Associations of Bar and Restaurant Smoking Bans with Smoking Behavior in the CARDIA Study: A 25-Year Study

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Web Material

Web Table 1. Comparison of Covariate Distributions between Imputed Sample and Original Sample

	Year 0			Year 7			Year 10			Year 15		
	Original Sample		Imputed Sample	Original Sample		Imputed Sample	Original Sample		Imputed Sample	Original Sample		Imputed Sample
	N	% or Mean (SD)	% or Mean (SD)	*N*	% or Mean (SD)	% or Mean (SD)	*N*	% or Mean (SD)	% or Mean (SD)	*N*	% or Mean (SD)	% or Mean (SD)
Variables with Missing Data												
Education, years	5,071	13.8 (2.3)	13.8 (2.3)	3,982	14.5 (2.5)	14.5 (2.5)	3,875	14.6 (2.6)	14.6 (2.6)	3,633	14.9 (2.5)	14.9 (2.5)
No. missing	0			24			20			11		
Marital Status												
Married	1,130	22	22	1,737	44	44	1,906	49	49	2,187	60	60
Unmarried	3,939	78	8	2,242	56	56	1,965	51	51	1,446	40	40
No. missing	2			27			24			11		
Employment Status												
Unemployed	1,405	28	28	900	23	23	814	21	21	732	20	20
Employed	3,664	72	72	3,081	77	77	3,057	79	79	2,899	80	80
No. missing	2			25			24			13		
Income, per $10,000	4,237	5.7 (3.7)	5.5 (3.7)	3,927	4.7 (3.0)	4.7 (3.0)	3,852	4.9 (2.9)	4.9 (2.9)	3,596	6.9 (4.6)	6.9 (4.6)
No. missing	834			79			43			48		
Has children that live with them												
Yes	1,355	27	27	1,934	49	49	2,110	55	55	2,174	60	61
No	3,713	73	73	2,045	51	51	1,754	45	45	1,426	40	39
No. missing	3			27			31			44		
Current Alcohol Use												
Yes	4,366	86	86	3,271	82	82	3,092	80	80	2,878	79	79
No	688	14	14	717	18	18	780	20	20	758	21	21
No. missing	17			18			23			8		

Web Table 1 Continued.

	Year 20			Year 25		
	Original Sample		Imputed Sample	Original Sample		Imputed Sample
	N	% or Mean (SD)	% or Mean (SD)	*N*	% or Mean (SD)	% or Mean (SD)
Variables with Missing Data						
Education, years	3,495	15.0 (2.6)	15.0 (2.6)	3,434	15.1 (2.7)	15.1 (2.7)
No. missing	15			12		
Marital Status						
Married	2,194	63	63	2,109	61	61
Unmarried	1,307	37	37	1,323	39	39
No. missing	9			14		
Employment Status						
Unemployed	780	22	22	1,123	33	33
Employed	2,721	78	78	2,306	67	67
No. missing	9			17		
Income, per $10,000	3,459	6.8 (4.3)	6.8 (4.3)	3,391	6.3 (4.1)	6.3 (4.1)
No. missing	51			55		
Has children that live with them						
Yes	2,012	58	58	1,703	50	50
No	1,455	42	42	1,680	50	50
No. missing	43			63		
Current Alcohol Use						
Yes	2,713	79	79	2,676	78	78
No	723	21	21	739	22	22
No. missing	74			31		

WEB APPENDIX 1

Description of Conditional Poisson Fixed-Effects Models

Models implemented in this analysis took the form:

$$\text{Log}(Y_{it}) = \beta_0 + \beta_1 BAN_{it} + \beta_2 I_{it} + \beta_3 S_{it} + \eta_c + \alpha_i + \varepsilon_{it}$$

Where:

Y_{it} represents the outcome of interest (current smoking, smoking intensity, or quit attempt)

BAN_{it} represents the time varying smoking ban exposure variable (β_1 represents the coefficient of interest that is presented in the Results of Table 2)

I_{it} represents a vector of time varying individual-level confounders (time since baseline, age, education, marital status, employment, income, living with children)

S_{it} represents time-varying state cigarette tax

η_c represents a fixed effect for state of residence
α_i represents the unobserved person-specific fixed effect
ε_{it} represents the time varying individual level error

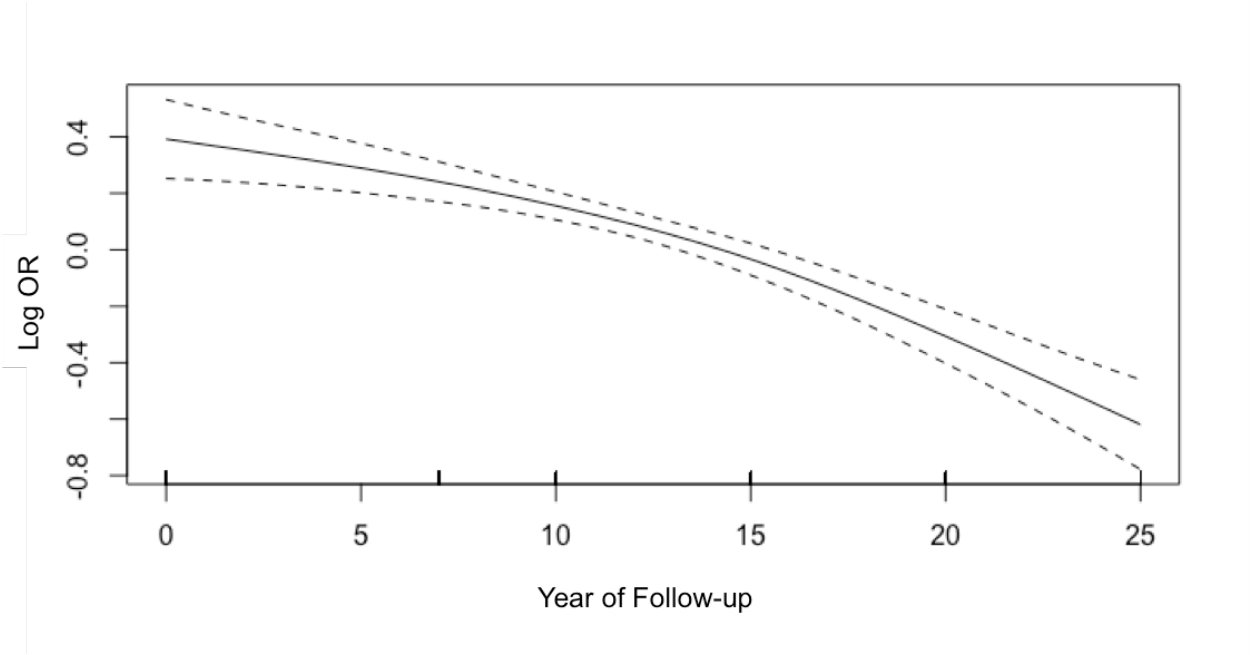
Models were implemented using the xtpoisson package in Stata version 13.1, with the “fe” and “vce(robust)” options. “fe” causes a fixed effects model to be implemented. The “robust” option causes a cluster-correlated robust variance estimate (the “Huber/White/sandwich estimator”) to be calculated, which corrects the variance for misspecification of the error term due to the binomial distribution of the outcome, accounts for clustering by participant, and is robust to serial correlation.

Reference:

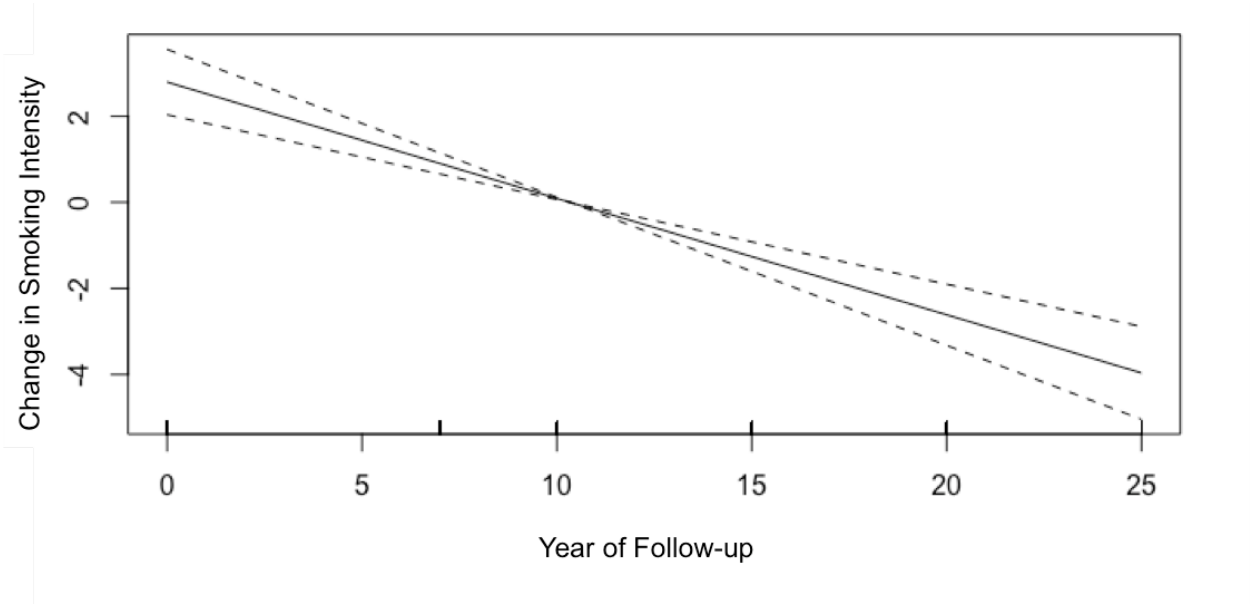
StataCorp. 2013. *Stata 13 Longitudinal-Data/Panel-Data Reference Manual*. College Station, TX: Stata Press.

Web Figure 1. Plots from Generalized Additive Models with Penalized Cubic Regression Spline Smoothing Displaying Secular Time Trends for A) Current Smoking (Versus No Current Smoking), b) Smoking Intensity (Average Number of Cigarettes Smoked per Day, Continuous), and c) Quit Attempt (Any Versus None). Models were adjusted for smoking ban status, age, sex, race, education, inflation-adjusted income, marital status, employment status, living with children, current alcohol use, state cigarette tax. Plots created in R (R Foundation for Statistical Computing, Vienna, Austria) using the "mgcv" package. The solid line reflects the estimated change in each outcome over time using a fitted GAM, adjusted for covariates. The dotted lines reflect 95% confidence intervals. The graph can be interpreted as follows: for current smoking, in year 0, the predicted log odds of current smoking was 0.4 higher than the overall mean during the entire study period, conditional on covariates. In year 20, the predicted log odds of current smoking was -0.3 lower than the overall mean, conditional on covariates.

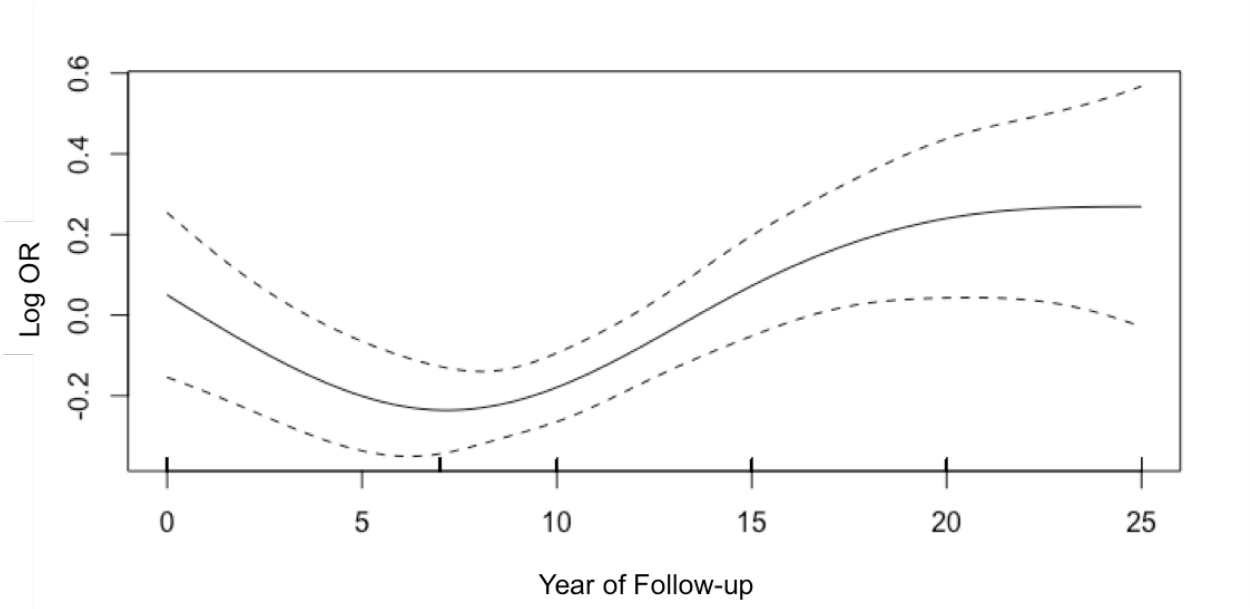
A) Current Smoking



B) Smoking Intensity



C) Quit Attempt



WEB APPENDIX 2

Sensitivity to Temporal Stationarity

Temporal stationarity of the independent and dependent variables and the errors from the smoking models was tested using the Harris-Tzavalis unit-root test, which is recommended when the number of panels is large and the number of time periods is small ($T = 6$ in our analysis). We found no evidence that errors from the smoking models are temporally non-stationary ($P < 0.0001$ when testing the null hypothesis that errors from the smoking models are non-stationary or contain a unit root).

References:

Harris, R. D. F., and E. Tzavalis. 1999. Inference for unit roots in dynamic panels where the time dimension is fixed. Journal of Econometrics 91: 201–226.

StataCorp. 2013. *Stata 13: STATA Panel Data Unit Root Tests.* College Station, TX: Stata Press. Available online at: http://www.stata.com/features/overview/panel-data-unit-root-tests/ and http://www.stata.com/manuals13/xtxtunitroot.pdf

Web Table 2. (Sensitivity Analyses that Supplement Manuscript Table 2) Association of 100% Hospitality Smoking Bans[a] with Within-Person Change in Smoking Risk, Smoking Intensity, and Quit Attempts, The Coronary Artery Risk Development in Young Adults Study (1985–2011)-Sensitivity Analysis Adjusting for (1) Exposure by 6 months Rather than 1 Year, (2) Adjusting for Diagnosis with a Chronic Condition, (3) Evaluating Only State-Level Smoking Bans, (4) Evaluating Smoking Intensity as a Count, and (5) Adjusting for Household Income as a Nonlinear Term.

Association of a 100% Hospitality Smoking Ban with:	**(1) Risk Ratio (95% CI) using a 6-month Exposure Lag[b]**	**(2) Risk Ratio (95% CI), Controlling for Diagnosis of Chronic Condition[b]**	**(3) Risk Ratio (95% CI) Evaluating Only State-Level Bans[b]**	**(4) Rate Ratio (95% CI) Evaluating Smoking Intensity as a Count[c]**	**(5) Risk Ratio (95% CI) Adjusting for Nonlinear Household Income[b,d]**
Current smoking (versus not current smoking) (*N* = 1,732)	0.94 (0.88, 0.99)	0.93 (0.87, 0.98)	0.92 (0.87, 0.98)	---	---
Smoking intensity (average number of cigarettes smoked per day: ≥10 versus <10 per day) among participants who ever smoked during follow-up (*N* = 1,197)	0.92 (0.84, 1.01)	0.92 (0.84, 1.01)	0.91 (0.82, 0.99)	---	---
Quit attempt (any versus none) by current smokers (*N* = 1,153)	1.11 (1.01, 1.20)	1.10 (1.01, 1.20)	1.08 (0.99, 1.17)	---	Income as cubic spline: 1.08 (0.99, 1.18) Income as dummy variables: 1.09 (1.00, 1.19).
Smoking intensity (average number of cigarettes smoked per day) modeled as a count outcome (*N* = 1,931)	---	---	---	0.91 (0.83, 1.00)	---

[a] 100% smoking bans mandated that all bars and restaurants be completely smoke-free with no exceptions. Exposure was lagged by 6 months in column (1) and 1 year in columns (2)-(5) to ensure exposures preceded outcome ascertainment. In column (3), the exposure included only smoking bans that were implemented at the state level, while all other models evaluated exposure to bans implemented at the state, county, or local level.

[b] Estimated using fixed effects Poisson models. Models were adjusted for the following time-varying covariates: time since baseline, age, education, marital status, employment status, income, current alcohol use, state cigarette tax and state of residence. Interactions between time-invariant variables (sex and race) and time since baseline were retained for current smoking and smoking intensity to allow the associations of these variables with the outcome to change over time (p-value for interactions <0.05). Note-conditional fixed effects models only include participants with a change in the outcome over the follow-up period. In column (2), a variable that indicated whether participants had been diagnosed with a chronic condition that might necessitate quitting smoking (hypertension, diabetes, cancer, or heart disease).

[c] Estimated using hybrid effects negative binomial models (39). To construct these models, we decomposed the time-varying independent variables (smoking ban status, time since baseline, age, education, marital status, employment status, income, current alcohol use, state cigarette tax, and state of residence) into two components- a person-specific mean (which estimates between-person effects) and the deviation of each observation from the person-specific mean (which estimates within-person effects). We implemented a random effects negative binomial model with a random intercept for subject that included time-invariant predictors (sex, race, center) as well as the person-specific means and deviations for each time-varying predictor. As above, interactions between sex and race and time were included to allow the associations of these variables with the outcome to change over time (p-value for interactions <0.05). We compared the coefficients of the person-specific means and the deviations for each time-varying predictor using a Wald test. If the null hypothesis was not rejected, there was no evidence that these associations differed and following recommended practice, we retained the within-person component only. The estimate presented in column (4) is the exponentiated deviation coefficient and confidence interval for the time-varying smoking ban exposure, controlling for the covariates listed above, and indicates that exposure to a smoking ban is associated with a 9% reduction in individual-level rate of cigarettes smoked per day.

[d] In order to better-control for confounding by income, a potential non-linear relationship between household income and smoking outcomes was explored via cubic splines (in adjusted generalized additive models) and dummy variables. Exploratory results found no evidence of non-linearity with smoking risk or intensity but there was a suggestion of non-linearity with quit attempts. Thus we present results where income was entered into the model as a cubic spline (9 knots to correspond to the 9 income categories) rather than as a linear term; and alternately as a series of dummy variables rather than a linear term. Results were virtually the same to when income was entered into the model as a linear term.

Web Table 3. (Supplement to Manuscript Figure 1) Comparison of Effect Modification Results[a] Between Models Adjusting for Secular Trend as a Linear Time Trend or as a Nonlinear Time Trend, The Coronary Artery Risk Development in Young Adults Study (1985–2011)

	Current Smoking **Risk Ratio (95% CI)**		**Smoking Intensity** **Risk Ratio (95% CI)**		**Quit Attempts** **Risk Ratio (95% CI)**	
	Linear Time Trend	**Nonlinear Time Trend**	**Linear Time Trend**	**Nonlinear Time Trend**	**Linear Time Trend**	**Nonlinear Time Trend**
Educational Attainment						
≤High School Degree	0.98 (0.91, 1.05)	1.04 (0.96, 1.13)	0.96 (0.85, 1.08)	1.03 (0.91, 1.18)	1.12 (1.00, 1.25)	1.06 (0.94, 1.20)
Some College/Associate's	0.96 (0.87, 1.06)	1.02 (0.92, 1.13)	0.95 (0.82, 1.11)	1.02 (0.88, 1.19)	1.15 (1.02, 1.29)	1.08 (0.95, 1.23)
≥Bachelor's Degree	0.78 (0.69, 0.89)	0.84 (0.73, 0.96)	0.79 (0.64, 0.98)	0.86 (0.69, 1.07)	1.00 (0.85, 1.17)	0.93 (0.78, 1.10)
P-interaction	<0.001	<0.001	0.2	0.2	0.2	0.1
Sex						
Men	0.94 (0.86, 1.02)	1.00 (0.92, 1.10)	0.93 (0.82, 1.06)	1.01 (0.88, 1.16)	1.00 (0.90, 1.13)	0.94 (0.82, 1.07)
Women	0.92 (0.85, 0.99)	0.98 (0.89, 1.07)	0.90 (0.79, 1.03)	0.97 (0.84, 1.12)	1.18 (1.07, 1.30)	1.10 (0.99, 1.23)
p-interaction	0.7	0.6	0.8	0.7	0.02	0.01
Income						
Quartile 1	0.98 (0.91, 1.06)	1.06 (0.97, 1.16)	0.93 (0.82, 1.06)	1.02 (0.89, 1.18)	1.23 (1.09, 1.38)	1.14 (1.01, 1.31)
Quartile 2	0.93 (0.84, 1.04)	1.00 (0.89, 1.12)	0.92 (0.78, 1.08)	1.00 (0.84, 1.18)	1.05 (0.91, 1.22)	1.00 (0.86, 1.16)
Quartile 3	0.83 (0.72, 0.95)	0.88 (0.76, 1.01)	0.89 (0.73, 1.08)	0.95 (0.78, 1.15)	0.98 (0.85, 1.14)	0.91 (0.78, 1.06)
Quartile 4	0.90 (0.79, 1.02)	0.95 (0.82, 1.08)	0.90 (0.73, 1.11)	0.95 (0.77, 1.18)	1.07 (0.92, 1.25)	1.03 (0.88, 1.21)
P-interaction	0.2	0.07	0.9	0.6	0.07	0.2

[a] Estimated using fixed effects Poisson models. Models were adjusted for the following time-varying covariates: age, education, marital status, employment status, income, current alcohol use, state cigarette tax, and state of residence. Secular time trends were controlled for as A) linear or B) non-linear (quadratic (time + time-squared) for current smoking and smoking intensity, restricted cubic splines with 6 knots for quit attempts) variables. Interactions between time-invariant variables (sex and race) and time since baseline were retained for current smoking and smoking intensity to allow the associations of these variables with the outcome to change over time (p-value for interactions <0.05). Note—conditional fixed effects models only include participants with a change in the outcome over the follow-up period.