Original investigation

The Impact of a City-Wide Indoor Smoking Ban on Smoking and Drinking Behaviors Across Emerging Adulthood

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Abstract

Introduction: Almost one-third of college students report recent cigarette use, primarily as “social smoking,” and often in conjunction with alcohol use. While city-wide indoor smoking bans effectively reduce the number of social opportunities to smoke (eg, bars and music clubs), little is known about how these bans may impact the smoking behaviors of college students. Furthermore, nothing is known about how indoor smoking bans may impact students’ drinking behaviors. The current study aims to determine the impact of a city-wide comprehensive indoor smoking ban on smoking and alcohol behaviors among a longitudinal sample of emerging adults.

Methods: Data are from a 6-year longitudinal study (10 waves of data collection) that began the summer before college enrollment. Participants ($N = 2244$; 60% female) reported on their past 3-month smoking and drinking behaviors using Internet-based surveys at each wave. Piecewise linear growth modeling was used to determine how a city-wide comprehensive indoor smoking ban (implemented in the Fall of 2005 between Waves 4 and 5) impacted smoking frequency, cigarette quantity, drinking frequency, and number of binge drinking episodes.

Results: Smoking and alcohol use increased from the summer before college through the semester before implementation of the city-wide smoking ban. While smoking frequency ($P < .001$) and cigarette quantity ($P < .05$) declined after the ban, drinking frequency increased ($P < .001$) and the number of binge drinking episodes remained stable.

Conclusions: Current findings suggest that comprehensive indoor smoking bans can influence the smoking behaviors of emerging adults, whereas trajectories of drinking are relatively unchanged.

Introduction

Emerging adults (ages 18–25) exhibit the highest substance use rates of any age group,^{1–4} with almost 40% of these individuals endorsing recent smoking behaviors⁵; and recent research has suggested an increase in the number of young adults who initiate smoking during this period.⁶ Among college students specifically, 21% report past-month smoking, rates which have remained consistent since the 1990s,⁵ with the majority of student smokers endorsing light

and/or intermittent smoking behaviors. In addition, 60% of college students identify as current drinkers, with 40% reporting binge drinking (four/five or more drinks at a sitting for women/men⁷). Further, national prevalence studies have demonstrated that cigarette smoking and alcohol use are strongly correlated during emerging adulthood.^{5,8}

College student smokers frequently report smoking while consuming alcohol and are considered by many as “social smokers.”^{9,10}

More than half of these students do not self-identify as smokers,¹¹ which may make them less likely to acknowledge a nicotine addiction or the associated health risks. Interventions targeting regular tobacco users may prove to be less successful with low-use individuals identifying as nonsmokers. This is especially concerning given 87% of daily smokers and almost 50% of occasional smokers continue smoking throughout college,¹² thus implicating the college years as a critical time for solidifying smoking habits.

The transition into university life is often associated with marked increases in drinking frequency and problem drinking,¹³ but less is known about the unique and increasingly prevalent population of college student social smokers. These students tend to report smoking strictly while in social situations (eg, parties, bars), and most often accompanied by heavy alcohol use.¹⁴ Whereas daily cigarette smoking may be stigmatized, smoking at parties while consuming alcohol is often considered normative and socially acceptable among college students.¹⁴

Higher rates of alcohol consumption, both normative and problematic, are linked to male gender, white ethnicity, fraternity/sorority affiliation, and higher family income.^{15–18} Most efforts to characterize college student social smokers have found them to be primarily white, better educated, and wealthier than their peers.^{12,19,20} Impulsivity has frequently been associated with college student drinking.^{21–23} Whereas the psychosocial correlates of social and light/intermittent smoking are less frequently reported, impulsivity has also been linked to cigarette smoking across a wide continuum of types of smokers, spanning all ages and frequencies of use.^{24–27} Further information regarding these students' particular demographic and risk factors, as well as trajectories of use, is needed for more effectively tailored interventions.

In an effort to limit the use of tobacco products in public, as well as exposure to secondhand smoke, many urban areas have enacted comprehensive legislation to ban smoking in and around public venues. Evaluations of these initiatives have been predominantly positive, showing reductions in area-specific smoking prevalence, initiation of tobacco use, and myocardial infarction hospitalization rates, as well as increases in smoking cessation.^{28–31} Indoor smoking bans in the home and the workplace have also been associated with reductions in smoking behaviors among adults and adolescents.^{32,33} Smoking legislation also appears to play a role in reducing the quantity of alcohol consumed, as well as rates of alcohol use disorders, among heavy smokers.^{34,35}

It is unclear, however, whether all smokers are affected equally by indoor smoking bans. That is, smoking bans may contribute to greater deterrence in smoking among some people than among others. While indoor smoking bans potentially reduce the number of social opportunities to smoke, little is known about how these bans may impact the smoking or drinking behaviors of college students. For example, socioeconomic status (SES) may be associated with the effectiveness of smoking bans, given that the availability of discretionary income contributes to the elasticity of smoking as well as drinking rates.³⁶ It is possible that individuals with greater discretionary income are more likely to socialize in establishments impacted by indoor smoking bans (eg, bars or clubs rather than dormitory rooms). It may also be the case that people with certain personality types, such as those high in impulsivity, may be less deterred from smoking and/or drinking in response to bans that make indoor smoking illegal. Highly impulsive students are more likely to believe that smoking results in certain positive outcomes, such as increased concentration and desirable social interactions,^{37,38} which may outweigh any potential negative expectations associated with indoor smoking bans.

In September of 2005, Austin, Texas, implemented a city-wide comprehensive indoor smoking ban in restaurants, bars, billiard parlors, live music venues, workplaces, and within 15 feet from an entrance or operable window of an enclosed area in which smoking is prohibited.³⁹ The ordinance was narrowly passed by Austin voters and did not include any other efforts to curb smoking rates (ie, tax increases, limits on marketing). The college campus was excluded from this ban and smoking and other tobacco use was still permitted on campus throughout the current study.

Our study aims to explore the longitudinal effect of Austin's comprehensive indoor smoking ban on the self-reported smoking and drinking behaviors of college students across emerging adulthood. We further sought to determine whether certain individual characteristics were associated with the effectiveness of the ban. Consistent with substantial previous research, we expected that smoking and drinking would increase as students left high school and entered college.^{1,2,40–42} We further expected that white men, members of fraternities and sororities, and those with higher SES (ie, greater disposable income) and greater trait impulsivity would show the greatest increases in both behaviors upon college entry.^{15–17,19,20} The city-wide indoor smoking ban, implemented during students' sophomore year of college, was expected to disrupt the normal trajectory of continued increases in the frequency of college student smoking and drinking. However, it was unknown how individual characteristics would be related to the effectiveness of the indoor smoking ban.

Methods

Participants

Data are from a 6-year longitudinal study (10 data waves; $N = 2244$; 60% female) that began the summer before enrollment at The University of Texas at Austin (Table 1). Participants were incoming freshmen between the ages of 17 and 19, who had not previously attended college. Of the 6390 who could be contacted and were invited to participate (94% of the incoming class), 4832 met the additional eligibility criteria of being unmarried. Interested students were randomly assigned to one of three study samples, including 3046 who were asked to complete web-based surveys.⁴³ Participants who completed the first survey ($N = 2244$, response rate 74%) are included in the current analyses; 55% identified as white, 18% Asian-American, 16% Hispanic/Latino, 4% black, and 7% belonging to other racial/ethnic groups (Table 1). The racial/ethnic and gender distribution was comparable to the university's enrollment demographics for 2003–2004. Internet-based surveys were administered twice annually during years 1–3 (Waves 1–7) and once a year during years 4–6 (Waves 8–10). Attrition from wave-to-wave ranged from 2%–7% and overall sample attrition across the 6-year study was 37%. Results from attrition analyses suggest that males were more likely to drop out of the study than females; however, no other variables included in the present analyses (covariates or substance use outcomes) were associated with attrition. Participants received \$30 for the completion of the high school survey, \$20 for the Years 1–3 fall surveys, \$25 for the Years 1–3 spring surveys, and \$40 for the Years 4–6 surveys.

Measures

Cigarette Smoking

Participants reported on past 3-month tobacco smoking frequency (0 = "never," 1 = "rarely use tobacco," 2 = "typically use but not in past three months," 3 = "occasionally," 4 = "weekly, but not daily," and

Table 1. Baseline Characteristics of the Study Participants, Austin, TX, 2004–2009

Characteristic	N (%) or Mean $\pm$ SD
Age	18.41 $\pm$ 0.35
Gender	
Female	1344 (59.9)
Male	900 (40.1)
Ethnicity	
White	1210 (55.0)
Black	93 (4.2)
Asian	404 (18.4)
Hispanic	342 (15.6)
Multi	150 (6.8)
Parent education ^a	
<high school	83 (3.7)
High school graduate	161 (7.2)
Some college	220 (9.9)
Junior college/trade school degree	100 (4.5)
College degree	883 (39.7)
Post-graduate degree	778 (35.0)
Family income	
<20 000	163 (7.9)
20 000–39 999	300 (14.5)
40 000–59 999	287 (13.9)
60 000–99 999	588 (28.4)
$\geq$ 100 000	731 (35.3)
First semester fraternity/sorority affiliation ^b	
Affiliated	242 (11.7)
Not-Affiliated	1829 (88.3)
Impulsivity	2.07 $\pm$ 0.06

^aCalculated as the highest education level across both parents.

^bMeasured at Wave 2 when participants were in their first semester of college.

5 = “daily”). Occasional or greater users were then asked to report the number of cigarettes smoked on a typical day. The prevalence of occasional or greater use of tobacco ranged by wave from 15% to 21%, with almost twice as many occasional users as weekly and daily users at each wave. The average number of cigarettes smoked on a typical day among occasional or greater users ranged from 2.52 ($SD = 3.85$) to 3.34 ($SD = 6.68$); daily smokers had a higher average number of cigarettes smoked at each wave (range 5.52 to 8.14) compared with weekly (range 1.43 to 4.29) and occasional smokers (range 1.62 to 2.14).

Alcohol Use

Participants reported their frequency of drinking as the number of drinking days in a typical week during the past 3 months (range 0–7) on the Daily Drinking Questionnaire.⁴⁴ A single item also assessed the number of binge drinking episodes (four/five or more drinks at a sitting for women/men) during the past 3 months (range 0–90).⁷

Covariates

Individual-level characteristics include gender, race/ethnicity (dichotomized as white/non-white), fraternity or sorority membership (using Wave 2 responses), and family income and parent education as proxies for SES. Participants also responded to eight true/false items from the Zuckerman–Kuhlman Personality Questionnaire to assess impulsivity at Wave 1 (summed score, range 0–8).⁴⁵

Statistical Analyses

A series of piecewise growth models were estimated for each of the four substance use measures using MPlus Version 7.11.⁴⁶ The

piecewise model allows for the estimation of two distinct trajectories of substance use while incorporating the fundamental aspects of growth modeling: interindividual variability in both initial status (ie, random intercepts) and growth over time (ie, random slopes).⁴⁷ Piecewise growth modeling is particularly beneficial for assessing the impact of a natural experiment because of the flexibility to segment the overall trajectory pattern based on a priori time points.^{48,49} The growth models were estimated with the maximum likelihood estimator with robust standard errors,⁵⁰ to accommodate the non-normal outcomes. With maximum likelihood estimation, participants with at least one wave of data were included in the analyses.

For each substance use measure the two piecewise trajectories were defined as Wave 1 (baseline) to Wave 4 and Wave 5 to Wave 10 to determine the development of reported substance use prior to and following the 2005 comprehensive indoor smoking ban that occurred between Waves 4 and 5. Model fit was assessed using the following goodness of fit indices: the root mean square error of approximation (RMSEA), the robust comparative fit index (CFI), the Tucker Lewis index (TLI), and the standardized root mean square residual (SRMR). According to criteria provided by Hu and Bentler,⁵¹ values for the CFI and TLI greater than 0.95 suggest ideal fit, while 0.90 and higher is acceptable. Further, values less than 0.05 are desired for the RMSEA, and less than 0.08 for the SRMR index. Conditional piecewise growth models were also performed to investigate the association of participant characteristics with each of the latent growth parameters.

Results

The unconditional piecewise growth models indicated that both self-reported tobacco smoking frequency ($\beta = 0.127$, $P < .001$) and cigarette quantity ($\beta = 0.089$, $P < .05$) increased from the summer prior to college enrollment up to the semester before the city-wide smoking ban (Table 2, Figure 1). After the ban there was a significant decrease in both smoking frequency ($\beta = -0.036$, $P < .001$) and quantity ($\beta = -0.036$, $P < .05$). This particular parameterization fit the smoking frequency data very well (RMSEA = 0.049; CFI = 0.952; TLI = 0.953; SRMR = 0.034); however, poorer fit was found with the cigarette quantity measure (RMSEA = 0.030; CFI = 0.739; TLI = 0.745; SRMR = 0.117).

Both self-reported drinking frequency ($\beta = 0.381$, $P < .001$) and number of binge episodes ($\beta = 1.222$, $P < .001$) increased prior to the indoor smoking ban. However, unlike the smoking measures, drinking frequency continued to rise after the ban ($\beta = 0.168$, $P < .001$) while the number of binge drinking episodes remained constant ($\beta = -0.080$, $P > .05$). Acceptable fit was found in both alcohol models (drinking frequency: RMSEA = 0.074; CFI = 0.902; TLI = 0.904; SRMR = 0.051; number of binge episodes: RMSEA = 0.035; CFI = 0.935; TLI = 0.937; SRMR = 0.05).

Table 3 shows the results of the conditional piecewise growth models, which tested the associations between sociodemographic and behavioral characteristics and the three growth parameters (baseline, slope or change between baseline and the indoor smoking ban, and slope or change after the indoor smoking ban) for each substance use measure. Relatively few characteristics were associated with either cigarette quantity or smoking frequency. Gender, fraternity/sorority affiliation, and parent education were not associated with smoking behaviors at baseline, before or after the indoor smoking ban. White students had higher baseline levels of smoking frequency ($\beta = 0.155$, $P < .05$) compared with non-white students.

Table 2. Sample Means and Estimated Growth Parameters from Unconditional Piecewise Growth Models for Cigarette and Alcohol Use, Relative to a Comprehensive Indoor Smoking Ban in Austin, TX, 2004–2009

	Cigarette quantity	Smoking frequency ^a	Drinking frequency ^b	Number of binge drinking episodes ^c
Wave	Mean (SD)			
1	0.44 (2.26)	0.67 (1.36)	0.82 (1.24)	2.16 (5.41)
2	0.55 (3.26)	0.69 (1.39)	1.24 (1.51)	2.92 (6.23)
3	0.61 (2.68)	0.76 (1.44)	1.31 (1.51)	3.51 (7.19)
4	0.63 (3.12)	0.82 (1.48)	1.38 (1.51)	3.75 (6.96)
5	0.49 (1.96)	0.76 (1.41)	1.33 (1.55)	3.50 (6.99)
6	0.49 (1.97)	0.78 (1.45)	1.55 (1.66)	3.82 (7.28)
7	0.47 (2.03)	0.71 (1.39)	1.80 (1.74)	4.24 (7.50)
8	0.44 (1.94)	0.67 (1.35)	1.94 (1.81)	4.13 (7.26)
9	0.44 (2.04)	0.64 (1.33)	1.84 (1.81)	3.51 (6.42)
10	0.46 (1.83)	0.66 (1.33)	1.94 (1.88)	3.31 (6.55)
Growth parameters				
Fixed effects				
Intercept (baseline)	0.479***	0.606***	0.899***	2.246***
Slope 1 (pre-ban, W1–4)	0.089*	0.127***	0.381***	1.222***
Slope 2 (post-ban, W5–10)	–0.036*	–0.036***	0.168***	–0.080
Random effects				
Intercept (baseline)	1.378***	1.311***	1.108***	19.694***
Slope 1 (pre-ban, W1–4)	0.336	0.345***	0.452***	10.647***
Slope 2 (post-ban, W5–10)	0.152**	0.066***	0.141***	1.629***

The line between data collection Waves 4 and 5 denotes the implementation of the city-wide comprehensive indoor smoking ban.

^aFrequency of smoking in past 3 months (range 0–5).

^bFrequency of drinking in a typical week (range 0–7).

^cNumber of binge drinking episodes in the past 3 months (range 0–90).

* $P < .05$; ** $P < .01$; *** $P < .001$.

Figure 1. Unconditional piecewise growth models and calculated fit indices for cigarette and alcohol use, relative to a comprehensive indoor smoking ban in Austin, TX, 2004–2009. *Note.* CFI = confirmatory fit index; RMSEA = root mean square error; SRMR = standardized root mean square residual; TLI = Tucker Lewis Index.

While race was not related to the growth in smoking frequency either before or after the indoor smoking ban, white students did have greater growth in cigarette quantity before the smoking ban compared with non-white students ($\beta = 0.283$, $P < .01$). Family income was only associated with smoking behaviors after the indoor smoking ban was enacted, such that students with a higher family

income had greater desistance in both cigarette quantity ($\beta = -0.017$, $P < .05$) and smoking frequency ($\beta = -0.011$, $P < .01$).

In contrast to the smoking measures, most of the sociodemographic characteristics were associated with one or both of the drinking measures. Females had higher drinking frequency at baseline ($\beta = -0.120$, $P < .05$), but males had greater growth compared

Table 3. Associations Between Baseline Characteristics (Estimates and Standard Deviations) and the Piecewise Growth Model Parameters Around a City-Wide, Comprehensive Indoor Smoking Ban, Austin, TX, 2004–2009

	Male	White	Fraternity/sorority affiliation	Family income	Parent education	Impulsivity
	β (SD)					
Cigarette quantity						
Intercept (baseline)	–0.107 (0.094)	–0.082 (0.129)	–0.067 (0.111)	0.016 (0.028)	–0.015 (0.042)	0.059 (0.025)*
Slope 1 (pre-ban)	0.150 (0.077)	0.283 (0.092)**	0.062 (0.119)	0.004 (0.021)	0.006 (0.034)	0.059 (0.021)**
Slope 2 (post-ban)	–0.017 (0.029)	–0.037 (0.031)	–0.016 (0.039)	–0.017 (0.007)*	0.009 (0.013)	–0.034 (0.009)***
Smoking frequency						
Intercept (baseline)	–0.034 (0.061)	0.155 (0.066)*	0.084 (0.094)	0.030 (0.016)	–0.014 (0.024)	0.093 (0.017)***
Slope 1 (pre-ban)	0.073 (0.042)	0.035 (0.041)	–0.133 (0.070)	0.003 (0.009)	0.014 (0.015)	0.015 (0.010)
Slope 2 (post-ban)	0.007 (0.018)	0.007 (0.018)	0.019 (0.027)	–0.011 (0.004)**	–0.001 (0.008)	–0.006 (0.005)
Drinking frequency						
Intercept (baseline)	–0.120 (0.058)*	0.327 (0.061)***	0.507 (0.106)***	0.016 (0.014)	–0.041 (0.023)	0.070 (0.015)***
Slope 1 (pre-ban)	0.112 (0.045)*	0.059 (0.047)	0.182 (0.081)*	0.041 (0.011)***	–0.021 (0.017)	0.032 (0.011)**
Slope 2 (post-ban)	0.030 (0.026)	0.117 (0.026)***	–0.167 (0.045)***	–0.006 (0.006)	0.025 (0.010)*	–0.005 (0.006)
Number of binge drinking episodes						
Intercept (baseline)	–0.209 (0.256)	1.233 (0.251)***	1.725 (0.526)***	0.140 (0.057)*	–0.056 (0.095)	0.216 (0.085)**
Slope 1 (pre-ban)	0.685 (0.220)**	0.406 (0.205)*	1.181 (0.442)*	0.056 (0.046)	–0.043 (0.071)	0.086 (0.061)
Slope 2 (post-ban)	–0.079 (0.094)	–0.062 (0.093)	–0.845 (0.178)***	–0.011 (0.020)	–0.018 (0.035)	0.013 (0.026)

Note. * $P < .05$; ** $P < .01$; *** $P < .001$.

with females in both drinking frequency ($\beta = 0.112$, $P < .05$) and number of binge drinking episodes ($\beta = 0.685$, $P < .01$) between baseline and the indoor smoking ban. White students had higher baseline levels of drinking frequency ($\beta = 0.327$, $P < .001$) and number of binge drinking episodes ($\beta = 1.233$, $P < .001$) compared with non-white students. An interesting pattern emerged in regards to drinking patterns and race, such that white race was associated with greater growth in binge drinking episodes before the indoor smoking ban ($\beta = 0.406$, $P < .05$) but was not related to an increase in drinking frequency. After the indoor smoking ban, white students had greater growth in drinking frequency ($\beta = 0.117$, $P < .001$) than non-white students while the number of binge drinking episodes was unrelated to race. Students who were in a fraternity or sorority in their first semester of college had a similar pattern in both drinking frequency and number of binge drinking episodes, such that baseline levels were higher ($\beta = 0.507$, $P < .001$; $\beta = 1.725$, $P < .001$, respectively), growth was higher pre-ban ($\beta = 0.182$, $P < .05$; $\beta = 1.181$, $P < .01$, respectively), the number of binge drinking episodes decreased rather than remained stable post-ban ($\beta = -0.845$, $P < .001$), and drinking frequency remained stable rather than increased post-ban ($\beta = -0.167$, $P < .001$) compared with non-fraternity/sorority affiliated students. Estimated family income was linked to baseline binge drinking, such that higher income students reported more binge drinking episodes during the summer prior to matriculation ($\beta = 0.140$, $P < .05$). Students with higher family income had greater growth in drinking frequency prior to the smoking ban ($\beta = 0.041$, $P < .001$), but family income was not related to either drinking behavior after the smoking ban. Students whose parents had less formal education had greater growth in drinking frequency after the indoor smoking ban was enacted ($\beta = 0.025$, $P < .05$).

Self-reported impulsivity was positively associated with baseline cigarette quantity ($\beta = 0.059$, $P < .05$), smoking frequency ($\beta = 0.093$, $P < .001$), drinking frequency ($\beta = 0.070$, $P < .001$), and number of binge drinking episodes ($\beta = 0.216$, $P < .01$). Impulsivity was also strongly associated with greater growth in both cigarette quantity ($\beta = 0.059$, $P < .01$) and drinking frequency ($\beta = 0.032$,

$P < .01$) before the indoor smoking ban was in place. Impulsivity was not associated with either drinking behavior after the indoor smoking ban was put into place, but students with higher impulsivity had higher levels of desistance in their reported cigarette quantity after the ban's implementation ($\beta = -0.034$, $P < .001$).

Discussion

Current findings support past research showing that substance use increases during the transition from high school into early college.^{1,2,4–6,52} We found that the implementation of a city-wide smoking ban interrupted the expected growth in smoking behavior and resulted in a decrease in both the daily quantity of cigarettes smoked and past 3-month smoking frequency. Furthermore, we found that the impact of the ban varied by sociobehavioral characteristics. The current results suggest that city-wide comprehensive indoor smoking bans can influence the smoking behaviors of college students, even when students are on a campus that permits smoking.

Similar to national trends of college students,⁵ both the typical number of cigarettes smoked per day and the frequency of smoking in the past 3 months increased in the overall sample from the semester prior to high school graduation into the sophomore year of college, when the comprehensive indoor smoking ban was implemented. Our study findings suggest that individual-level efforts to prevent or reduce smoking among college students should focus on students identifying as white and students reporting higher trait impulsivity at college entry, as these students exhibited the highest levels of smoking upon college entry and greater increases in smoking behaviors during the first few semesters after enrollment. However, unlike national trends, both measures of smoking showed decline beginning the semester after the implementation of the comprehensive indoor smoking ban.

Students reporting a higher family income at college enrollment reported a greater decrease in their smoking behaviors following the ban. Perhaps these students, who had more discretionary income, were more likely to be smoking (and drinking) at bars, dance clubs,

or local restaurants. Their social smoking would then have a greater likelihood of decreasing when these locations became smoke-free. It is also possible that students with higher SES place a greater value on compliance with legal requirements. Although there are many factors contributing to substance use, it is clear that SES remains an important predictor of smoking.⁵³

Somewhat surprisingly, the city-wide comprehensive indoor smoking ban had an even greater impact on students who self-reported higher impulsivity. This is the first study, to our knowledge, to show that those high in impulsivity may be responsive to environmental constraints on behavior. The ban influenced the quantity of cigarettes smoked rather than the frequency of smoking. In other words, while city-wide smoking policies may not prevent an impulsive student from smoking, they may decrease the number of cigarettes she/he smokes on any one occasion. The measure of impulsivity in this study tapped into the domain of impulsive action (ie, poor inhibitory control), rather than impulsive choice (ie, poor decision making).⁵⁴ It is possible students high in impulsivity were more strongly influenced by the ban because there were fewer offers of cigarettes from peers and therefore fewer opportunities to make a compulsive action.

Another important consideration is that after the implementation of the indoor smoking ban patrons were required to leave establishments in order to smoke a cigarette, thereby decreasing the amount of socialization around smoking. It is possible that this contributed to an increase in perceived peer disapproval of smoking. Previous work with smokers in Europe found that awareness of smoking restrictions was associated with an increase in perceived disapproval of smoking and discomfort smoking in public.⁵⁵ Furthermore, the smoke-free legislation impacted quit attempts and smoking cessation through perceived disapproval⁵⁵ and personal support for the legislation and attitudes about quitting.³¹ While the current study did not assess these psychosocial variables related to smoking cessation, previous research has shown that smoking among college students tends to be a social activity.¹⁴ Social norms could also explain why the policy had a greater impact on the smoking behaviors of impulsive students—students high in impulsivity are more likely to have positive expectancies regarding smoking, and, more specifically, believe in the social benefits of smoking.³⁸ Future research should examine the smoking expectancies of college students, especially those who self-report as highly impulsive, to determine if changes explain the impact of smoking legislation and to further develop strategies to decrease tobacco use.

Despite the effects on smoking behaviors, the city-wide comprehensive indoor smoking ban had little effect on the rates of self-reported alcohol use. Drinking frequency continued to increase after the ban, whereas the number of binge drinking episodes remained about the same as before the ban was implemented. While counter to our hypothesis, our finding of differential impact of the indoor smoking ban on smoking and drinking behaviors supports international research showing that smoke-free policies do not, in general, impact alcohol consumption among adult smokers.³⁴

It is also important to note that, in the current study, the mean age at Wave 5 (after the ban was implemented) was just over 20 years of age. The pattern of alcohol use found in this study is therefore consistent with other studies that find the frequency of drinking continues to increase throughout emerging adulthood, whereas the quantity of consumption per drinking occasion tends to abate once students reach legal drinking age.^{5,56} Given that previous research has shown that the location of drinking influenced whether

smoke-free policies influenced drinking among smokers,⁵⁷ it is also possible that we did not see a decline in drinking behaviors in our sample because the majority of the sample was under the legal drinking age when the indoor smoking ban went into effect. The impact of indoor smoking bans on drinking behaviors may vary based on the age of the individual, a factor we were unable to test due to the relative homogeneity of age within our study sample.

The somewhat surprising finding that both drinking frequency and number of binge drinking episodes decreased for members of fraternity and sororities after the smoking ban also is supported by this prior research, which found that smoke-free policies did result in a decrease in alcohol use among the highest-risk drinkers.³⁴ Given that fraternity and sorority membership is associated with a higher likelihood of owning a fake ID,⁵⁸ it is possible that these students were more likely to be drinking alcohol in locations that permitted smoking prior to the indoor smoking ban. While membership in these organizations may contribute to higher rates of alcohol use (supported in this study as well with higher baseline and pre-ban growth), our results suggest that restrictions on other substances, such as tobacco smoking, may lead to a decrease in alcohol use among this high-risk group of college students.

Limitations

Despite the important findings of this study, there are limitations. The substance use measures were based on an average self-report of behavior occurring in the past 3 months, so it is possible that we did not capture extremely rare tobacco users. This is particularly true of the cigarette quantity measure that was only asked of participants who noted occasional or greater use of tobacco in the past 3 months. This potential exclusion of users could explain the poorer fit of the cigarette quantity model compared with the other three models (cigarette frequency, drinking frequency, and number of binge drinking episodes). A number of statistical techniques were attempted to improve the fit of the cigarette quantity model, including correlating the error terms for adjacent time periods and testing various shapes (eg, intercept-intercept, linear-intercept, and linear-quadratic). Given that none of these techniques improved the fit of the cigarette quantity model, the findings related to this outcome should be interpreted cautiously. While a significant strength of this study is the use of a longitudinal sample that allowed for the determination of individual changes in substance using behaviors, an inherent weakness is sample attrition. However, we found no significant differences in substance use between participants who were retained in the sample after the ban and those who withdrew prior to Wave 4.

Whereas this study is unique because it capitalized on the opportunity to analyze a natural experiment, there are a number of limitations due to a lack of measures related to smoking behaviors. For example, students were not asked about where they engaged in tobacco or alcohol use (eg, dormitory rooms, off-campus housing, or city-based bars/clubs). Related, it was not possible to test the effectiveness of the ban on participants with different smoking styles (eg, social vs. solitary). The current study also did not include psychosocial variables related to smoking initiation or cessation, including peer approval or attitudes towards smoking, which limited the ability to examine theoretical mechanisms explaining the impact of the indoor smoking ban.

Future research should focus on the role of different styles and settings of smoking behavior, specifically how these differences may be impacted by comprehensive indoor smoking bans, and the mechanisms explaining these relationships. Because most college students

engage in smoking while in social settings, such as parties and bars, it is possible that social smokers who smoke only when they drink might show greater decreases in smoking when bars no longer allow smoking. Conversely, heavier or more dependent smokers who smoke regardless of the social setting might be less deterred by indoor smoking bans. While not comprehensive, post-hoc analyses were run to determine if the indoor smoking ban had a differential impact based on smoking behaviors freshman year (results available upon request). Declines in smoking frequency and cigarette quantity after the ban were seen among students who were weekly or greater smokers at Wave 2 and a decline in smoking frequency was also seen among students who were never smokers at Wave 2. However, there were a relatively small number of weekly or greater smokers in the current study, so future research should aim to replicate these analyses in a larger study sample.

This study was also limited to the impact of a ban among full-time students at one university that permitted smoking on-campus in one relatively large city, which limits the generalizability of the findings. Future research should examine the role of city-wide indoor smoking bans on the substance use among other emerging adult populations, including those enrolled in 2-year or vocational schools and emerging adults not enrolled in college. Finally, without a control jurisdiction, it is impossible to make causal inferences that the policy change led to the observed changes in smoking. It may be, for example, that more negative opinions about smoking led to the implementation of the ban, and that these views could have resulted in reductions in smoking even without a ban. Nevertheless, current findings clearly indicate that smoking is reduced when a comprehensive indoor ban is in place.

Conclusions

We seized the opportunity of a natural experiment to determine how a city-wide comprehensive indoor smoking ban impacts self-reported tobacco and alcohol use among emerging adults.⁵⁹ While limited to the existing questionnaires of the original study, the findings demonstrate the utility of secondary data analysis, and more specifically piecewise growth modeling, in evaluating the effectiveness of public health policies. Study results demonstrate that drinking behaviors are not likely impacted by city-wide smoking policies. However, both the quantity and frequency of tobacco use decreased after the implementation of the ban, even though these students were on a campus that continued to permit smoking. The college years are a time when smoking habits are established, making it a critical time for intervention. While this study adds to the increasing evidence that city-wide indoor smoking bans are effective in decreasing the rates of smoking, it also supports the need for comprehensive smoking bans on college campuses.

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Declaration of Interests

None declared.

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