Original investigation

Impact of Total Vending Machine Restrictions on US Young Adult Smoking

Mike Vuolo PhD¹, Brian C. Kelly PhD², Joy Kadowaki JD²

¹Department of Sociology, Ohio State University, Columbus, OH; ²Department of Sociology, Purdue University, West Lafayette, IN

Corresponding Author: Mike Vuolo, PhD, Department of Sociology, Ohio State University, 238 Townshend Hall, 1885 Neil Avenue Mall, Columbus, OH 43210, USA. Telephone: 614-292-6681; Fax: 614-292-6687; E-mail: vuolo.2@osu.edu

Abstract

Introduction: In an analysis of smoking using a longitudinal sample of US young adults, we extend research on tobacco vending machine restrictions beyond its prior focus on minors by examining the influence of total vending machine restrictions, which apply to adult-only facilities and represents the only remaining vending machine exemption since the enactment of the Family Smoking Prevention and Tobacco Control Act. We identify whether the passage of a restriction influences an individual's smoking on repeated observations, and if the propensity is lower among those who live in locations with a restriction.

Methods: Combining a repository of US tobacco policies at all geographic levels with the nationally-representative geocoded National Longitudinal Survey of Youth 1997 and Census data, we use multilevel logistic regression to examine the impact of total vending machine restrictions on any past 30-day smoking and past 30-day smoking of one pack per day among young adults (ages 19–31), while accounting for other tobacco control policy, community, and individual covariates.

Results: We find that total vending machine restrictions decrease any recent smoking ($OR = 0.451$; $p < .01$), net of other covariates. Though the passage of a restriction does not alter an individual's smoking over time, living longer in an area that has a restriction lowers the propensity that an individual will smoke at all ($OR = 0.442$; $p < .05$). We find no effect of total vending machine restrictions on smoking a pack daily.

Conclusions: Total vending machine restrictions appear to be an effective, yet highly underutilized, means of tobacco control.

Implications: Past scientific inquiries examining vending machine restrictions have focused upon minor access, adolescent perceptions of availability, and subsequent smoking. The potential for total vending machine restrictions, which extend to adult-only facilities, to influence patterns of smoking among those of legal age, remains significant. Those who are subject to total vending machine restrictions for longer periods are less likely to have recently smoked, but individuals do not change their smoking behavior in response to the passage of a restriction. These restrictions do not affect heavy smokers. Such policies are an effective but underutilized policy mechanism to prevent smoking among young adults.

Introduction

Tobacco use has declined considerably among young people in the United States over the past 2 decades.¹ During this period, numerous

tobacco control policies have been implemented across several governmental levels; some have specifically targeted youth, while others have been aimed at the wider population.^{2,3} The Family Smoking

Prevention and Tobacco Control Act (TCA) of 2009 included a provision effective in 2010 that banned tobacco vending machine sales, with the exception of adult-only facilities.⁴ In this article, we consider the latter exception. Namely, we ask whether the exception for adult-only facilities is associated with young adult smoking patterns over time. Despite the exception, some states, counties, and municipalities have taken a step to ban vending machines even in adult-only facilities, known as total vending machine restrictions. Through the use of a longitudinal, geocoded nationally representative survey, we compare smoking patterns among young adults residing in the presence and absence of a total vending machine restriction, while controlling for other tobacco control policies and a large battery of risk factors for smoking at the community and individual level. Thus, do total vending machine restrictions make any difference in terms of smoking patterns among young people who may frequent adult-only facilities?

Total vending machine restrictions that extend to adult-only facilities are not widespread. Figure 1 depicts a map of the locations that have such a restriction as of end of year 2013 (see the Data section for a description of the data source). The only state-level total vending machine restriction is in Vermont. Such restrictions are also uncommon at the county-level, with only 36 counties throughout the United States passing such a policy. Of these, 26 apply only to unincorporated areas, thus limiting their reach inside urbanized areas. Instead, local municipalities have led the way, with 553 locales passing total vending machine restrictions. These bans in adult-only facilities, however, are far from evenly spread. With numerous municipalities passing vending machine restrictions, coverage is widespread in Massachusetts (especially the eastern part of the state), northern and southwestern New Jersey, and the metropolitan areas corresponding to San Francisco, Los Angeles, San Diego, Minneapolis-St Paul, and Birmingham. Restrictions are also common in other parts of California and Minnesota, as well as

Connecticut. They are largely absent in other parts of the country. Considering all three geographic levels of policy (and accounting for the differing population coverage of unincorporated and incorporated county restrictions), 9.3% of the US population lives in a location with a total vending machine restriction. Thus, total vending machine restrictions are a tobacco control policy that has been less widely utilized throughout the United States than other such policies.

There is considerable precedent to examine point of sale restrictions, as studies have identified such restrictions as effective in reducing smoking behaviors, notably both initiation and relapse.⁵⁻¹³ The restriction of tobacco vending machines is one such possible point of sale restriction. Past research on restrictions on tobacco vending machines has primarily focused on restrictions to minor access; this literature has largely shown that several types of restrictions on vending machines have reduced minor access to tobacco and subsequently adolescent perceptions of availability and underage use.¹⁴⁻²¹ Within the United States, however, the research on minors, while motivating the vending machine restriction in the TCA, is now largely moot in the face of that federal policy. Instead, we argue that the remaining exception for adult-only facilities within the TCA deserves empirical scrutiny. Given its applicability to adult-only facilities, we are naturally interested in how restrictions on vending machines within such facilities affect young adult smoking patterns, which is particularly important since young adulthood is the period during which tobacco use peaks.²²

To our knowledge, no research has examined the potential for total vending machine restrictions to affect the smoking behaviors of young adults using contemporaneous policy data. The only such study of young adult smoking examined the effect of state-level vending machine restrictions on youth access during adolescence (age 17) on later smoking behaviors.²³ While an important finding, it considers a long-term effect of adolescent policy exposure to young adult smoking behaviors and would not account for the current policy

Figure 1. Geographic coverage of total vending machine restrictions in the United States. *Note:* Data is current as of 2013. There are no total vending machine restrictions in Alaska or Hawaii. *Source:* American Nonsmokers' Rights Foundation USTobacco Control Laws Restricted Use Database.

environment in which those young adults live nor policies that apply to adult-only facilities. We thus contribute to this research by considering whether contemporaneous restrictions in adult-only facilities affect young adult smoking patterns. We also add to this literature by expanding beyond the focus on state policies to include county and local policy levels as well, which [Figure 1](#) clearly demonstrates is important when considering total vending machine restrictions. We anticipate that total vending machine restrictions will have an effect on young adult smoking through impeding easy access within adult-only facilities such as bars and nightclubs. Similar to findings regarding the effect of indoor smoking bans on this group of smokers,^{24–26} we hypothesize that total vending machine restrictions will primarily have an impact on social smokers whose casual pattern of smoking leads them to be opportunistic in consumption. In contrast, heavy smokers would be more likely to arrive prepared with cigarettes or more willing to leave the venue due to the habitual nature of their smoking and thus less likely to be affected by such restrictions.

As briefly noted in a paper focused on clean air restrictions,²⁴ total vending machine restrictions also have an effect on young adult smoking while the analyses control for other tobacco policies. We expand upon this issue through an examination of the influence of total vending machine restrictions on smoking behaviors within a longitudinal sample of young adults, which locates the focus of analysis on spaces of access among individuals legally permitted to purchase tobacco products. We first identify the main effect of total vending machine restrictions in a longitudinal hierarchical model. Utilizing an advantage only available with longitudinal data, we then follow with a decomposition of this effect that allows us to determine if total vending machine restrictions affect the same individual's smoking behavior over time as policies change, as well as determine whether living in a location with such a restriction makes it less likely that an individual will smoke at all.

Methods

Individual-Level Data Source

The individual-level data come from the National Longitudinal Survey of Youth 1997 (NLSY97). The NLSY97 has a large nationally representative, geocoded sample ($N = 8984$) tracking youth transitions into adulthood, with an oversample of black and Latino youth. Adolescents (12 to 16) were randomly sampled during 1997 and surveyed annually. The retention rate was nearly 83% in 2011. The restricted-access, geocoded NLSY97 identifies the respondents' core-based statistical area (CBSA; ie, metropolitan or micropolitan area), county, and state. We analyzed a subset of respondents whose city of residence could be identified by combining CBSA and county information with a variable assessing whether the respondent lived in a principal city within the metro area. Thus, our analyses focus on those living in the largest principal city of a CBSA, given the importance of the local level within a broader multilevel policy context. We also restrict analyses to waves 2004 and later (ages 19–31), as this was the first year in which CBSA data is available, such that our analysis included all waves from 2004 to 2011. This subset amounts to 19 668 observations among 4341 individuals within 487 cities. [Table 1](#) shows the individual-level descriptive statistics at age 26 for the whole sample and the analytic sample, demonstrating considerable similarity on all variables with two exceptions. Blacks are somewhat overrepresented, while whites are underrepresented. People in the subset are also more likely to work. All variables, except for static individual level characteristics, are time-varying, meaning that

they are measured each year. Our statistical model, described below, accounts for the repeated observations per individual, as well as the nesting of individuals in cities.

Dependent Variables

We created two outcome variables based upon self-reports: one indicating any cigarette use during the past 30 days (pooled mean across all individuals and years = 34.5%) and a second variable for heavy use for those who reported smoking at least a pack per day during the past 30 days (pooled mean = 4.9%).

Independent Variable

City-level policy data come from the Americans for Nonsmokers' Rights Foundation (ANRF) restricted use tobacco policy database. ANRF collected a complete national repository of tobacco-related ordinances and regulations within the country by date. From the ANRF repository, we created a location-year dataset for each data year (2004–2011) using the effective date for all policies included in the analysis. All policy information is statistically at the city-level, but accounts for all higher geographic level policies at the county, state, and federal levels (eg, if the state has a restriction, then all cities within that state are coded as having that restriction in those years; if the county has a restriction that applies to incorporated areas, which would thus cover the principal city, then that city is coded as having that restriction in those years). The main predictor variable is an indicator variable for whether or not the respondent lived in a location with a total vending machine restriction. The pooled mean in our analytic sample is 10.4%, very close to the coverage of the US population at large noted above (9.3%). The underutilization of total vending machine restrictions relative to other tobacco control policies is further underscored by the averages in [Table 1](#).

Additional Policy Controls

To consider the independent effect of total vending machine restrictions, we also included additional policies as covariates, coded in a similar fashion as total vending machine restrictions; that is, also taking into account all geographic levels. First, we included an indicator variable for whether the location is subject to a comprehensive smoking ban, which requires all workplaces, restaurants, and bars to be completely smokefree with no indoor exceptions. Second, we included excise taxes, which is the sum of all taxes levied in a given location across geographic levels. Third, youth tobacco possession restrictions is an indicator variable for whether it is illegal for minors to possess tobacco in that location. Fourth, an indicator variable is included for whether the location has any advertising restrictions (above and beyond that of the Tobacco Master Settlement Agreement [MSA] and TCA). Finally, we included an indicator for whether there is a restriction on single cigarette sales, including complete coverage for all respondents following the nationwide restriction of such sales in the TCA.

Community and Individual Level Covariates

In addition to a host of tobacco control policies, we included a considerable battery of control variables at both the individual-level and the city-level. In a longitudinal dataset, researchers must choose between year and age as the time metric based upon theoretical considerations.²⁷ Given that age is central to patterns of substance use among young adults, we chose age as our time metric, including a quadratic term as this fit the data better than any other polynomial for age. Age in 1997 is also included in the models to control for

Table 1. Descriptive Statistics for Subset and All Respondents, Age 26

Individual-level variable	Subset in largest cities: percentage or mean (SD)	All respondents: percentage or mean (SD)
Tobacco control policy variables		
Comprehensive clean indoor air ban	45.34%	—
Youth possession restriction	77.17%	—
Single cigarette sale restriction	24.33%	—
Complete vending machine restriction	10.17%	—
Any advertising restriction	65.54%	—
Excise taxes (\$)	1.44 (1.15)	—
Census variables		
Population		
Less than 100 000	21.98%	—
100 000–250 000	17.70%	—
250 000–500 000	13.16%	—
500 000–1 000 000	19.48%	—
1 000 000 or greater	27.68%	—
Population density (persons/mi ²)	5730.48 (6860.56)	—
Owner-occupied housing (%)	50.09 (9.76)	—
Minors (%)	23.46 (3.48)	—
Female-headed households (%)	11.57 (3.48)	—
Non-Hispanic whites (%)	47.81 (20.57)	—
NLSY97 variables		
Any past 30 days tobacco use	34.62%	34.68%
Past 30 days smoked pack daily	5.34%	6.26%
Gender: female	50.52%	48.81%
Race/ethnicity		
White	39.87%	49.56%
Black	34.28%	26.82%
American Indian	0.72%	0.69%
Asian or Pacific Islander	1.76%	1.80%
Hispanic	21.94%	19.80%
Other	1.43%	1.34%
US native	95.84%	95.71%
Age in 1997		
12	20.76%	19.71%
13	20.51%	20.11%
14	20.26%	20.49%
15	20.05%	20.86%
16	18.41%	18.82%
Age 17 past 30 days any smoking	30.12%	32.60%
Parents' education		
Less than HS	16.84%	16.02%
HS	29.62%	32.90%
Some college	24.52%	25.22%
Bachelor's	29.02%	25.86%
Parent health		
Good–Excellent	76.63%	75.21%
Fair–poor	12.99%	13.12%
No parent health info	10.38%	11.67%
Baseline depression (0–15)	4.37 (2.45)	4.36 (2.43)
HS grades: mostly As	12.45%	10.98%
Peers smoking—1997		
Almost none—less than 10%	28.47%	26.18%
About 25%	21.80%	22.16%
About half—50%	24.41%	24.48%
About 75%	17.31%	18.68%
Almost all—more than 90%	8.00%	8.50%
Living with parent	21.83%	19.94%
Education		
HS dropout	10.57%	10.56%
HS or GED	25.08%	27.20%
Some college, not enrolled	23.29%	23.75%
2-year degree	4.91%	5.09%
4-year degree	25.69%	23.79%
Enrolled in HS	0.39%	0.42%

Table 1. Continued

Individual-level variable	Subset in largest cities: percentage or mean (SD)	All respondents: percentage or mean (SD)
Enrolled in college	10.07%	9.19%
Moved between counties	12.55%	14.30%
Employment status		
None	24.74%	33.64%
Part-time	20.39%	16.69%
Full-time	54.87%	49.67%
Job schedule		
None	17.29%	17.18%
Day	54.18%	55.64%
Night	4.93%	4.45%
Irregular	23.61%	22.74%
Married	24.05%	29.94%
Parent	45.00%	48.47%

GED = General Educational Development; HS = high school. The time-invariant controls were measured in the 1997 survey, which include gender, race/ethnicity, US nativity, age cohort, parents' education, parent self-reported health, HS grades, and peer smoking in 1997. Baseline depression was measured in 2004.

cohort effects. We included a wide range of individual-level risk factors for tobacco use within the models. Regarding family, we included time-varying indicator variables for whether the respondent lived with a parent, was married, and had children.^{28–30} We also accounted for recent moves via a dummy variable for a past year move across at least one county. For work-related risk factors, we included time-varying categorical variables for job status and job schedule.³¹ To assess peer-related influences, we included the percentage of peers who smoked in 1997, the only year it was measured.³² For academic performance, we included a dummy variable for receiving “mostly A’s” in high school.³³ To control for the respondent’s mental health,³⁴ the dataset included a five-item scale for depression asking whether the respondent in the last month has been a very nervous person, felt calm and peaceful, felt downhearted and blue, has been a happy person, and felt so down in the dumps that nothing could cheer you up, of which we use the 2004 baseline measure ($\alpha = 0.77$). To account for intergenerational health influences,^{35,36} we included parents’ self-reported health from 1997. We included several measures for socioeconomic status. We measured socioeconomic status of household of origin by respondent-reported parents’ education level.^{37,38} The respondent’s socioeconomic status was assessed by a time-varying measure that combined school enrollment status and degree attainment.^{28,33,38,39} Finally, we included controls for race/ethnicity,^{40,41} US nativity, and gender.⁴² The descriptive statistics in Table 1 provide additional details on the coding of categorical variables.

Additionally, several city-level measures from Census data are included as controls.⁴³ Census data come from the 2000 and 2010 decennial censuses, with linear interpolation for in-between years and official estimates used for 2011. To include both population size and density, we created a categorical measure of population, while density is considered continuous (logged due to skewness). We included the percentage of female-headed households, as a useful proxy for other economic measures such as poverty and income. To measure ties to the community, we used the percentage of owner-occupied housing. Finally, we included the percentage of non-Hispanic whites and percentage of minors to account for community racial and age composition, respectively.

Analysis

Given the various levels of analysis and a binary outcome, we used multilevel logistic regression models, also known as mixed effects

models, to estimate the effects of total vending machine restrictions on young adult smoking, net of the other individual, community, and policy control variables. In our analysis using a typical hierarchical structure, observations at each age are nested within individuals, whom are nested within cities. Our three-level model thus includes random intercepts for both the individual-level (Level 2) and the city-level (Level 3). These models adjust for the person- and city-level averages through a variance parameter that defines a normal distribution for each of those averages. At the lowest level of observation (Level 1), the predictors represent time-varying measures for both the city and the individual. At the individual-level, we have the time-invariant characteristics of the respondent. Because we do not include static city characteristics, the random intercept is the only term at Level 3. All models used the “xtmelogit” procedure in Stata 14.0.

We first describe a model for the overall effect of total vending machine restrictions. This effect, however, does not distinguish between whether the bans are associated with a change in the same individual’s behavior over time as a location enacts a restriction (known as a within-person effect), or if those who live in locations where bans have been in place longer have a lower overall average probability of smoking at all (known as a between-person effect). The changing policy environment thus provides an advantage in that we can make this distinction by decomposing the vending machine effect into between- and within-person effects. As is typical,^{44–46} the between-person effect is computed by taking an individual-level average for years spent living in a location with a total vending machine restriction, which is simply the proportion of years living in such a location. The within-person effect is computed through a time-varying person-centered version by subtracting the presence of a total vending machine restriction (ie, 0 or 1) from a person’s average on the restriction, or that proportion of years living in that location calculated for the between-person effect.

Supplementary Appendix Table A contains the full results for the models discussed below. For further information on modeling, data, and results for variables other than vending machines, see (MV, BCK and JK).²⁴

Results

Table 2 displays the results of our models for the effect of a total vending machine restriction. Models 1 and 3 display the main effect for the two outcome variables. Net of other policy, city, and individual

Table 2. Multilevel Logistic Regression of Smoking Outcomes in National Longitudinal Survey of Youth 1997

	Any tobacco use/past 30 days		Pack daily/past 30 days	
	Model 1	Model 2	Model 3	Model 4
	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
Total vending machine restriction	0.451** (0.246, 0.826)		1.169 (0.487, 2.805)	
Between-individual		0.442* (0.235, 0.832)		1.101 (0.440, 2.755)
Within-individual		0.508 (0.150, 1.715)		1.893 (0.184, 19.480)

CI = confidence interval. [Supplementary Appendix Table A](#) displays models with all covariates. All models contain variance components accounting for the differences in averages on the outcomes across individuals (Level 2) and cities (Level 3); time-invariant controls for gender, race/ethnicity, US nativity, age cohort, parents' education, parent self-reported health, baseline depression, high school grades, and peer smoking in 1997; time-varying respondent controls for age, living with a parent, education, recent move between counties, employment status, job schedule, marital status, and parent status; time-varying city controls for population, population density, owner-occupied housing, percentage minors, female-headed households, percentage non-Hispanic whites; and, time-varying policy context controls for comprehensive smoking bans, youth tobacco possession restrictions, single cigarette sale restrictions, any tobacco advertising restrictions, and cigarette excise taxes.

* $p < .05$; ** $p < .01$ (two-tailed).

level covariates, we find a significant effect of total vending machine restrictions on any recent tobacco use. Relative to living in a location without a total vending machine restriction, the presence of such a restriction reduces the odds of any recent smoking by 54.9% ($p < .01$). By contrast, there is no significant effect for heavy use. Considering the significant effect for any recent smoking, however, we would like to know if the passage of a total vending machine restriction changes smoking behavior over time (within-person effect), or if the average propensity to smoke at all is lower in locations that have vending machine restrictions for longer (between-person effect).

As mentioned above, an advantage of longitudinal multilevel policy measures is the ability to decompose total vending machine restrictions into between- and within-person effects, given that the changing nature of the policy implies that the variable resides statistically at the lowest of the three levels in the hierarchical structure with the time-varying measures. Thus, Models 2 and 4 show this decomposition for each of the two outcomes while still controlling for policy, community, and individual level covariates. The between-effect represents the effect of differences in individuals' average years living in a location with a total vending machine restriction, and is thus an individual-level effect (Level 2 in the statistical model). The within-effects represent an individual's deviation from their average at each time point, such that the effect is at the observation-level (Level 1).

For any recent smoking, the within-person effect is nonsignificant, implying that total vending machine restrictions do not influence a given person's likelihood of smoking as the policy changes over time. That is, individuals do not change their smoking behavior in response to the passage of a total vending machine restriction. On the other hand, the results indicate a significant between-person effect. Higher average time living in a location with a total vending machine restriction distinguishes which individuals in which locations are more likely to have recently smoked. That is, living in a location with a total vending machine restriction reduces the likelihood that an individual will smoke over the observation period at all. Recall that the between-person effect is coded as an average that represents a respondent's proportion of years living in a location with a total vending machine restriction. So those who never lived in location with a ban are coded 0, while those who resided in a location with a restriction in all observation years are coded 1. Thus, a one-unit increase in the between-person effect represents the difference between an individual who never resided in a city with a vending machine restriction and one who always resided in a city with

such a policy. The individual living in a location that had a restriction across all years is 55.8% less likely to have recently smoked on average across the observations ($p < .05$). For two individuals separated by 0.5 on the between-person effect (eg, an individual never residing in a city with a vending restriction and one residing half the time; or a person residing one-quarter of the time and one residing three-quarters of the time), the individual with more time living in a location with a restriction is 33.5% less likely to recently smoke ($[e^{(-0.817 \times 0.5)} - 1] \times 100\%$). As with the main effect, there is no significant between- or within-person effect for heavy smoking.

Discussion

With the enactment of the TCA, tobacco vending machines were restricted across the United States, but with the exception of adult-only facilities. By comparing individual-level young adult smoking among locations that have also banned vending machines in adult-only facilities to those locations that have not, the results of our analyses indicate that expanding the restriction to cover all facilities may improve public health. Specifically, such restrictions impact any recent smoking among young adults, but they do not influence heavy smoking. The within-person findings imply that passing a total vending machine restriction will not impact a given individual's tobacco-related behavior over time; young adults do not alter their existing smoking behavior in response to a new total vending machine restriction. However, the between-person findings suggest that total vending machine restrictions could improve tobacco-related health over time because the likelihood of a young adult smoking at all is lower in locations that have had such a restriction for longer, thus potentially limiting the number of young people who take up smoking. These results were robust to the inclusion of numerous additional tobacco control policy covariates; in fact, total vending machine restrictions were one of just two significant policies (the other being comprehensive indoor smoking bans²⁴).

As a whole, the results primarily indicate that total vending machine restrictions, which mainly affect nightlife spaces that have been defined as "adult," including those that serve alcohol, decrease the probability that young people smoke at all. Young people who already smoke, regardless of the frequency, are largely unaffected by the enactment of total vending machine restrictions. As noted earlier, such young adults who already smoke may simply be prepared via prior purchase of tobacco in other locations or exhibit greater

willingness to leave the venue to purchase cigarettes. Nonsmoking young adults in total vending machine restriction contexts, by contrast, have limited access to purchase tobacco within nightlife settings and such reduced access within the venue may prevent smoking among those who do not already regularly do so. Other scholars have noted the importance of limiting tobacco sales within nightlife settings, including marketing and promotions, in terms of inhibiting smoking behaviors.^{9,47,48} Similarly, other tobacco control policies such as comprehensive clean air policies, which cover nightlife settings, have also been shown to reduce any recent smoking among young adults.^{24–26} The limitation of smoking within nightlife settings via each of these policies may be a critical means of reducing tobacco use among young adults and ultimately promoting public health.

Total vending machine restrictions appear to be an effective, yet highly underutilized, means of tobacco control. Emerging from policies initially aimed at reducing youth access, they extend the focus of access to the wider adult population. Though we lack CBSA geocodes for the respondents' place of residence when they were minors, other scholars have noted a lasting effect into young adulthood of state-level vending machine policies restricting youth access during adolescence.²³ Together with our study, there is evidence to support further adoption of vending machine restrictions. Indeed, the TCA has taken this step in all but adult-only facilities. Although total vending machine restrictions extending to these facilities have been implemented in some locales, we noted that just 9% of the entire US population live in such a location (and 10% of young adults in our sample). While other tobacco control policies are often enacted at the state level, only one state (Vermont) has taken the step to implement total vending machine restrictions. Given how few governmental bodies at all levels have passed total vending machine restrictions, the exception in the TCA does not appear to have motivated new legislation. Even among those places with restrictions, no states or counties and only 31 local municipalities have passed total vending machine restrictions between the TCA's enactment in June 2010 and the available policy data in 2013. Of course, many adult-only facilities in locations that allow vending machines may still opt not to have a vending machine, and adult-only facilities within locations with total vending machine restrictions might possibly sell cigarettes over the counter in some locales. Yet, our results showing that young adults in locations that have such restrictions on vending machine access in adult spaces are less likely to smoke indicate that wider adoption of total vending machine restrictions still can be a means of improving tobacco-related public health.

Supplementary Material

Supplementary Appendix Table A can be found online at <http://www.ntr.oxfordjournals.org>

Funding

This work was supported by the National Institute on Drug Abuse (grant #R03DA034933; PI: MV).

Declaration of Interests

None declared.

Acknowledgments

This research was conducted with restricted access to Bureau of Labor Statistics (BLS) data. The authors would like to thank the staff at the American Nonsmokers' Rights Foundation (ANRF), particularly Maggie Hopkins and

Laura Walpert. The views expressed here do not necessarily reflect the views of the BLS, NIDA, or ANRF. The authors thank Charlie Carter for contributions to this research. We also thank Emily Harris, Alexandra Marin, Jake Brosius, and Emily Ekl for research assistance.

References

1. Nelson DE, Mowery P, Asman K, et al. Long-term trends in adolescent and young adult smoking in the United States: metapatterns and implications. *Am J Public Health*. 2008;98(5):905–915. doi:10.2105/AJPH.2007.115931.
2. DiFranza JR, Dussault, GF. The federal initiative to halt the sale of tobacco to children—the Synar Amendment, 1992–2000: lessons learned. *Tob Control*. 2005;14(2):93–98. doi:10.1136/tc.2004.009373.
3. Lantz PM, Jacobson PD, Warner KE, et al. Investing in youth tobacco control: a review of smoking prevention and control strategies. *Tob Control*. 2000;9(1):47–63. doi:10.1136/tc.9.1.47.
4. Family Smoking Prevention and Tobacco Control Act of 2009, Pub.L. 111–31, U.S. Statutes at Large. 2009;123:1776–1858.
5. Paynter J, Edwards R. The impact of tobacco promotion at the point of sale: a systematic review. *Nicotine Tob Res*. 2009;11(1):25–35. doi:10.1093/ntr/ntn002.
6. Robertson L, McGee R, Marsh L, et al. A systematic review on the impact of point-of-sale tobacco promotion on smoking. *Nicotine Tob Res*. 2015;17(1):2–17. doi:10.1093/ntr/ntu168.
7. DiFranza JR. Which interventions against the sale of tobacco to minors can be expected to reduce smoking? *Tob Control*. 2012;21(4):436–442. doi:10.1136/tobaccocontrol-2011-050145.
8. Henriksen L. Comprehensive tobacco marketing restrictions: promotion, packaging, price and place. *Tob Control*. 2012;21(2):147–153. doi:10.1136/tobaccocontrol-2011-050416.
9. Shahrir S, Wipfli H, Avila-Tang E, et al. Tobacco sales and promotion in bars, cafes and nightclubs from large cities around the world. *Tob Control*. 2011;20(4):285–290. doi:10.1136/tc.2010.040220.
10. Stead LF, Lancaster, T. A systematic review of interventions for preventing tobacco sales to minors. *Tob Control*. 2000;9(2):169–176. doi:10.1136/tc.9.2.169.
11. Forster JL, Murray DM, Wolfson M, et al. The effects of community policies to reduce youth access to tobacco. *Am J Public Health*. 1998;88(8):1193–1198. doi:10.2105/AJPH.88.8.1193.
12. Rigotti, NA, DiFranza JR, Chang Y, et al. The effect of enforcing tobacco-sales laws on adolescents' access to tobacco and smoking behavior. *N Engl J Med*. 1997;337(15):1044–1051. doi:10.1056/NEJM199710093371505.
13. Jason LA, Ji PY, Anes MD, et al. Active enforcement of cigarette control laws in the prevention of cigarette sales to minors. *JAMA*. 1991;266(22):3159–3161. doi:10.1001/jama.1991.03470220075030.
14. Kanda H, Osaki Y, Ohida T, et al. Age verification cards fail to fully prevent minors from accessing tobacco products. *Tob Control*. 2011;20(2):163–165. doi:10.1136/tc.2010.036947.
15. Schneider S, Meyer C, Yamamoto S, et al. Implementation of electronic locking devices for adolescents at German tobacco vending machines: intended and unintended changes of supply and demand. *Tob Control*. 2009;18(4):294–301. doi:10.1136/tc.2008.028035.
16. Thomson CC, Gokhale M, Biener L, et al. Statewide evaluation of youth access ordinances in practice: effects of the implementation of community-level regulations in Massachusetts. *J Public Health Man*. 2004;10(6):481–489. doi:10.1097/00124784-200411000-00002.
17. Lewit EM, Hyland A, Kerrebrock N, et al. Price, public policy, and smoking in young people. *Tob Control*. 1997;6(suppl 2):S17–S24. doi:10.1136/tc.6.suppl_2.S17.
18. DiFranza JR, Savageau JA, Aisquith, BF. Youth access to tobacco: the effects of age, gender, vending machine locks, and “it’s the law” programs. *Am J Public Health*. 1996;86(2):221–224. doi:10.2105/AJPH.86.2.221.
19. Forster JL, Hourigan ME, Kelder S. Locking devices on cigarette vending machines: evaluation of a city ordinance. *Am J Public Health*. 1992;82(9):1217–1219. doi:10.2105/AJPH.82.9.1217.

20. Schneider S, Gruber J, Yamamoto S, et al. What happens after the implementation of electronic locking devices for adolescents at cigarette vending machines? A natural longitudinal experiment from 2005 to 2009 in Germany. *Nicotine Tob Res.* 2011;13(8):732–740. doi:10.1093/ntr/ntr067.
21. Botello MT, Haynie DL, Iannotti RJ, et al. Tobacco control policy and adolescent cigarette smoking status in the United States. *Nicotine Tob Res.* 2009;11(7):875–885. doi:10.1093/ntr/ntp081.
22. Hammond D. Smoking behaviour among young adults: beyond youth prevention. *Tob Control.* 2005;14(3):181–185. doi:10.1136/tc.2004.009621.
23. Gruzza RA, Plunk AD, Hipp PR, et al. Long-term effects of laws governing youth access to tobacco. *Am J Public Health.* 2013;103(8):1493–1499. doi:10.2105/AJPH.2012.301123.
24. Vuolo M, Kadowaki J, Kelly BC. A multilevel test of constrained choices theory: the case of tobacco clean air restrictions. *J Health Soc Behav.* In press.
25. Shang C. The effect of smoke-free air law in bars on smoking initiation and relapse among teenagers and young adults. *Int J Environ Res Public Health.* 2015;12(1):504–520. doi:10.3390/ijerph120100504.
26. Song AV, Dutra LM, Neilands TB, et al. Association of smoke-free laws with lower percentages of new and current smokers among adolescents and young adults: an 11-year longitudinal study. *JAMA Pediatr.* 2015;169(9):e152285. doi:10.1001/jamapediatrics.2015.2285.
27. Yang Y. Aging, Cohorts, and Methods. In: Binstock RH, George LK, eds. *Handbook of Aging and the Social Sciences*. 7th ed. New York, NY: Academic Press; 2010:17–30.
28. Bachman JG, Wadsworth KN, O'Malley PM, et al. *Smoking, Drinking, and Drug Use in Young Adulthood: the Impacts of New Freedoms and Responsibilities*. Mahwah, NJ: Lawrence Erlbaum; 1997.
29. Fleming CB, White HR, Catalano RF. Romantic relationships and substance use in early adulthood: an examination of the influences of relationship type, partner substance use, and relationship quality. *J Health Soc Behav.* 2010;51(2):153–167. doi:10.1177/0022146510368930.
30. Brown SL, Rinelli LN. Family structure, family processes, and adolescent smoking and drinking. *J Res Adolescence.* 2010;20(2):259–273. doi:10.1111/j.1532-7795.2010.00636.x.
31. Johnson MK. Further evidence on adolescent employment and substance use: differences by race and ethnicity. *J Health Soc Behav.* 2004;45(2):187–197. doi:10.1177/002214650404500205.
32. Alexander C, Piazza M, Mekos D, et al. Peers, schools, and adolescent cigarette smoking. *J Adolescent Health.* 2001;29(1):22–30. doi:10.1016/S1054-139X(01)00210-5.
33. Schulenberg JE, Bachman JG, O'Malley PM, et al. High school educational success and subsequent substance use: a panel analysis following adolescents into young adulthood. *J Health Soc Behav.* 1994;35(1):45–62. doi:10.2307/2137334.
34. Swan GE, Javitz HS, Jack LM, et al. Heterogeneity in 12-month outcome among female and male smokers. *Addiction.* 2004;99(2):237–250. doi:10.1111/j.1360-0443.2003.00629.x.
35. Schuck K, Otten R, Engels RCME. Bidirectional influences between parents and children in smoking behavior: a longitudinal full-family model. *Nicotine Tob Res.* 2013;15(1):44–51. doi:10.1093/ntr/nts082.
36. Braveman P, Egerter S, Williams DR. The social determinants of health: coming of age. *Annu Rev Publ Health.* 2011;32:381–398. doi:10.1146/annurev-publhealth-031210-101218.
37. Soteriades ES, DiFranza JR. Parents' socioeconomic status, adolescents' disposable income, and adolescents' smoking status in Massachusetts. *Am J Public Health.* 2003;93(7):1155–1160. doi:10.2105/AJPH.93.7.1155.
38. Pampel FC, Mollborn S, Lawrence EM. Life course transitions in early adulthood and SES disparities in tobacco use. *Soc Sci Res.* 2014;43:45–59. doi:10.1016/j.ssresearch.2013.08.005.
39. Margolis R. Educational differences in healthy behavior changes and adherence among middle-aged Americans. *J Health Soc Behav.* 2013;54(3):353–368. doi:10.1177/0022146513489312.
40. Robinson LA, Murray DM, Alfano CM. Ethnic differences in predictors of adolescent smoking onset and escalation: a longitudinal study from 7th to 12th grade. *Nicotine Tob Res.* 2006;8(2):297–307. doi:10.1080/14622200500490250.
41. Pampel FC. Racial convergence in cigarette use from adolescence to the mid-thirties. *J Health Soc Behav.* 2008;49(4):484–498. www.jstor.org/stable/27638773. Accessed January 17, 2016.
42. Pampel FC. Cigarette diffusion and sex differences in smoking. *J Health Soc Behav.* 2001;42(4):388–404. doi:10.2307/3090186.
43. Mathur C, Erickson DJ, Stigler MH, et al. Individual and neighborhood socioeconomic status effects on adolescent smoking: a multilevel cohort-sequential latent growth analysis. *Am J Public Health.* 2013;103(3):543–548. doi:10.2105/AJPH.2012.300830.
44. Halaby CN. Panel models for the analysis of change and growth in life course studies. In: Mortimer JT, Shanahan MJ, eds. *Handbook of the Life Course*. New York, NY: Kluwer/Plenum; 2003:503–527.
45. Rabe-Hesketh S, Skrondal A. *Multilevel and Longitudinal Modeling Using Stata, Volume I: Continuous Responses*. 3rd ed. College Station, TX: Stata Press; 2012.
46. Raudenbush SW, Bryk AS. *Hierarchical Linear Modeling: Applications and Data Analysis Methods*. 2nd ed. Thousand Oaks, CA: Sage; 2002.
47. Gilpin EA, White VM, Pierce JP. How effective are tobacco industry bar and club marketing efforts in reaching young adults? *Tob Control.* 2005;14(3):186–192. doi:10.1136/tc.2004.009712.
48. Sepe E, Ling PM, Glantz SA. Smooth moves: bar and nightclub tobacco promotions that target young adults. *Am J Public Health.* 2002;92(3):414–419. doi:10.2105/AJPH.92.3.414.