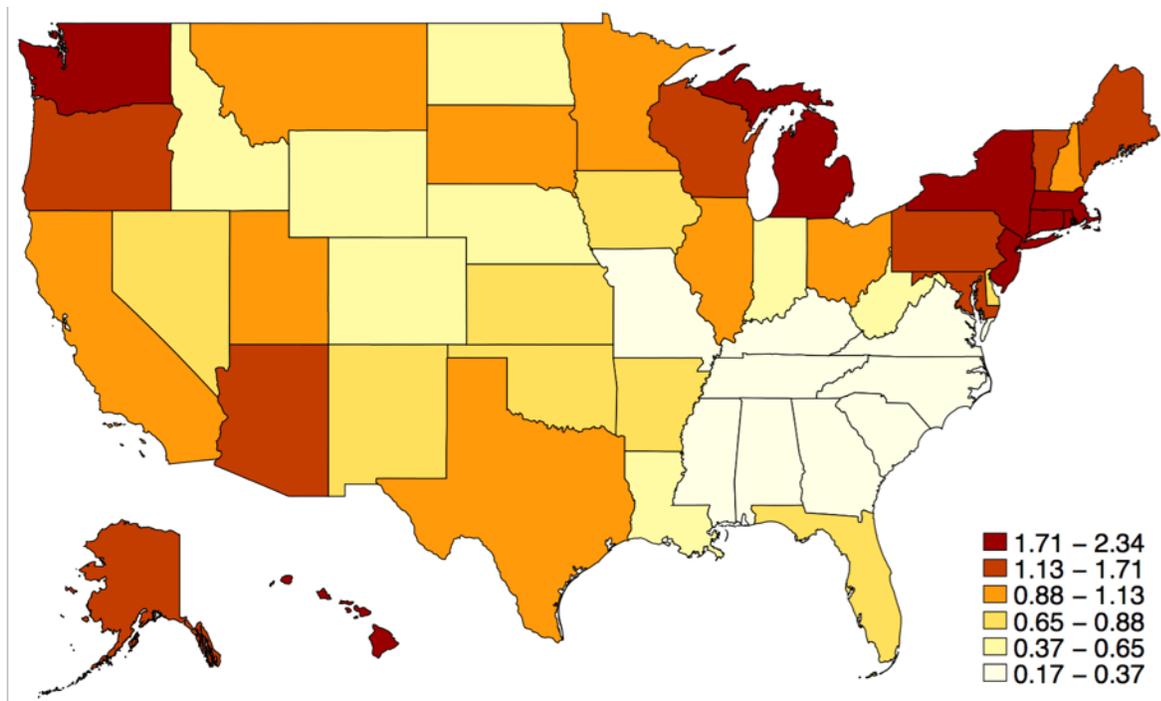
Cluster-robust errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: Results of a linear regression of current year life expectancy (or smoking prevalence) with adjustment for state-year cigarette taxes five years later (t+5), county-year income per capita, share female, share Black, share over 65, share under 18, and share with high school, and fixed effects for county. 95% confidence intervals reflect Huber-White robust standard errors clustered at the state level. Cigarette tax dollars are inflation-adjusted to 2016 year dollars.

Figure S1. Geographic variation in state cigarette tax rates

Panel A. Average cigarette tax (\$ per pack) by state during the study period



Panel B. Average annual change in cigarette tax (\$ per pack) by state during the study period

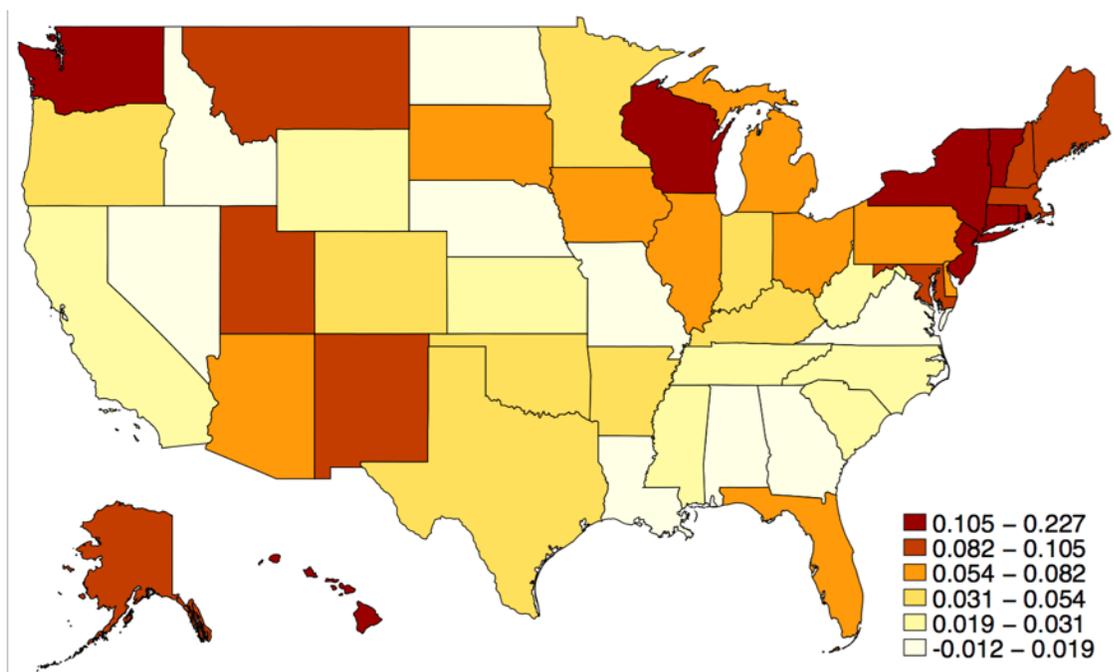


Figure S2. National trends in life expectancy, non-smoking prevalence, and cigarette tax rates

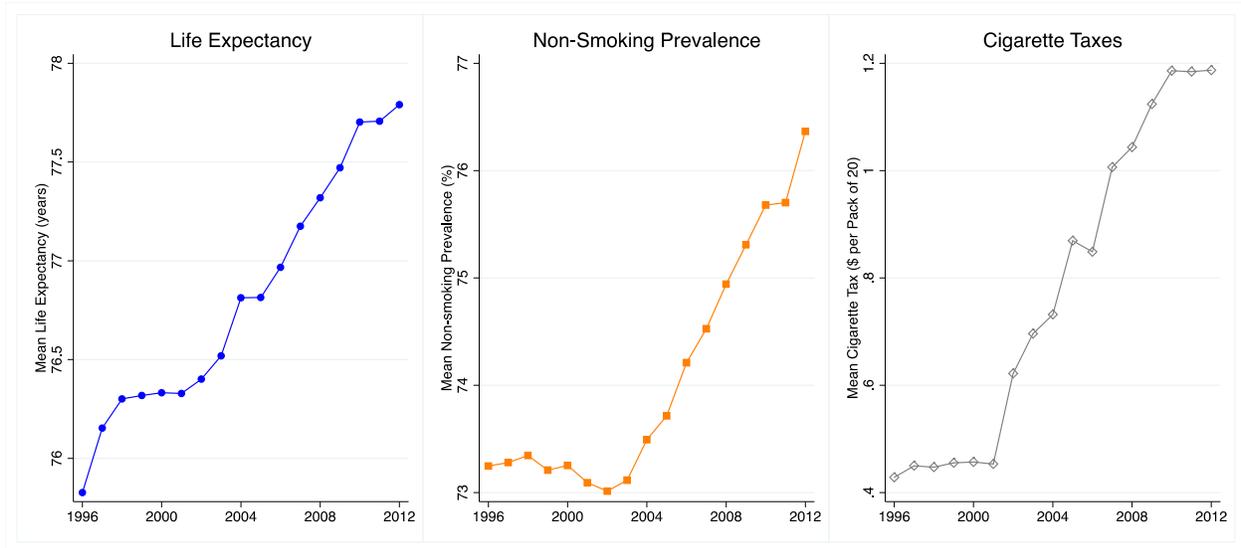
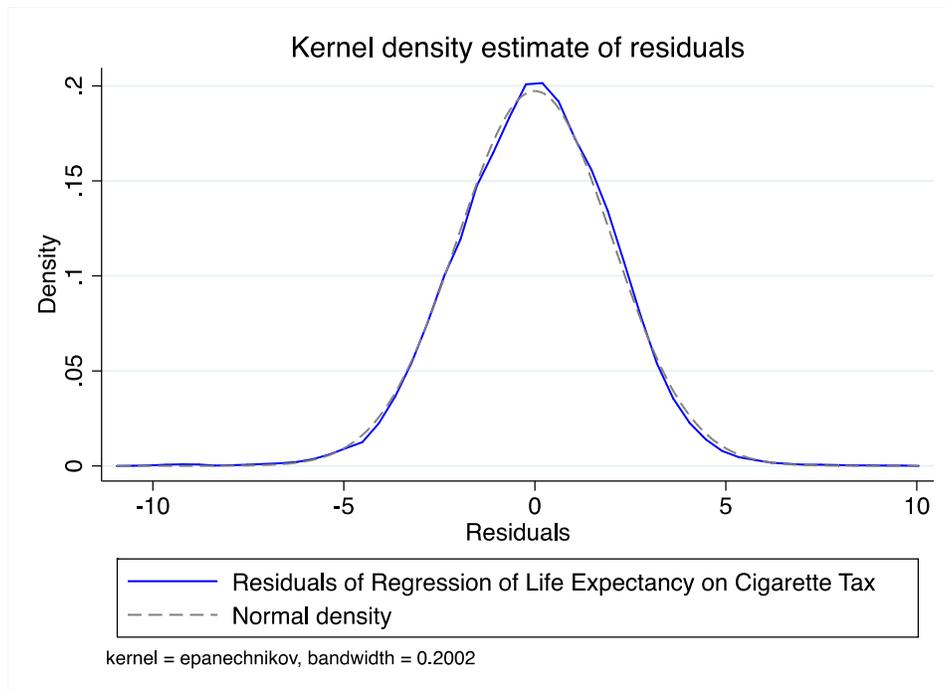


Figure S3. Residuals from a regression of life expectancy on cigarette taxes and smoking prevalence on cigarette taxes

Panel A. Life Expectancy: Distribution of residuals relative to a normal distribution



Panel B. Smoking Prevalence: Distribution of residuals relative to a normal distribution

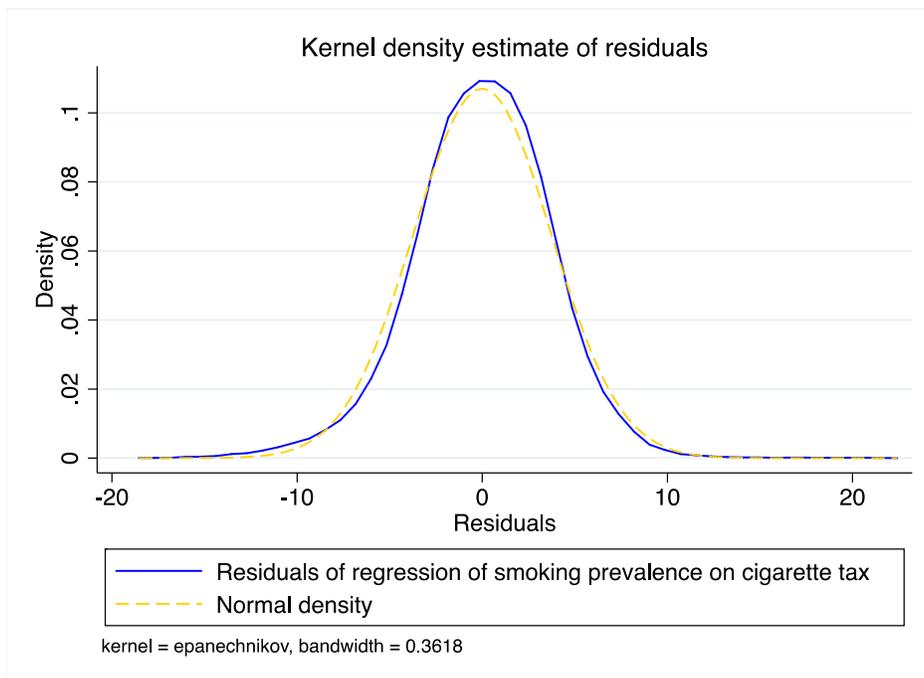
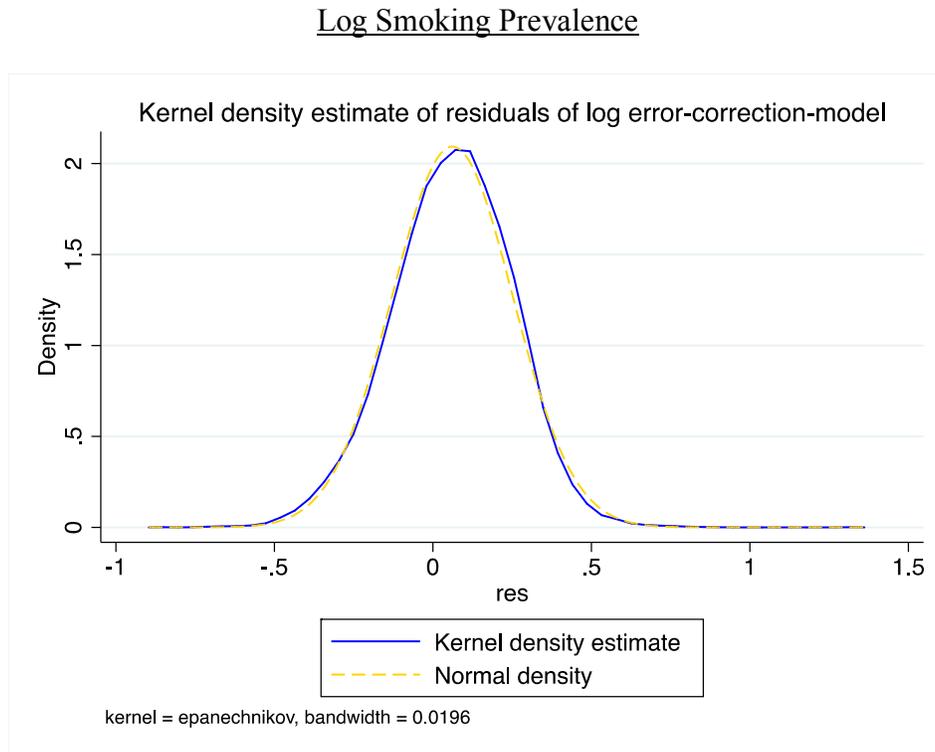
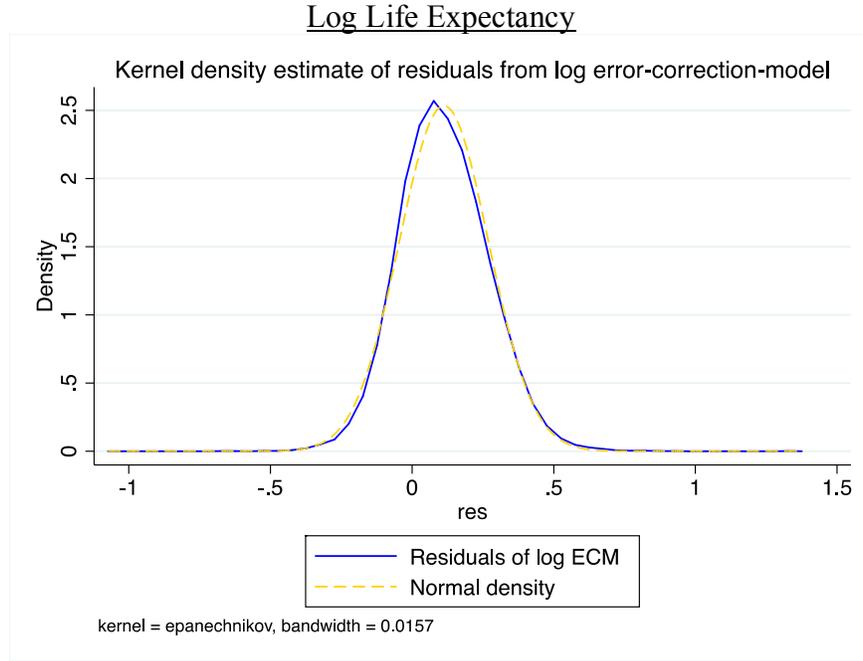


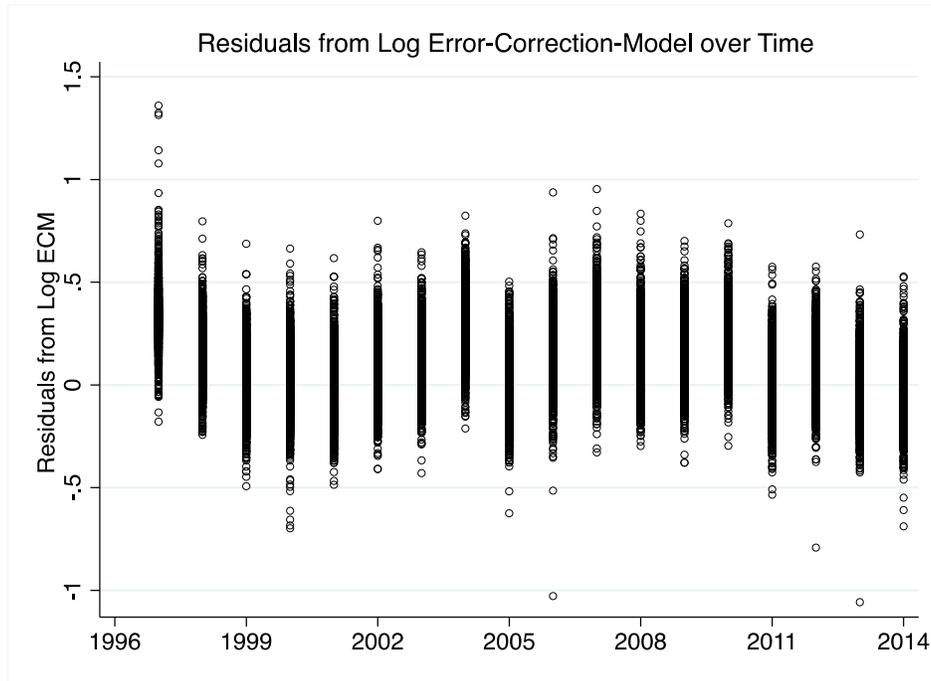
Figure S4. Residuals from the log error-correction models

Panel A. Distribution of residuals relative to a normal distribution



Panel B. Residuals over time

Log Life Expectancy



Log Smoking Prevalence

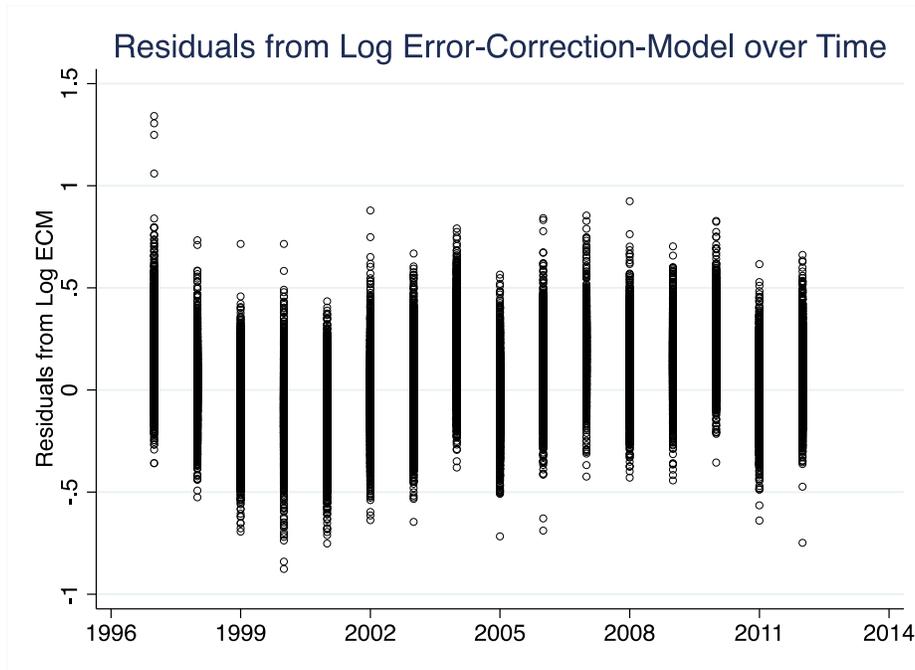
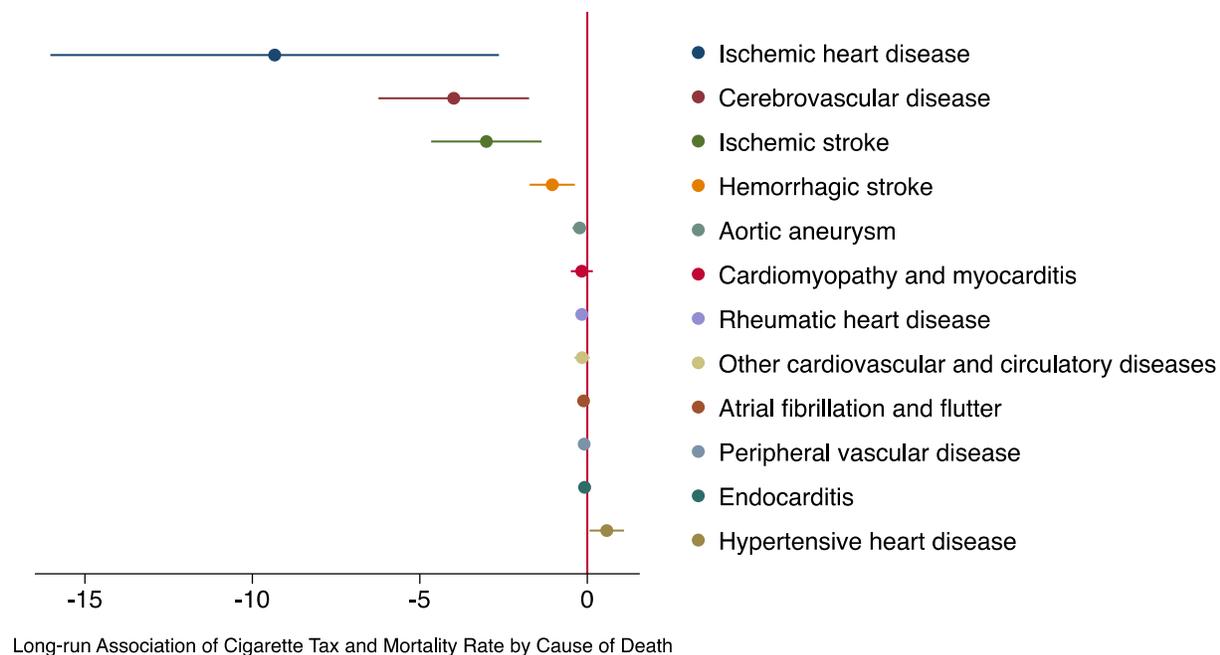
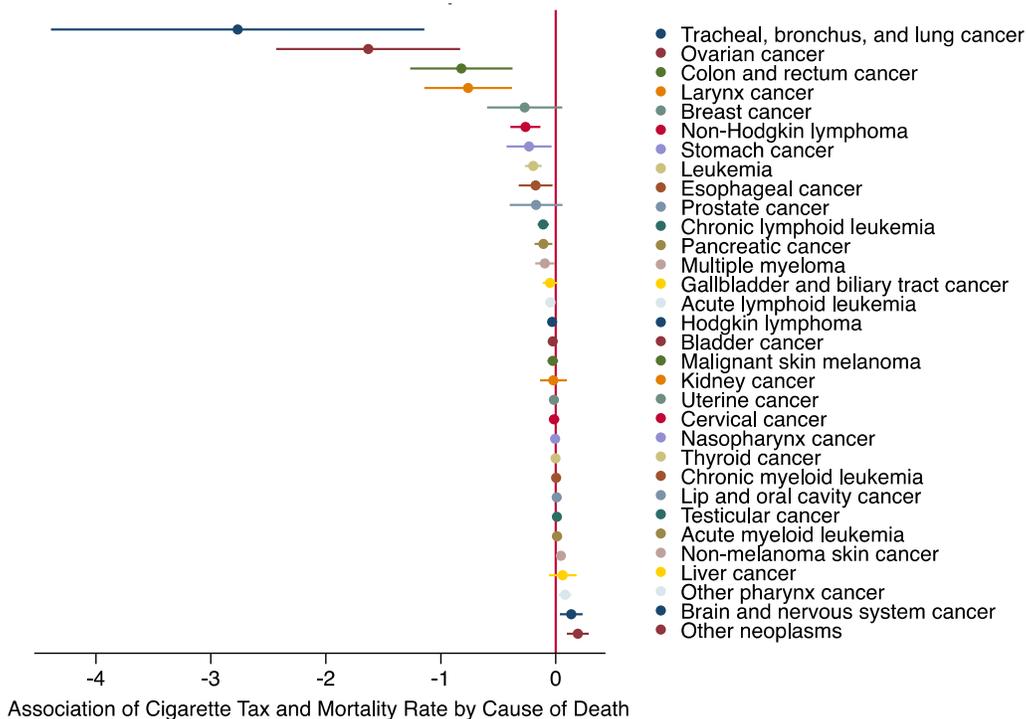


Figure S5. Long-run Association of Cigarette Tax and Mortality Rates by Cause of Death

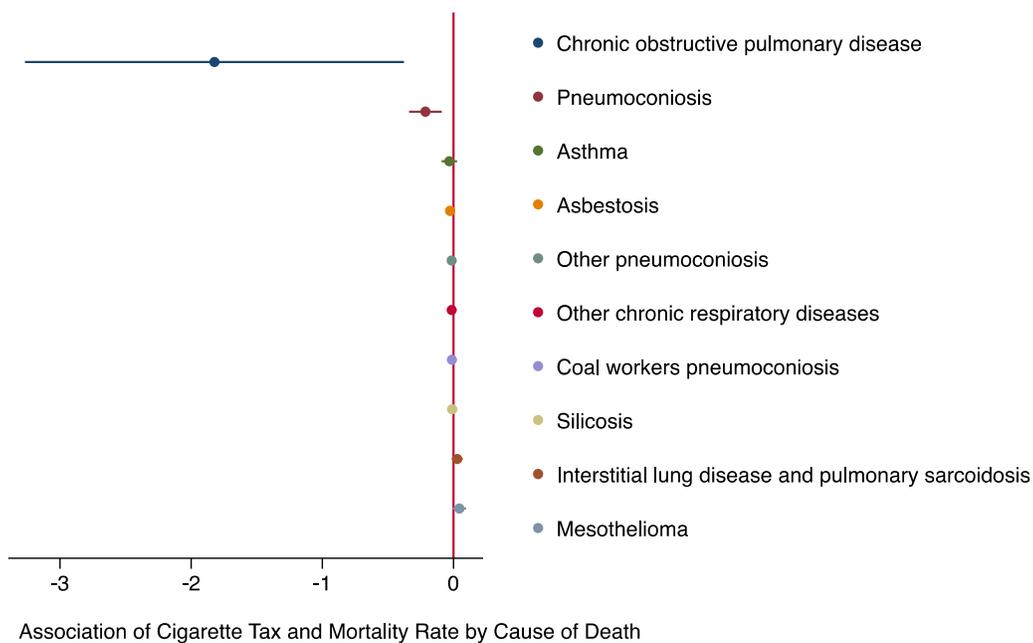
Panel A. Cardiovascular Disease Related Mortality



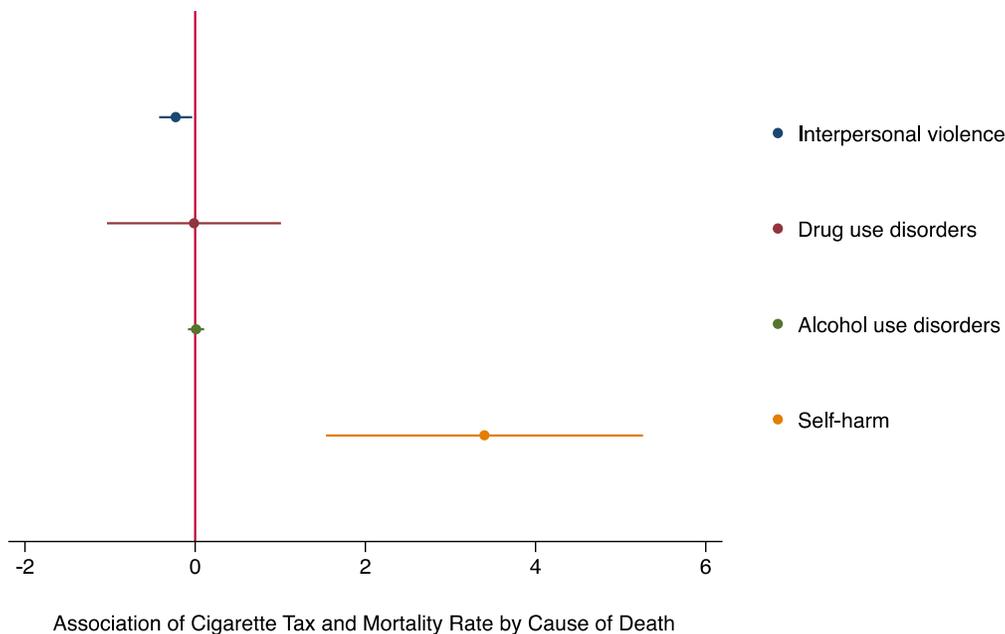
Panel B. Cancer Related Mortality



Panel C. Respiratory Disease Related Mortality



Panel D. Injury Related Mortality



Notes: Long-run changes in annual mortality rate by cause of death at the county-level from the main regression analysis with adjustment for county-year income per capita, share female, share Black, share over 65, share under 18, and share with high school, and fixed effects for county. 95% confidence intervals reflect Huber-White robust standard errors clustered at the state level.

Negative values represent reductions in cause-specific age-standardized mortality rates (deaths per 100,000 population). Cigarette tax dollars are inflation-adjusted to 2016 year dollars. See **Table S8** for results after a multiple test adjustment using the adaptive Holm step-down procedure for each major condition type.

Figure S6. Sensitivity analysis: main error-correction-model with annual state smoking-related policies included as time-varying covariates



Association of Cigarette Tax and County-level Life Expectancy, Controlling for Other State Smoking-Related Policies

Notes: Long-run changes in life expectancy at the county-level from the main regression analysis with adjustment for various state-year smoking policies and for county-year income per capita, share female, share Black, share over 65, share under 18, and share with high school, and fixed effects for county. 95% confidence intervals reflect Huber-White robust standard errors clustered at the state level. Positive values represent increases in life expectancy. Cigarette tax dollars are inflation-adjusted to 2016 year dollars. Data on state policies was obtained from the Centers for Disease Control and Prevention's State Tobacco Activities Tracking and Evaluation (STATE) System. (<https://chronicdata.cdc.gov/Legislation/CDC-STATE-System-Tobacco-Legislation-Licensure/eb4y-d4ic>).

Note, the following state tobacco legislation categories were not analyzed because they lacked sufficient within-state variation over time to include those policies in a panel fixed effects model as a time-varying explanatory variable:

- Preemption; Preemption on Advertising; Restrictions; Display
- Preemption; Preemption on Advertising; Restrictions; Other
- Preemption; Preemption on Advertising; Restrictions; Promotion
- Preemption; Preemption on Advertising; Restrictions; Sampling
- Preemption; Preemption on Licensure ; Restrictions; Over-the-Counter
- Preemption; Preemption on Licensure ; Restrictions; Vending Machines
- Smokefree Indoor Air; Government Multi-Unit Housing; Restrictions; Type of Restriction in Living Area of Government Multi-Unit Housing
- Smokefree Indoor Air; Personal Vehicles; Restrictions; Type of Restriction in Personal Vehicle
- Smokefree Indoor Air; Private Multi-Unit Housing; Restrictions; Type of Restriction in Living Area of Private Multi-Unit Housing