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State Alcohol Policies, Taxes, and Availability as Predictors of Adolescent Binge Drinking Trajectories into Early Adulthood

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Abstract

Background and Aims: A number of alcohol policies in the United States have been presumed to reduce underage youth drinking. This study characterized underage youth binge drinking trajectories into early adulthood and tested associations with the strength of the alcohol policy environment, beer excise taxes, and number of liquor stores.

Design: Longitudinal cohort study.

Setting: USA.

Participants: A national cohort of 10th graders in 2010 (n=2753), assessed annually from 2010–2015.

Measurements: Participants reported on their 30-day binge drinking (defined as consuming 5+ (for boys) or 4+ (for girls) drinks within 2 hours). We scored the strength of 19 state-level policies at baseline and summarized them into an overall score and two subdomain scores. We also assessed state beer excise taxes (dollars/gallon) and linked the number of liquor stores in 1-km to participant's geocoded address.

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Author Contributions

Study concept and design: Fairman, Gilman

Acquisition, analysis, or interpretation of data: All authors

Drafting of the manuscript: Fairman

Critical revision of the manuscript for important intellectual content: All authors

Statistical analysis: Fairman

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Information on Author Access to Data

Dr. Fairman had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Disclosure of Potential Conflicts of Interest

None reported

Findings: We identified five binge drinking trajectories: low-risk (32.9%), escalating (26.1%), late-onset (13.8%), chronic (15.1%), and decreasing (12.0%). Lower overall alcohol policy strength was associated with increased risk of being in the escalating vs. low-risk binge drinking class (relative risk ratio, RRR = 1.4 per 1 SD in policy score; 95% CI [1.2, 1.8]). Higher beer excise taxes were associated with a reduced risk of being in the escalating class (RRR = 0.2 per 1 dollar increase; 95% CI [0.1, 0.6]). The number of liquor stores was not significantly associated with any binge drinking trajectory.

Conclusions: In the US, stronger state alcohol policies and higher beer excise taxes appear to be associated with lower risk of escalating alcohol consumption trajectories among underage youth.

Keywords

alcohol; binge drinking; policy; taxes; adolescents; outlets

INTRODUCTION

Excessive drinking is a serious but preventable global health concern for underaged youth, which increases the risk for serious injury, especially motor vehicle crashes, violence, including homicide, suicide, intimate partner violence, and sexual assault, as well as alcohol use disorder (1). Despite recent declines in underage drinking and alcohol-related traffic fatalities, underage excessive drinking continues to claim about 4,300 lives annually in the United States (2–4). Starting in 1984, the US raised the minimum legal drinking age to 21 years nationwide for alcohol possession and purchase which has been associated with declines in underage drinking and traffic fatalities (5–8). Today, more than a dozen additional policies targeting underage youth drinking, alcohol providers, and drinking and driving have been adopted to varying degrees and strengths (9). Recent evidence has suggested that stronger policies, rather than just their presence or absence, is associated with lower underage traffic fatality rates and binge drinking (10–15). However, what remains unclear is the extent to which stronger alcohol policies are related to the prospective risk of underage drinking over time.

Evaluating the contribution of these additional alcohol policies in reducing alcohol outcomes has been a challenge. Policy enactment and strength may be correlated within states and recent evidence suggests an increase in implementation of less effective policies over time (16). The combined effects of these alcohol policies are uncertain. As a result, researchers have started to focus on the relationship between the overall alcohol policy environment and drinking outcomes. One US study showed that stronger consumption/possession policies were associated with lower rates of past-month binge drinking among adults (12). Another research group reported that US states with an overall stronger alcohol policy environment had lower state-level and individual-level binge drinking among adults and adolescents (13–15). However, these studies were based on cross-sectional and ecological designs, which limit the ability to make causal inferences and are uninformative about how alcohol policies might influence drinking behaviors over time.

Data from longitudinal cohort studies could provide insights about causality and changes over time, but such studies have been scarce. Researchers in a 2012 Dutch study found that

increasing alcohol retail inspections did not reduce weekly adolescent drinking, but did reduce drunkenness among drinkers over three years (17). More recently, researchers reported that lower alcohol policy comprehensiveness and enforcement in Californian cities increased adolescent heavy drinking over 1–2 years (18). Notable gaps in the literature remain regarding whether the alcohol policy environment is associated with drinking development over longer periods of time, specifically during late adolescence when excessive drinking risk increases (19).

Policies that affect drinking rates in general, such as alcohol costs and outlet density, might also influence underaged drinking. Raising the alcohol costs via taxes and limiting the density and location of alcohol outlets has been hypothesized to decrease the general demand and availability of alcohol. In the US, states impose specific excise taxes based on alcohol volume by beverage type (beer, wine, and spirits) at the wholesale or retail level, increasing costs, which is consistently correlated with lower drinking rates, including in some studies of underage youth (20–22). By contrast, researchers have reported mixed evidence for alcohol outlet density and individual consumption (23,24). As with other policies, there has been insufficient evidence from longitudinal studies.

The objective of this research was to determine how alcohol policies are related to binge drinking among underaged youth over time. Specifically, we sought to determine the extent to which the alcohol policy environment, beer excise taxes, and the number of liquor stores were associated with underage binge drinking trajectories. Evidence from prior studies has shown different population subgroups of drinking trajectories over time (25–28). Building upon prior work of others (29), we developed summary measures of the overall policy environment and subdomains targeting to underaged youth and alcohol providers. A focus on beer excise taxes was motivated by prior research that showed beer accounted for two-thirds of alcohol consumed during binge drinking (30). Finally, we explored relationships between binge drinking trajectories and individual alcohol policies.

METHODS

Study Design and Participants

The NEXT Generation Health Study followed a nationally-representative cohort of US 10th-graders starting in 2010. School districts or groups of school districts served as the primary sampling unit; 80 out of 137 (58.4%) selected schools participated. Students were surveyed annually with school-based assessment in the spring semester at Wave 1 and web-based assessments during the spring at five subsequent waves (Waves 2–6); retention was 78.2% or better at each wave. A total of 2785 were surveyed, but due to missing data on the outcome or other key variables, a small number ($n = 32$) could not be included in analyses ($n = 2753$). Students at Wave 1 were sampled from 22 states (sample size): California (570), Colorado (26), Connecticut (31), Florida (528), Georgia (76), Idaho (25), Illinois (264), Kentucky (89), Louisiana (160), Massachusetts (86), Michigan (23), Minnesota (16), Nevada (23), New York (133), Ohio (71), Oregon (34), Pennsylvania (110), South Dakota (86), Tennessee (85), Texas (77), West Virginia (78), and Wisconsin (162). Students provided assent with parental consent and then consent upon reaching adulthood. The study protocol was

approved by the institutional review board (IRB) for the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development.

Measures

Binge Drinking.—Binge drinking was defined as consuming five (for boys)/four (for girls) or more drinks either in a row or on an occasion within two hours. At each wave, frequency was assessed as the number of binge drinking occasions within the last 30 days (*never*, *1–2*, *3–5*, *6–9*, or *10 or more times*). Responses were recoded to reflect the minimum frequency value of each category (*never*=0, *1–2*=1, etc.).

Baseline Demographics.—Sex (male, female), race/ethnicity (White, Black, Hispanic, other), and family affluence (low, moderate, high) were assessed at baseline. The Family Affluence Scale is a validated measure of self-reported family SES based on four items: the number of computers in the household, whether the adolescent has their own bedroom, family automobile ownership, and family vacations taken within the last year (31).

Alcohol Policies.—Data on alcohol policies in effect on January 1, 2010 prior to Wave 1 were obtained from the Alcohol Policy Information System (APIS) and other public sources (9,32). Underage youth policies examined included possession, consumption, internal possession, purchasing, use/lose, and false identification (ID). Alcohol provider policies examined included furnishing, on-premise servers, on-premise bartenders, off-premise sellers, keg registration, responsible beverage service (RBS) training, retailer support for false IDs, hosting underage drinking parties, dram shop liability, and social host civil liability. General alcohol policies examined included suppliers of false IDs, alcohol control retail distribution, Sunday sales, and beer excise taxes (\$) per gallon at the wholesale/retail level (see Table 1 for descriptions). With exception of beer excise taxes, the strength of each policy was scored based on enactment and presence of exceptions or restrictions that weaken the policy. Scores were calibrated to range from 0 (no law) to 1 (reflecting the strongest existing law). An overall score of alcohol policies (excluding beer excise taxes) was based on the sum of the standardized individual policy scores. Overall scores were then standardized to the national distribution by subtracting the national mean (0) and dividing by the national standard deviation (0.3). Subdomain scores for underage youth and alcohol provider policies were similarly created. Scores were then inverted, such that higher scores indicated weaker alcohol policy environments. Details of the scoring procedure are available in the online supplement.

Liquor Stores and Neighborhood Measures.—Students' geocoded home address at Wave 1 were linked to neighborhood-level number of liquor stores, demographics, and socioeconomic disadvantage. The number of off-premise liquor stores within 1-km was based on business address data provided by Dun & Bradstreet (www.dnb.com). Median age and socioeconomic conditions of Census tracts were obtained from the 2006–2010 American Community Survey (ACS). Following prior work (33), a single measure of socioeconomic disadvantage was created by retaining the first, largest factor (53% of total variance) from a principal component analysis of 10 income, educational, and employment indicators (details available in the online supplement).

Analysis

We used latent growth mixture modeling (GMM) to identify binge drinking trajectories across six waves. Binge drinking frequency was treated as having a negative binomial distribution to deal with non-normality and over-dispersion in count responses. Our GMM analyses examined solutions with up to 10 trajectory classes unless models failed to converge. We compared linear (slope) and non-linear (quadratic) growth trajectory models, tested for within-class factor (co)variances, and selected the best model based on Bayesian information criterion (BIC), sample size per latent class, and substantive theory. Full-information maximum likelihood (ML) dealt with partially missing data, which is valid under data missing at random assumptions (34). We used 500 random starts with 100 final stage optimizations to help ensure that the best loglikelihood for the ML procedure was replicated, indicating a greater confidence that the models converged on a global, rather than local solution. Participants were assigned to a binge trajectory class based on their most likely class membership. We accounted for the complex survey design in these analyses using *Mplus* version 7.4 (35).

Binge drinking trajectory class membership then served as the dependent variable in multinomial logistic regression models. Model 1 estimated associations with the overall policy environment, beer excise taxes, and liquor stores controlling for other individual- and neighborhood-level covariates. Model 2 estimated independent associations for underage youth and alcohol provider policy scores on binge drinking trajectories. Exploratory analyses probed associations with individual alcohol policies. Exponentiated regression coefficients were interpreted as relative risk ratios (RRR). Analyses accounted for the clustered sampling design and sampling weights via the *svy* command in Stata version 14 (36).

RESULTS

Summary of the Sample, Alcohol Policies, and Binge Drinking Trajectories

At Wave 1, participants were 55% female, aged 16.2 years, 40% White, 30% Hispanic, and 25% Black, and 46% of moderate affluence (Table 2). Mean (SD) of overall and underage youth policy scores in sampled states were both 0.3 (0.6), respectively; 0.1 (0.9) for the alcohol provider policy score. Thus, alcohol policies in the 22 states represented in the sample were slightly weaker than the entire US. No participants were sampled from Utah, which was an outlier as having the strongest alcohol policies (see the online supplement for the distribution of policy scores for all US states). Average beer excise taxes per gallon was \$0.30 (0.02) and participants lived near about 0.9 (1.5) liquor stores within 1-km.

Mean number of past 30-day binge drinking occasions increased from 0.65 (Wave 1) to 1.27 (Wave 6; see dotted line in Figure 1) and binge drinking was moderately correlated between waves (for example, $r_{w1-w2} = 0.44$, $r_{w2-w3} = 0.39$, $r_{w3-w4} = 0.40$, $r_{w4-w5} = 0.57$, and $r_{w5-w6} = 0.51$). The 5-class latent GMM was chosen the best model (BIC = 32917.98). A low-risk binge drinking class was the largest (32.9%), characterized by little to no binge drinking over the study period (Figure 1). An escalating trajectory class (26.1%) represented the largest group of binge drinkers and was characterized by little to no binge drinking at Wave

1, which then increased over time and peaked by Wave 5. Chronic (15.1%) and decreasing (13.8%) trajectory classes both had relatively high binge drinking frequency at Wave 1 that either slightly increased over time (chronic) or declined (decreasing). A late-onset trajectory class (13.8%) was characterized by little to no binge drinking until Wave 6. Models extracting a higher number of classes were rejected due to small class sizes (less than 5% in each class) and marginal improvement in model fit. Model fit statistics and trajectory plots for all models are available in the online supplement.

Associations Between Alcohol Policies and Binge Drinking Trajectories

A standard deviation increase in the overall alcohol policy score, indicating a weaker alcohol policy environment, was associated with membership in the escalating vs. low-risk binge drinking trajectory class (RRR = 1.44; 95% CI [1.17, 1.77]) after controlling for beer excise taxes, the number of liquor stores, and other neighborhood- and individual-level factors (Model 1, Table 3). The overall alcohol policy score was not associated with being in any of the other trajectory classes; an omnibus F-test indicated a statistically significant difference between all four binge drinking trajectories and the low-risk class ($F_{4,18} = 3.06$; $p = 0.04$). Each dollar increase in beer excise taxes was associated with a lower risk of being in the escalating (RRR = 0.21; 95% CI [0.07, 0.58]) and late-onset classes (RRR = 0.35; 95% CI [0.13, 0.96]). The number of liquor stores within 1-km was not associated with any binge drinking trajectory.

We then examined the subdomains of underage youth and alcohol provider policies associated with binge drinking trajectories (Model 2; Table 3). Weaker underage youth policy scores were associated with being in the escalating trajectory class (RRR = 1.24; 95% CI [1.03, 1.49]), while weaker alcohol provider policy scores were positively associated with both membership in the escalating (RRR = 1.35; 95% CI [1.17, 1.55]) and decreasing classes (RRR = 1.39; 95% CI [1.08, 1.78]). Estimates for beer excise taxes and the number of liquor stores remained relatively unchanged from Model 1.

Finally, our exploratory analyses examined associations with individual alcohol policies (Table 4). Weaker furnishing policies were associated with membership in the escalating (RRR = 1.52), chronic (RRR = 1.51), and decreasing (RRR = 1.33) binge drinking trajectory classes. Weaker purchase (RRR = 1.28) and RBS training policies (RRR = 1.19) were associated with the escalating class, weaker internal possession (RRR = 1.43) and use/lose policies (RRR = 1.28) were associated with the late-onset class, and weaker false ID for youth (RRR = 1.95) and furnishing policies (RRR = 1.33) were associated with the decreasing class. There were a few inverse associations between social host liability policies and the escalating class (RRR = 0.83), age of off-premise seller policy and the chronic class (RRR = 0.52), and consumption policies and the decreasing class (RRR = 0.63).

DISCUSSION

We expected that underaged youth exposed to weaker alcohol policies in late adolescence would be at risk for binge drinking over time. Our results confirm that weaker alcohol policies are associated with a 40% increased risk of membership in the escalation binge drinking class compared to those who in the low-risk class; about a quarter of underaged

youth by ages 20–21 escalate their binge drinking to about twice a month while a third abstain. Risk may be higher for weaker alcohol provider policies than for underage youth policies, but differences were not significant. Beer excise taxes also strongly predicted binge drinking with each dollar increase associated with a 3-to-4-fold decrease in risk of escalating or late-onset (around age 21) binge drinking. However, our evidence was inconclusive with respect to our other binge drinking trajectory classes or the number of liquor stores.

The five binge drinking trajectories we identified (low-risk, escalating, late-onset, chronic, and decreasing) were similar to those found in prior studies using similar methods (25,37–42). Several of these studies have identified a large group characterized by little to no binge drinking (~36%–70%), and while our low-risk group (33%) was at the low end of this range, this difference could be due to the age period we examined and identifying a late-onset group (14%). Studies have reported a trajectory similar to our escalation group, but its prevalence and age of onset varies likely due to differences in the age of the sample and number of classes extracted (25,26,40,41). Chronic and decreasing binge drinking trajectories have been frequently identified in past studies and are less prevalent (<10%). In studies that have followed younger adolescents (e.g., 12-to-13-year-olds), researchers have identified early onset (before 16) binge drinking patterns that quickly escalate and then either persists into early adulthood or declines during late adolescence (38–40). Since our data were censored for ages before 16, our chronic and decreasing trajectories might correspond to these early onset patterns.

Our findings were less clear or inconclusive concerning alcohol policies and the lower prevalent binge drinking trajectories (late-onset, chronic, and decreasing). Weaker alcohol provider policies were associated with being in the decreasing class, which might have reflected differences in binge drinking at baseline, yet similar evidence for the chronic class was lacking. Small class sizes in these trajectory groups might have limited statistical power to detect clear associations. Alternatively, these alcohol policies could be less effective in predicting early onset, high-risk binge drinking where more proximal risk factors, such as parental and peer influences, are more relevant. With respect to the late-onset binge drinking group, we might expect these policies to have limited effect at preventing binge drinking once youth reach the legal drinking age.

Consistent with research on alcohol taxes and consumption (20), membership in the escalating and late-onset binge drinking trajectories was inversely related to beer excise taxes. Higher beer costs might reduce opportunities and quantities of alcohol underage youth can consume and reduce rates of adult drinking which is related to youth drinking (22). However, our findings were inconclusive for beer excise taxes and chronic or decreasing binge drinking trajectories. Heavier drinkers may be less sensitive to price (43). Variation in these findings could also be due to the extent taxes are passed through to consumers, which can vary by beverage cost and alcohol type (44,45). Wine and liquor excise taxes might also play a role; however, we note that few youth during this age period consume wine and the correlation among beer, wine, and liquor excise taxes tends to be high (46,47).

Our evidence does not support an association between living near more off-premise liquor stores during late adolescence and later binge drinking trajectory. One interpretation of this

finding is that neighborhood alcohol availability in late adolescence may not be relevant to binge drinking development into early adulthood. However, we were unable to include other potential sources of alcohol availability, such as grocery stores, gas stations, and on-premise outlets (e.g., bars and restaurants) could have affected these findings. Additionally, alcohol outlet density may poorly capture true availability among underage youth who may be more likely to obtain alcohol from family and peer sources (48–50). Adolescent exposure to alcohol availability might also not adequately reflect changes over time once youth leave the familial home after high school and attend college. Between-study variation in the population under study (adolescents vs adults), drinking outcomes (any alcohol use vs heavy use), and sample representativeness (urban vs national) might further contribute to the mixed findings as seen in the literature.

Several individual alcohol policies were associated with binge drinking trajectories, including weaker furnishing, purchase, and RBS training policies. Exemptions to furnishing policy include when alcohol is provided by a parent or legally-aged spouse. Parents may believe that providing a safe, supervised drinking environment promotes responsible drinking behaviors, but the evidence suggests otherwise (51,52). Weaker purchasing policies exclude exemptions for minors working with law enforcement to check merchant compliance, which might contribute to minors having greater success in illegally buying alcohol. Underage-looking confederates presenting no age identification succeed in purchasing alcohol 36%-to-50% of the time (53–55). Weaker RBS training policies allow voluntary rather than mandatory training and lack incentives for participation by alcohol licensees. Mixed evidence from one study showed RBS training was associated with lower underage drinking fatal crash ratios, but higher per capita beer consumption (56). Some prior evidence supports associations between these stronger individual policies and lower beer per capita consumption and underage driving fatalities (10). However, due to concerns that some of these associations could be due to chance, our findings with respect to individual policies would benefit from replication in other samples.

Our findings should be viewed within the context of the following limitations. These data do not capture the degree to which policies are enforced at local levels, which may vary by communities and impact drinking (57). Truancy and drop-out from high school and attrition from longitudinal studies could be related to binge drinking in the sample, which could limit the generalizability of these findings (58). Our measure of binge drinking assessed only frequency categories, rather than discrete counts, which might have affected the identification of trajectory groups. Finally, although the study evaluated policies in effect prior to recruitment of the sample, it is possible that these policies were adopted in response to high rates of underage drinking in the population, potentially complicating causal inferences. Additional complexities not addressed in this study, but which may affect these findings were time-varying effects, including how earlier policies might affect the adoption of later policies and changes in policies over time.

These limitations notwithstanding, this study adds new longitudinal evidence for stronger alcohol policies in reducing the risk of underage binge drinking from late adolescence to early adulthood. Cohorts followed further into adulthood are needed to determine whether the alcohol policy environment has lasting influence on binge drinking. Independent

replication of these findings in other national cohorts (e.g., Add Health) could provide confirmatory evidence and future studies building on these findings should examine how drinking behaviors are associated with time-varying exposure to different alcohol policy environments either due to policies themselves changing over time or individuals migrating to different environments.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Past 30-day number of binge drinking occasions across waves (mean cohort age) in the overall sample and by latent growth trajectory classes.

Table 1.**Alcohol Policies in the United States and District of Columbia and Percentage of Policy Coverage^a**

Policy	Description	Coverage
<i>Underage Youth Policies</i>		
Possession	Possession for those under age 21 is prohibited.	100%
Purchase	Purchase or attempt to purchase for those under 21 is prohibited.	90%
Consumption	Consuming alcohol for those under age 21 is prohibited.	65%
Internal Possession	Evidence of consumption (e.g., blood alcohol content), but does not require any specific evidence of possession or consumption.	16%
Use/Lose	Suspension or revocation of driving privileges as penalty for possession, purchase, or consumption.	76%
False ID (Youth)	Prohibits use of false identification to obtain alcohol.	100%
<i>Alcohol Provider Policies</i>		
Furnishing	Prohibits providing alcohol to minors.	100%
Age of On-Premise Server	Specifies a minimum age of 21 for servers (e.g., waitpersons).	6%
Age of On-Premise Bartender	Specifies a minimum age of 21 for bartenders.	35%
Age of Off-Premise Seller	Specifies a minimum age of 21 for employees to sell alcohol.	20%
Keg Registration	Specifies special requirements for the sale or purchase of beer kegs (e.g., ID number, identify of purchaser, or location where it will be consumed).	59%
Responsible Beverage Service (RBS) Training	Establishes requirements or incentives for retail alcohol outlets to participate in programs to prevent alcohol sales to minors.	69%
False ID (Retailer Support)	Provisions that assist retailers in avoiding sales to potential buyers who present false identification.	88%
Hosting Drinking Parties	Liability against individuals (social hosts) responsible for underage drinking events on property they own, lease, or otherwise control.	47%
Dram Shop Liability	Civil liability faced by commercial servers for injuries or damages caused by their intoxicated or underage drinking patrons	88%
Social Host Liability	Civil liability faced by noncommercial servers for injuries or damages caused by their intoxicated or underage drinking guests.	61%
<i>General Policies</i>		
False ID (Suppliers)	Provisions that target those who produce, lend, or supply false IDs	47%
State Alcohol Control	State-run retail distribution system for beer, wine, or spirits.	Varies
Sunday Sales	Alcohol sales on Sunday are prohibited or limited.	27%
State Excise Taxes	Taxes levied per gallon at the retail level for beer, wine, or spirits.	Varies

Sources: Alcohol Policy Information System (<https://alcoholpolicy.niaaa.nih.gov>), last accessed 19 May 2017; US Department of Health and Human Services (2011) Report to Congress on the Prevention and Reduction of Underage Drinking.

^aPercent of states that have enacted the policy as of January 1, 2009 inclusive of 50 US states and the District of Columbia.

Table 2.

Descriptive Statistics of the Sample and Alcohol Policies at Wave 1 (n=2753).

Characteristic	n/mean	%/SD
<i>Individual</i>		
Female, n (%)	1513	(55.0%)
Age, mean (SD)	16.2	(0.5)
Race/Ethnicity, n (%)		
White	1100	(40.0%)
Black	685	(24.9%)
Hispanic	829	(30.1%)
Other ^a	139	(5.0%)
Family Affluence, n (%)		
Low	907	(32.9%)
Moderate	1271	(46.2%)
High	575	(20.9%)
<i>Alcohol Policy, mean (SD)</i>		
Overall Alcohol Policy Score	0.3	(0.6)
Underage Youth Policy Score	0.3	(0.6)
Alcohol Provider Policy Score	0.1	(0.9)
Beer Excise Taxes (\$)	0.3	(0.2)
Number of Liquor Stores in 1 km	0.9	(1.5)

^aIncluded Asian, American Indian or Alaska Native, and Native Hawaiian or Other Pacific Islander.

Table 3.

Latent Binge Drinking Trajectory Classes Associated with Summary Alcohol Policy Scores^a, Beer Excise Taxes, and Liquor Stores (n=2753).

Models ^b	Binge Drinking Trajectory Classes (reference: Low-Risk; n=1046)								Overall Significance Test					
	Escalating (n=666)		Chronic (n=388)		Late-Onset (n=361)		Decreasing (n=292)							
	RRR	95% CI	RRR	95% CI	RRR	95% CI	RRR	95% CI	F-test ^c	p-value				
Overall Alcohol Policies (Model 1)														
Overall Policy Score	1.44	1.17	1.77	1.05	0.78	1.43	1.03	0.73	1.45	1.28	0.91	1.79	3.06	0.04
Beer Excise Taxes (in US dollars)	0.21	0.07	0.58	0.72	0.30	1.71	0.35	0.13	0.96	0.71	0.27	1.87	6.29	<0.01
Number of Liquor Stores within 1 km	0.97	0.87	1.09	1.13	0.94	1.36	0.98	0.88	1.09	0.86	0.69	1.07	2.85	0.05
Domain-Specific Policies (Model 2)														
Underage Youth Policies	1.24	1.03	1.49	1.00	0.77	1.30	1.04	0.82	1.31	1.07	0.65	1.79	1.71	0.19
Alcohol Provider Policies	1.35	1.17	1.55	1.12	0.94	1.35	1.02	0.70	1.48	1.39	1.08	1.78	7.53	<0.01
Beer Excise Taxes (in US dollars)	0.22	0.09	0.50	0.71	0.28	1.81	0.34	0.12	0.98	0.73	0.24	2.21	6.67	<0.01
Number of Liquor Stores within 1 km	0.98	0.87	1.10	1.14	0.94	1.38	0.97	0.86	1.10	0.88	0.68	1.13	1.81	0.17

Relative risk ratio (RRR); Confidence Interval (CI).

^aPolicy scores were standardized to US national distribution. Higher scores indicated weaker policy environments.

^bModel controlled for neighborhood (median age, socioeconomic disadvantage) and individual factors (sex, race/ethnicity, family affluence).

^cF-tests had 4 and 18 degrees of freedom for the numerator and denominator, respectively.

Table 4.

Latent Binge Drinking Trajectory Classes Associated with Individual Alcohol Policies^a (n=2753).

Models	Binge Drinking Trajectory Classes (reference: Low-Risk; n=1046)								Overall Significance Test					
	Escalating		Chronic		Late-Onset		Decreasing							
	(n=666)		(n=388)		(n=361)		(n=292)							
	RRR	95% CI	RRR	95% CI	RRR	95% CI	RRR	95% CI	F-test ^b	p-value				
<i>Individual Underage Youth Policies (Model 3)^{c,e}</i>														
Possession	1.12	0.93	1.34	1.04	0.82	1.32	0.97	0.76	1.24	1.58	0.69			
Purchase	1.28	1.03	1.58	1.29	0.90	1.85	1.01	0.75	1.38	1.29	2.78			
Consumption	1.16	0.76	1.76	0.99	0.70	1.41	0.80	0.56	1.12	0.63	0.43	0.93	5.07	0.01
Internal Possession	0.79	0.47	1.32	0.85	0.50	1.45	1.43	1.16	1.76	0.90	0.68	1.19	5.09	0.01
Use/Lose	1.00	0.76	1.31	0.86	0.61	1.23	1.28	1.04	1.57	1.05	0.84	1.32	2.61	0.07
False ID: Youth	0.86	0.67	1.11	0.78	0.50	1.21	1.13	0.81	1.60	1.95	1.22	3.12	4.15	0.01
<i>Individual Alcohol Provider Policies (Model 4)^{d,e}</i>														
Furnishing	1.52	1.07	2.16	1.51	1.01	2.26	1.17	0.88	1.56	1.33	1.01	1.75	1.94	0.15
Age of On-Premise Server	1.24	0.87	1.77	0.84	0.53	1.34	1.03	0.66	1.62	0.68	0.38	1.20	3.63	0.02
Age of On-Premise Bartender	0.99	0.72	1.36	1.04	0.69	1.58	1.20	0.80	1.78	1.30	0.88	1.93	0.51	0.73
Age of Off-Premise Seller	0.58	0.32	1.05	0.52	0.32	0.85	1.52	0.91	2.52	0.94	0.63	1.41	6.13	<0.01
Keg Registration	1.14	0.94	1.38	1.03	0.77	1.39	0.95	0.74	1.22	1.09	0.89	1.32	0.89	0.49
RBS Training	1.19	1.04	1.36	1.21	0.89	1.65	0.99	0.76	1.29	0.89	0.72	1.10	3.10	0.04
False ID: Retailer Support	0.82	0.58	1.16	0.83	0.52	1.32	0.84	0.59	1.21	0.82	0.59	1.14	0.46	0.76
Hosting Underage Drinking Parties	0.84	0.52	1.34	0.64	0.34	1.20	1.08	0.68	1.70	1.01	0.71	1.45	2.15	0.12
Dram Shop Liability	1.34	0.99	1.81	0.97	0.62	1.51	0.95	0.63	1.44	1.30	0.74	2.28	2.29	0.10
Social Host Liability	0.83	0.72	0.96	0.92	0.65	1.30	1.00	0.71	1.40	1.00	0.80	1.25	2.39	0.09
<i>Individual General Policies (Model 5)^{c,d,e}</i>														
False ID: Suppliers	0.92	0.75	1.13	0.91	0.71	1.17	1.12	0.88	1.43	0.87	0.61	1.23	1.71	0.19
State Alcohol Control	1.22	0.87	1.72	1.04	0.66	1.62	0.91	0.64	1.29	1.07	0.84	1.35	0.82	0.53
Sunday Sales	0.93	0.79	1.09	1.02	0.83	1.26	0.89	0.64	1.25	1.02	0.88	1.18	0.61	0.66

Relative risk ratio (RRR); Confidence Interval (CI).

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Policy scores were standardized to US national distribution. Higher scores indicated weaker policies.
F-tests had 4 and 18 degrees of freedom for the numerator and denominator, respectively.
Model controlled for alcohol provider policy score.
Model controlled for underage youth policy score.
Model controlled for neighborhood (median age, socioeconomic disadvantage) and individual factors (sex, race/ethnicity, family affluence)s