Youth Drinking in the United States: Relationships With Alcohol Policies and Adult Drinking

Ziming Xuan, ScD, SM, MA[a], Jason G. Blanchette, MPH[b], Toben F. Nelson, ScD[c], Thien H. Nguyen, MPH[a], Scott E. Hadland, MD, MPH[d], Nadia L. Oussayef, JD, MPH[a], Timothy C. Heeren, PhD[e], Timothy S. Naimi, MD, MPH[a,b]

abstract

BACKGROUND: The relationship between the alcohol policy environment (ie, the combined effectiveness and implementation of multiple existing alcohol policies) and youth drinking in the United States has not been assessed. We hypothesized that stronger alcohol policy environments are inversely associated with youth drinking, and this relationship is partly explained by adult drinking.

METHODS: Alcohol Policy Scale (APS) scores that characterized the strength of the state-level alcohol policy environments were assessed with repeated cross-sectional Youth Risk Behavior Survey data of representative samples of high school students in grades 9 to 12, from biennial years between 1999 and 2011.

RESULTS: In fully adjusted models, a 10 percentage point increase in APS scores (representing stronger policy environments) was associated with an 8% reduction in the odds of youth drinking and a 7% reduction in the odds of youth binge drinking. After we accounted for youth-oriented alcohol policies, the subgroup of population-oriented policies was independently associated with lower odds of youth drinking (adjusted odds ratio 0.94; 95% confidence interval 0.92–0.97) and youth binge drinking (adjusted odds ratio 0.96; 95% confidence interval 0.94–0.99). State-level per capita consumption mediated the relationship between population-oriented alcohol policies and binge drinking among youth.

CONCLUSIONS: Stronger alcohol policies, including those that do not target youth specifically, are related to a reduced likelihood of youth alcohol consumption. These findings suggest that efforts to reduce youth drinking should incorporate population-based policies to reduce excessive drinking among adults as part of a comprehensive approach to preventing alcohol-related harms. Future research should examine influence of alcohol policy subgroups and discrete policies.

Departments of [a]Community Health Sciences and [e]Biostatistics, Boston University School of Public Health, Boston, Massachusetts; [b]Section of General Internal Medicine, Boston Medical Center, Boston, Massachusetts; [c]Division of Epidemiology and Community Health, University of Minnesota School of Public Health, Minneapolis, Minnesota; and [d]Division of Adolescent/Young Adult Medicine, Boston Children's Hospital, Boston, Massachusetts

Dr Xuan helped design the study, supervised statistical analysis, interpreted data and results, and drafted and revised the manuscript; Mr Blanchette coordinated data collection on alcohol policies, contributed to the development of the Alcohol Policy Scale, conducted statistical analyses, interpreted data and results, and made critical revisions of the manuscript for important intellectual content; Dr Nelson contributed to conception and design of the study, contributed to interpretation of data results, and made critical revisions of the manuscript for important intellectual content; Ms Nguyen collected data, conducted statistical analyses, and made critical revisions of the manuscript for important intellectual content; Dr Hadland contributed to the analytic design and interpretation of data and revised the manuscript for important intellectual content; Ms Oussayef contributed to the acquisition and interpretation of alcohol policy data and made critical revisions of the manuscript for important intellectual content; Dr Heeren contributed to study conceptualization and design, interpreted data and results, and made critical revisions of the manuscript for important intellectual content; Dr Naimi conceptualized and designed the study, supervised the study, interpreted data and results, and drafted and revised the manuscript; and all authors approved the final manuscript as submitted.

WHAT'S KNOWN ON THIS SUBJECT: Youth drinking is associated with adult drinking. Alcohol policies can influence youth and adult drinking. However, it is unknown whether alcohol policies influence youth drinking patterns directly or through their effect on adult drinking.

WHAT THIS STUDY ADDS: Alcohol policies, including population-oriented policies, are protective for youth drinking. The effect of population-oriented policies may be mediated though effects on adults. These findings suggest that efforts to reduce youth drinking should rely on policies that address all age groups.

Alcohol is the most commonly used drug among adolescents in the United States and is responsible for >4300 deaths annually among those ≤20 year of age.[1–3] Alcohol use is also a contributor to the leading causes of death among people aged 10 to 20 years and is a risk factor for a number of acute and long-term health, developmental, and social problems.[3–5] Although underage youth (ie, those ≤20 years of age) may drink less often than adults, they typically drink larger quantities than adults when they do drink, and youth aged 12 to 20 years consume approximately two-thirds of their alcohol during binge drinking occasions.[6,7]

Alcohol policies are a critical means by which to reduce underage drinking and related harms.[5,8–10] Although most policies to reduce youth drinking are youth-specific,[9] some population-oriented policies (ie, those that are not youth-specific) such as alcohol taxes have been shown to reduce underage drinking and binge drinking.[11–13] In addition, the Institute of Medicine has concluded that "it is possible that the most effective way to reduce the extent and adverse consequences of youthful drinking would be to reduce the extent and consequences of adult drinking."[5]

However, the relationship between most population-oriented policies and youth drinking has not been assessed, and if there is a relationship it is not clear whether it is due to the effects of those policies on adult consumption. This is plausible because adults model drinking behavior for underage youth,[14–17] shape alcohol expectancies in which choices about alcohol consumption are made by youth,[18,19] and supply most of the alcoholic beverages consumed by youth.[20,21] In addition, youth alcohol consumption and drinking-related behaviors occur in a social context that is related to adult behaviors and other social determinants.[17,22,23] Finally, there is evidence that the relationship between alcohol taxes and youth drinking is partly mediated through changes in adult binge drinking.[13]

Most policy studies have examined the effects of discrete alcohol policies.[24–28] However, all states use multiple alcohol policies, which may result in combined or interactive effects,[29,30] and this overall alcohol policy environment varies widely in US states.[24] Our research team recently developed a scale to measure the policy environment in US states and Washington, DC. Alcohol Policy Scale (APS) scores, with higher scores representing stronger mixes of alcohol policies, demonstrate good construct validity to predict lower odds of binge drinking and alcohol-impaired driving among adults.[29,31,32]

To date, no study has assessed the relationship between the alcohol policy environment and youth drinking in the United States, nor the independent relationships between population-oriented versus youth-oriented policies and youth drinking. As shown in Fig 1, the objectives of this study were to assess the relationship of the alcohol policy environments with youth drinking and youth binge drinking, determine the independent relationships between population-oriented policies and youth-oriented policies and youth drinking behaviors, and examine whether adult drinking mediates the relationship between population-oriented policies and youth drinking.

METHODS

Policy Data Sources

All policy data sources used uniform ascertainment methods across all states.[31] The primary source for 13 of the 29 policies was the Alcohol Policy Information System, which has tracked selected alcohol policies since 1999.[33] Eighteen additional data sources were used to collect and code data about policies and their key provisions.[31] When multiple data sources were available for some policies, sources were cross-checked and discrepancies were resolved by a public health lawyer using the legal research database WestlawNext.[34]

Determining APS Scores

A panel of 10 alcohol policy experts was engaged to assist with 3 tasks: nominating and selecting existing alcohol policies, rating the relative efficacy of those policies, and developing implementation ratings for each policy.[31]

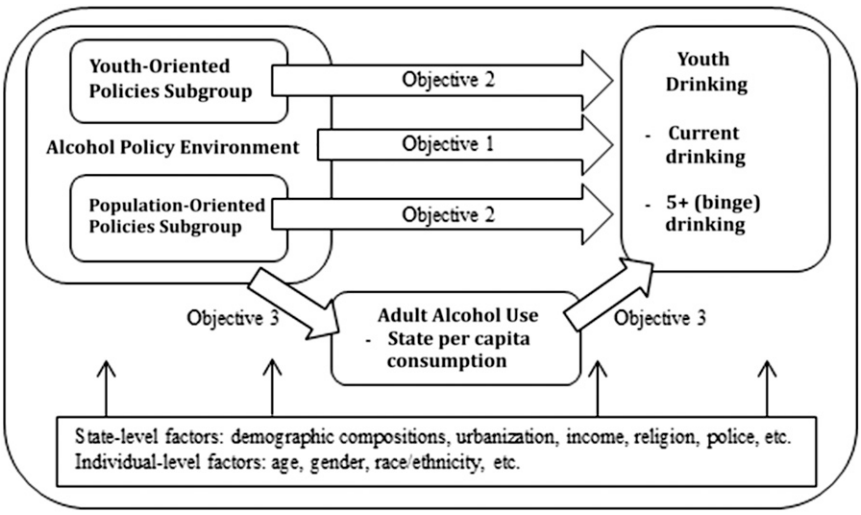

FIGURE 1
Conceptual model of relationships between the state alcohol policy environment and policy subgroups with adult alcohol use and youth drinking.

Forty-seven alcohol control policies were initially nominated as effective by panelists.[35] We excluded policies that did not exist in the United States, were promulgated at the federal level, did not vary between states, or lacked reliable cross-state data. Examples of excluded policies were blood alcohol content 0.05 laws (do not exist in the United States), restrictions on mass media advertising (promulgated federally), public intoxication laws (all states prohibit public intoxication), and mandatory substance abuse assessment for driving under the influence offenders (no reliable cross-state data). The 8 policies excluded because of inadequate or missing data had low average efficacy ratings.[35] Ultimately, 29 policies met inclusion criteria.[31]

An efficacy rating (ER) was developed for each policy. Based on standardized descriptions, panelists independently rated the efficacy of each policy in 4 domains: reducing binge drinking among adults, reducing impaired driving among adults, reducing drinking among underage youth, and reducing drinking and driving among youth. Because this was a study of youth, ERs for reducing drinking among youth were used for this study.

In consultation with panelists, investigators also developed a legislative implementation rating (IR) for each policy.[31] Factors informing policy IRs were typically based on its statutory design (ie, provisions making the policy broadly applicable, effective, or enforceable). IR scales were reviewed by all panelists and revised by investigators after they reviewed the feedback. For each policy, the IR scale score, by state and year, could range from 0.0 (*no policy*) to 1.0 (*full implementation*). Although IR scores could vary by state-year, the scoring criteria applied to each policy were uniform across state-years.

Using Policy Data to Calculate APS Scores

Five methods were used to calculate APS scores for each of the 50 US states and Washington, DC from 1999 to 2011. Method 1 involved adding 1 point for each existing policy, method 2 involved summing ERs for each existing policy, method 3 involved summing IRs for each existing policy, method 4 involved summing the products of ERs and IRs for each existing policy, and method 5 involved summing the products between of ERs and IRs for each existing policy by using the inverse of the ER rank relative to other policies. We rescaled all APS scores into standardized ranges by dividing each APS score over the maximum possible APS score of the particular method and multiplying by 100, allowing scores from each method to be compared with the other methods.

Youth- Versus Population-Oriented Policy Subgroups

Alcohol policies were divided into 2 mutually exclusive groups: youth-oriented policies (n = 10) and population-oriented policies (n = 19).[29] Population-oriented policies were defined as policies that are not designed primarily for people under the legal drinking age, whereas youth-oriented policies were those that are designed specifically for people ≤20 years of age.

Youth Drinking Data Source, Measures

Youth drinking data were obtained from biennial state-based Youth Risk Behavior Surveys (YRBS) from 1999 to 2011 (7 survey years). YRBS is a school-based survey developed by the Centers for Disease Control and Prevention that has assessed health risk behaviors among a representative sample of schools and students in 9th through 12th grades since 1991. Over the life of the survey YRBS has used nearly identical methods and questions, and the survey has been validated, including with respect to alcohol questions.[36,37] Data from states with response rates ≥60% are cleaned and weighted to be representative of that state's population of students in grades 9 through 12. For the study period from 1999 through 2011, the total number of states with weighted data (which were used for analyses) ranged from 20 to 44 states per survey year and included a total of 637 106 respondents from 238 state-year strata. Alcohol consumption was defined as consumption of ≥1 drinks of alcohol during the past 30 days; binge drinking was defined as reporting ≥1 days of consuming ≥5 drinks "in a row" within the past 30 days. The reliability kappas for these 2 items (70.9 for youth drinking; 67.6 for youth binge drinking) were calculated previously with the 1999 data and were considered substantial.[36,37]

State- and Individual-Level Covariates, State per Capita Alcohol Consumption

State-level covariates included proportions of the population aged ≥21 years, gender, race or ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and other race), level of urbanization, median household income, religiosity (proportion Catholic), number of police officers per capita, and geographic region (Northeast, Midwest, South, and West); year was modeled as a categorical variable. Individual-level covariates included age, gender, race or ethnicity, and past-month tobacco use.

State adult per capita alcohol consumption was obtained from the Alcohol Epidemiologic Data System (AEDS), sponsored by the federal government.[38] AEDS extracts the volume of each beverage type (beer, spirits, wine) annually in each state, from complete sales and tax receipts reports or alcohol shipment data, and converts these data into gallons of ethanol. Per capita consumption was

determined based on the population aged ≥21 years of age for each state and year based on US Census data. Per capita consumption from AEDS is highly correlated with adult alcohol consumption, based on population-based surveys.[39]

Analytic Methods

APS scores from each of the 5 calculation methods were used to predict the same-year prevalence of youth drinking and binge drinking in states; in subsequent analyses APS scores from the method with the highest goodness of fit (method 3, $P < .0001$, $R^2 = 0.29$ for both youth drinking and binge drinking; see the Appendix) were used to predict the odds of individual-level youth drinking and youth binge drinking in the same state-year. Individual-level odds ratios were based on an absolute 10 percentage point increase of APS scores using generalized estimating equations models adjusting for YRBS weights with multiple-year adjustment and the clustering of individuals within sampling units. Because Utah may be considered an outlier with respect to alcohol consumption, we conducted a sensitivity analysis excluding Utah. Additional analyses were stratified on the basis of gender, grade, and race or ethnicity and on the basis of policy subgroup (youth-oriented vs population-oriented policies).

Finally, mediation analyses were conducted to determine whether per capita alcohol consumption explained the association between population-oriented policies and youth drinking measures.[40] Sobel's SE approximation was used to test the significance of the mediating variable effect.[41]

RESULTS

Relationship Between APS Scores and Youth Drinking

In bivariate analyses, a 10 percentage point increase in the APS score was associated with >10% lower odds of drinking and binge drinking (Table 1). In fully adjusted models accounting for state- and individual-level covariates and year, a 10 percentage point increase in the APS score was associated with reduced odds of youth drinking (adjusted odds ratio [AOR] 0.92; 95% confidence interval [CI], 0.90–0.95) and youth binge drinking (AOR 0.93; 95% CI, 0.91–0.96). In a sensitivity analysis that excluded Utah from the fully adjusted model, results were similar and remained significant.

Among demographic subgroups, reduced odds of drinking and binge drinking were similar and significant on the basis of gender, grade level, and among non-Hispanic white and Hispanic youth (Table 2). For non-Hispanic black youth and non-Hispanic other races, however, there was no significant relationship between APS scores and either drinking or binge drinking.

TABLE 1 OR of Individual-Level Youth Drinking and Binge Drinking Associated With a 10 Percentage Point Increase in the State-Level APS Score in US States, YRBS, Biennial Years 1999–2011

Models[a,b]	Youth Drinking,[c] OR (95% CI)	Youth Binge Drinking, OR (95% CI)
Bivariate model	0.85 (0.83–0.87)	0.87 (0.84–0.89)
Adjusted for individual-level covariates	0.87 (0.85–0.88)	0.89 (0.87–0.91)
Also adjusted for state-level covariates	0.91 (0.88–0.93)	0.92 (0.90–0.95)
Also adjusted for year	0.92 (0.90–0.95)	0.93 (0.91–0.96)

OR, odds ratio.

[a] State APS scores were used to predict odds of individual-level youth drinking and youth binge drinking in the same state-year. Odds ratio is based on an absolute 10 percentage point increase of the APS score, with generalized estimating equations adjusted for YRBS weights with multiple-year adjustment and the clustering of individuals within sampling units.

[b] Individual-level covariates included age, gender, race or ethnicity, and past month tobacco use. State-level covariates include proportion of adults aged ≥21 y of age, gender distribution, race or ethnicity distribution, degree of urbanization, median household income, religiosity, police officers per capita, and geographic region. Year was treated as a categorical variable.

[c] Youth drinking was defined as ≥1 d of consuming alcohol during the past 30 d. Binge drinking was defined as ≥1 d of having ≥5 drinks of alcohol "in a row, that is, within a couple of hours" during the past 30 d.

Independent Effects of Population-Oriented Versus Youth-Oriented Policy Subgroups

Across the 238 state-year strata, the correlation between population-oriented APS scores and youth-oriented APS scores was $r = 0.51$ ($P < .01$). In adjusted models for individual-level drinking measures, there were significant inverse associations between the population-oriented policy subgroup and the odds of youth drinking and binge drinking, and also between the youth-oriented policy subgroup and youth drinking and binge drinking (Table 3). In a model that also controlled for the youth-oriented policy subgroup, the population-oriented policies subgroup was independently inversely associated with youth drinking (AOR 0.94; 95% CI, 0.92–0.97) and youth binge drinking (AOR 0.96; 95% CI, 0.94–0.99). The youth-oriented policy subgroup was also independently inversely associated with youth drinking (AOR 0.98; 95% CI, 0.96–0.99) and binge drinking (AOR 0.97; 95% CI, 0.95–0.99) after we controlled for the population-oriented policy subgroup.

Adult Consumption as Mediator of Population-Oriented Policies and Youth Drinking Relationship

Across the 238 state-year strata, general population-oriented policies were significantly inversely associated with state adult per capita alcohol consumption ($r = -0.46$, $P < .01$), and adult per capita consumption was positively correlated with youth drinking prevalence ($r = 0.46$, $P < .01$) and binge drinking prevalence ($r = 0.49$, $P < .01$). For example, Fig 2 shows

TABLE 2 AORs of Individual-Level Youth Drinking and Binge Drinking Associated With a 10 Percentage Point Increase in the State-Level APS Score, by Demographic Characteristics, YRBS, Biennial Years 1999–2011

Models[a,b]	Youth Drinking,[c] AOR (95% CI)	Youth Binge Drinking, AOR (95% CI)
Gender		
Male	0.91 (0.89–0.94)	0.94 (0.90–0.97)
Female	0.93 (0.90–0.96)	0.92 (0.89–0.95)
School grade		
9th and 10th	0.94 (0.91–0.96)	0.93 (0.90–0.96)
11th and 12th	0.92 (0.89–0.95)	0.93 (0.90–0.97)
Race or ethnicity		
Non-Hispanic white	0.90 (0.87–0.92)	0.90 (0.88–0.93)
Non-Hispanic black	1.00 (0.94–1.06)	0.98 (0.90–1.06)
Hispanic	0.93 (0.88–0.98)	0.94 (0.88–0.99)
Non-Hispanic other	0.94 (0.89–1.01)	0.98 (0.91–1.06)

[a] State APS scores were used to predict odds of individual-level youth drinking and youth binge drinking in the same state-year. OR is based on absolute 10 percentage point increase of the APS score, with generalized estimating equations adjusted for YRBS weight with multiple-year adjustment and the clustering of individuals within sampling units.
[b] Individual-level covariates included age, gender, race or ethnicity, and past month tobacco use. State-level covariates include proportion of adults aged ≥21 y of age, gender distribution, race or ethnicity distribution, degree of urbanization, median household income, religiosity, police officers per capita, and geographic region. Year was treated as a categorical variable.
[c] Youth drinking was defined as ≥1 d of consuming alcohol during the past 30 d. Binge drinking was defined as ≥1 d of having ≥5 drinks of alcohol "in a row, that is, within a couple of hours" during the past 30 d.

the correlations of the overall policy scale (n = 29 policies) and the 2 policy subgroups with youth drinking prevalence in 2005 (the study midpoint). Because population-oriented policies were significantly inversely associated with youth drinking and binge drinking for individual-level analysis (Table 3), we assessed adult per capita consumption as a possible mediator of the relationship between population-oriented policies and youth drinking measures. After we controlled for adult per capita consumption, the adjusted association between the population-oriented policies and youth drinking was partially mediated (AOR 0.96; 95% CI, 0.93–0.98; Sobel test statistic = −5.93, $P < .001$), and the association between population-oriented policies and youth binge drinking was fully mediated (AOR 0.97; 95% CI, 0.95–1.00; Sobel test statistic = −4.80, $P < .001$).

TABLE 3 AORs of Individual-Level Youth Drinking and Binge Drinking Associated With a 10 Percentage Point Increase in Modified APS Score Based on Age-Related Policy Subgroups, YRBS, Biennial Years 1999–2011

Policy Group Exposure Variable[a]	Youth Drinking,[b] AOR (95% CI)	Youth Binge Drinking, AOR (95% CI)
Population-oriented policy subgroup (n = 19)		
Adjusted model[c]	0.93 (0.91–0.96)	0.95 (0.93–0.97)
Also controlling for youth policies[c]	0.94 (0.92–0.97)	0.96 (0.94–0.99)
Youth-oriented policy subgroup (n = 10)		
Adjusted model[c]	0.96 (0.94–0.98)	0.95 (0.94–0.97)
Also controlling for population policies[c]	0.98 (0.96–0.99)	0.97 (0.95–0.99)

[a] Population-oriented policies consisted of policies that target the general population (eg, alcohol taxes, hours of alcohol sales). Youth-oriented policies target primarily underage youth (eg, policies related to the minimum legal drinking age). Methods used to calculate the 2 modified APS scores were identical to those used for calculating the APS score based on all 29 policies, but they used restricted sets of mutually exclusive policies.
[b] Youth drinking was defined as ≥1 d of consuming alcohol during the past 30 d. Binge drinking was defined as ≥1 d of having ≥5 drinks of alcohol "in a row, that is, within a couple of hours" during the past 30 d.
[c] For all models, the modified state APS scores were used to predict odds of individual-level youth drinking and youth binge drinking in the same state-year. AOR is based on absolute 10 percentage point increase of the APS scores, with generalized estimating equations adjusted for YRBS weight with multiple-year adjustment and the clustering of individuals within sampling units. Individual-level covariates included age, gender, race or ethnicity, and past month tobacco use. State-level covariates include proportion of adults ≥21 y of age, gender distribution, race or ethnicity distribution, degree of urbanization, median household income, religiosity, police officers per capita, and geographic region. Year was treated as a categorical variable.

DISCUSSION

This is the first study to assess the relationship between the alcohol policy environment (based on 29 expert-nominated policies) and alcohol consumption among high school students in the United States. We found strong inverse relationships between state alcohol policies and the odds of individual-level youth drinking and binge drinking. Specifically, a 10 percentage point increase in APS score (representing stronger policy environments) was associated with an 8% reduction in the odds of youth drinking and a 7% reduction in the odds of binge drinking in fully adjusted models. This finding adds to the literature by demonstrating the effect size associated with the multiple alcohol policies that exist in all states.

In an international context, the Alcohol Policy Index developed by Brand et al,[42] which weighted policies based on their efficacy and implementation, was inversely related to per capita alcohol consumption in 30 countries. Paschall et al[11] found an inverse relationship between Brand's policy index and national youth drinking prevalence. Based on Brand's index, Gilligan et al[43] found a significant inverse association between higher alcohol prices and other policies with weekly drinking among youth but no significant relationship with drinking to the point of subjective intoxication.

We also found an inverse relationship between population-oriented policies (ie, those not specifically targeting youth) and youth drinking measures, even after we controlled for youth-oriented policies. This finding supports the literature that some population-oriented policies (eg, increased alcohol taxation, reduced alcohol outlet density) are associated with a reduced likelihood of youth drinking.[17,22,44] Accounting for youth-oriented policies when

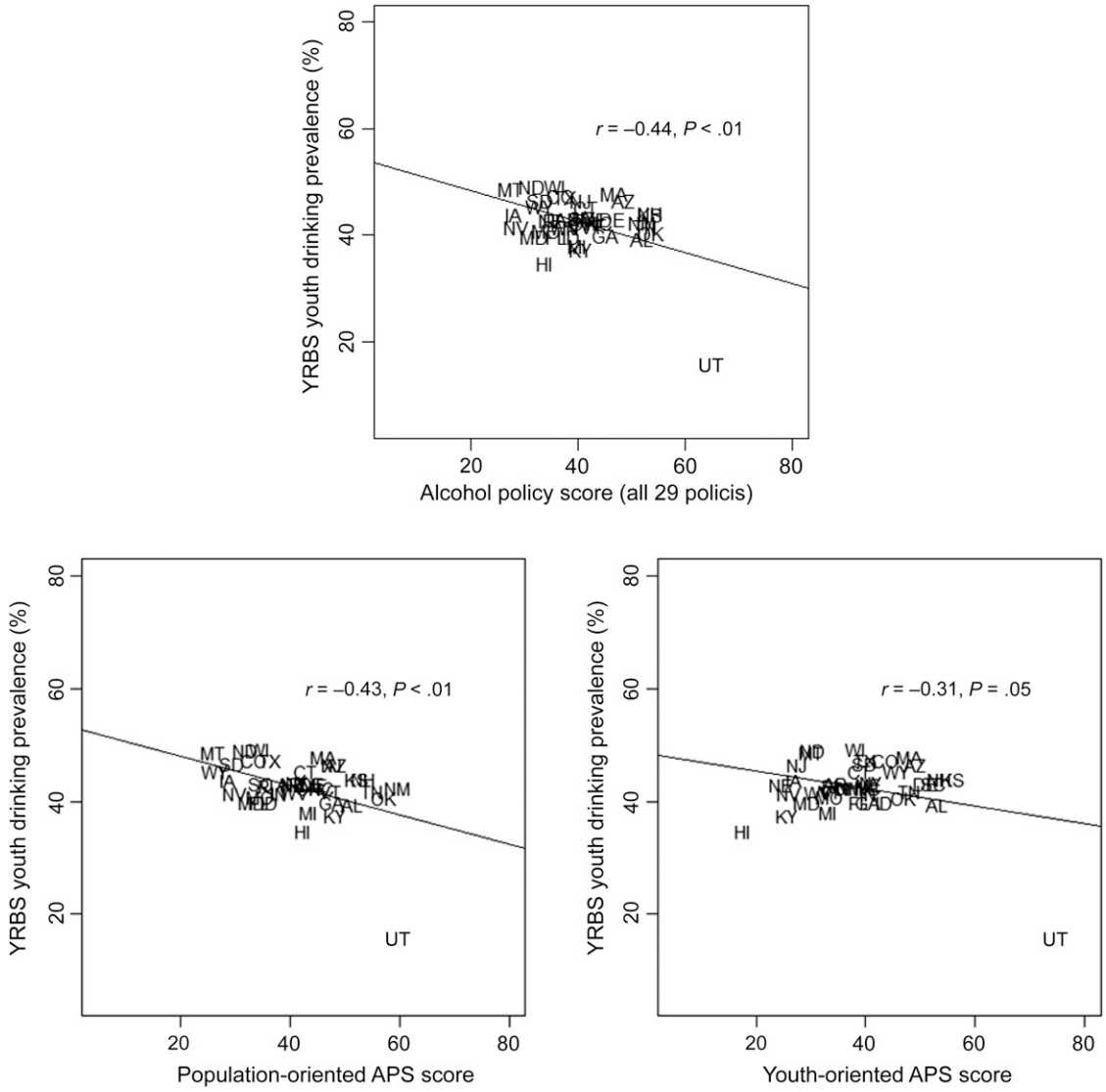

FIGURE 2
Correlations (*r*) of state-level youth drinking prevalence with APS and age-targeted policy subgroups, state YRBS, 2005 (the study midpoint).

examining the effect of population-oriented policies also adds to previous research by minimizing confounding stemming from the fact that states with stronger population-oriented alcohol policies also tend to have stronger youth-oriented policies.

We also found evidence that adult drinking mediates the relationship between population-oriented policies and youth drinking. This finding is consistent with our previous work demonstrating that the relationship between state alcohol taxes (which do not target youth) and youth drinking is partly mediated through reduced adult binge drinking.[13] Therefore, it is likely that there are both direct and indirect pathways by which population-oriented alcohol policies may influence youth consumption. Overall, these findings lend empirical support to the Institute of Medicine's judgment that parents and adults must be a key target of strategies to reduce and prevent underage drinking.[5]

The effect magnitude of the APS for reducing the odds of youth binge drinking was similar to that for reducing the odds of adult binge drinking.[29] For youth drinking measures, however, APS score calculation methods that incorporated policy efficacy ratings (in addition to implementation ratings) did not improve goodness of fit, whereas incorporating both efficacy and implementation ratings improved goodness of fit to predict adult binge drinking.[31] One possible explanation is that panelists' policy efficacy ratings for adults had greater construct validity than their efficacy ratings for youth. Another possibility is that effects of youth-oriented policies in some studies

may be confounded by the presence or subsequent adoption of population-oriented policies that might overestimate the effect of youth-oriented policies.

Relationships between APS scores and youth drinking measures were similar between gender and between grade categories but inconsistent between race and ethnicity categories, a finding that is similar to our previous work exploring relationships between APS scores and adult binge drinking.[29] In both instances there were no statistically significant relationships between respondents who were non-Hispanic black and of non-Hispanic other races. Of note, black adults and youth both have a lower prevalence of drinking and binge drinking compared with other racial and ethnic groups,[29,31] and they may be subject to other state- or individual-level influences for which we did not account.

Despite controlling for unrestricted time effects in generalized estimating equations models, these analyses are largely cross-sectional. However, many of the policies included in the APS scales have evidence of effectiveness based on longitudinal studies,[28,44–47] which reduces concern about reverse causation. Although we accounted for a wide range of relevant state- and individual-level covariates, confounding remains a potential threat to validity. The efficacy and implementation ratings developed by the investigators and panelists were informed by a limited evidence base and are therefore partly subjective.[48] Furthermore, policies that are promulgated at the federal or local levels, those that did not vary between states, and those with insufficient data were not incorporated in the APS scores. Therefore, it is possible that our APS–youth drinking effect sizes underestimate the impact of all alcohol policies within states.

Enforcement efforts contribute to the effectiveness of some policies,[49] but there are no publicly available cross-state data about enforcement for most policies. Overall, limitations related to the imprecision of the policy exposure variables may have biased the results toward the null hypothesis. Finally, the YRBS samples include high-school aged youth who attend school and are therefore not representative of all underage youth, especially those 19 to 20 years of age.

CONCLUSIONS

State alcohol policies, including those that do not target youth specifically, are inversely associated with youth drinking and binge drinking. These findings are relevant to policy debates about the best way to prevent and reduce underage drinking, and about the importance of comprehensive strategies that also include policies to reduce excessive drinking among adults. To the extent that alcohol use and intoxication at young ages are strong predictors of alcohol-related problems in adulthood,[50–52] the findings are also relevant to optimizing strategies to reduce alcohol-related health and social costs among the general population. Future work should better evaluate the independent effect of additional policy subgroups (eg, those affecting price, physical availability of alcohol) and discrete policies on youth drinking measures. Among adults, we found that 2 policies (state taxes and alcohol outlet density) accounted for almost half of the effects size based on all assessed policies.[29]

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ABBREVIATIONS

AEDS: Alcohol Epidemiologic Data System
AOR: adjusted odds ratio
APS: Alcohol Policy Scale
CI: confidence interval
ER: efficacy rating
IR: implementation rating
YRBS: Youth Risk Behavior Surveys

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Address correspondence to Timothy S. Naimi, MD, MPH, Section of General Internal Medicine, Boston Medical Center, 801 Massachusetts Ave, Boston, MA 02118. E-mail: tim.naimi@bmc.org

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REFERENCES

1. Centers for Disease Control and Prevention. Fact sheets: underage drinking. 2012. Available at: www.cdc.gov/alcohol/fact-sheets/underage-drinking.htm. Accessed June 5, 2014
2. Centers for Disease Control and Prevention. Alcohol-related disease impact (ARDI). 2014. Available at: http://apps.nccd.cdc.gov/DACH_ARDI/Default/Default.aspx. Accessed June 5, 2014
3. US Department of Health and Human Services. Surgeon General's call to action to prevent and reduce underage drinking. 2007. Available at: www.surgeongeneral.gov/library/calls/underagedrinking/index.html. Accessed June 5, 2013
4. Miller JW, Naimi TS, Brewer RD, Jones SE. Binge drinking and associated health risk behaviors among high school students. *Pediatrics*. 2007;119(1):76–85
5. Bonnie RJ, O'Connell ME, eds. *Reducing Underage Drinking: A Collective Responsibility*. Washington, DC: National Academies Press; 2004
6. Naimi TS, Siegel M, DeJong W, O'Doherty C, Jernigan D. Beverage- and brand-specific binge alcohol consumption among underage youth in the US. *J Subst Use*. 2014:1–7
7. National Institute on Alcohol Abuse and Alcoholism. Underage drinking. 2013. Available at: http://pubs.niaaa.nih.gov/publications/UnderageDrinking/UnderageFact.htm. Accessed June 5, 2014
8. Grube JW, Stewart K. Preventing impaired driving using alcohol policy. *Traffic Inj Prev*. 2004;5(3):199–207
9. DeJong W, Blanchette J. Case closed: research evidence on the positive public health impact of the age 21 minimum legal drinking age in the United States. *J Stud Alcohol Drugs Suppl*. 2014;75(Suppl 17):108–115
10. Toomey TL, Wagenaar AC. Policy options for prevention: the case of alcohol. *J Public Health Policy*. 1999;20(2):192–213
11. Paschall MJ, Grube JW, Kypri K. Alcohol control policies and alcohol consumption by youth: a multi-national study. *Addiction*. 2009;104(11):1849–1855
12. Chaloupka FJ, Grossman M, Saffer H. The effects of price on alcohol consumption and alcohol-related problems. *Alcohol Res Health*. 2002;26(1):22–34
13. Xuan Z, Nelson TF, Heeren T, et al. Tax policy, adult binge drinking, and youth alcohol consumption in the United States. *Alcohol Clin Exp Res*. 2013;37(10):1713–1719
14. Akers RL, Krohn MD, Lanza-Kaduce L, Radosevich M. Social learning and deviant behavior: a specific test of a general theory. *Am Sociol Rev*. 1979;44(4):636–655
15. Ary DV, Tildesley E, Hops H, Andrews J. The influence of parent, sibling, and peer modeling and attitudes on adolescent use of alcohol. *Int J Addict*. 1993;28(9):853–880
16. van der Vorst H, Engels RC, Meeus W, Deković M, Van Leeuwe J. The role of alcohol-specific socialization in adolescents' drinking behaviour. *Addiction*. 2005;100(10):1464–1476
17. Bendtsen P, Damsgaard MT, Huckle T, et al. Adolescent alcohol use: a reflection of national drinking patterns and policy? *Addiction*. 2014;109(11):1857–1868
18. Foley KL, Altman D, Durant RH, Wolfson M. Adults' approval and adolescents' alcohol use. *J Adolesc Health*. 2004;35(4):345, e317–326
19. Smith GT, Miller TL, Kroll L, Simmons JR, Gallen R. Children's perceptions of parental drinking: the eye of the beholder. *J Stud Alcohol*. 1999;60(6):817–824
20. Needle R, McCubbin H, Wilson M, Reineck R, Lazar A, Mederer H. Interpersonal influences in adolescent drug use: the role of older siblings, parents, and peers. *Int J Addict*. 1986;21(7):739–766
21. Wagenaar AC, Toomey TL, Murray DM, Short BJ, Wolfson M, Jones-Webb R. Sources of alcohol for underage drinkers. *J Stud Alcohol*. 1996;57(3):325–333
22. Nelson TF, Naimi TS, Brewer RD, Wechsler H. The state sets the rate: the relationship among state-specific college binge drinking, state binge drinking rates, and selected state alcohol control policies. *Am J Public Health*. 2005;95(3):441–446
23. Nelson DE, Naimi TS, Brewer RD, Nelson HA. State alcohol-use estimates among youth and adults, 1993–2005. *Am J Prev Med*. 2009;36(3):218–224
24. Fell JC, Fisher DA, Voas RB, Blackman K, Tippetts AS. The impact of underage drinking laws on alcohol-related fatal crashes of young drivers. *Alcohol Clin Exp Res*. 2009;33(7):1208–1219
25. Wagenaar AC, Maldonado-Molina MM, Wagenaar BH. Effects of alcohol tax increases on alcohol-related disease mortality in Alaska: time-series analyses from 1976 to 2004. *Am J Public Health*. 2009;99(8):1464–1470
26. Hingson R, Merrigan D, Heeren T. Effects of Massachusetts raising its legal drinking age from 18 to 20 on deaths from teenage homicide, suicide, and nontraffic accidents. *Pediatr Clin North Am*. 1985;32(1):221–232
27. Chang K, Wu CC, Ying YH. The effectiveness of alcohol control policies on alcohol-related traffic fatalities in the United States. *Accid Anal Prev*. 2012;45:406–415
28. Wagenaar AC, Toomey TL. Effects of minimum drinking age laws: review and analyses of the literature from 1960 to 2000. *J Stud Alcohol Suppl*. March 2002;No. 14:206–225
29. Xuan Z, Blanchette J, Nelson TF, Heeren T, Oussayef N, Naimi TS. The alcohol policy environment and policy subgroups as predictors of binge drinking measures among US adults. *Am J Public Health*. 2015;105(4):816–822

30. Ponicki WR, Gruenewald PJ, LaScala EA. Joint impacts of minimum legal drinking age and beer taxes on US youth traffic fatalities, 1975 to 2001. *Alcohol Clin Exp Res*. 2007;31(5):804–813

31. Naimi TS, Blanchette J, Nelson TF, et al. A new scale of the US alcohol policy environment and its relationship to binge drinking. *Am J Prev Med*. 2014; 46(1):10–16

32. Xuan Z, Blanchette J, Nelson TF, Heeren T, Nguyen T, Naimi TS. The alcohol policy environment and impaired driving in US states, and the contribution of non-driving policies. *Int J Alcohol Drug Res*. 2015, in press

33. National Institute of Alcohol Abuse and Alcoholism. Alcohol Policy Information System (APIS). 2013. Available at: www.alcoholpolicy.niaaa.nih.gov/. Accessed January 14, 2014

34. Thomson Reuters. WestlawNext. Available at: http://next.westlaw.com. Accessed October 5, 2011

35. Nelson TF, Xuan Z, Babor T, et al. Rating the efficacy and strength of evidence of alcohol control policies for the US: a comparative assessment. *Am J Prev Med*. 2013;45(1):19–28

36. Brener ND, Kann L, McManus T, Kinchen SA, Sundberg EC, Ross JG. Reliability of the 1999 Youth Risk Behavior Survey questionnaire. *J Adolesc Health*. 2002; 31(4):336–342

37. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977;33(1):159–174

38. LaVallee RA, Yi HY. *Surveillance Report #95: Apparent per Capita Alcohol Consumption: National, State, and Regional Trends, 1977–2010*. Bethesda, MD: NIAAA, Division of Epidemiology and Prevention Research, Alcohol Epidemiologic Data System; 2012

39. Nelson DE, Naimi TS, Brewer RD, Roeber J. US state alcohol sales compared to survey data, 1993–2006. *Addiction*. 2010; 105(9):1589–1596

40. MacKinnon DP, Lockwood CM, Hoffman JM, West SG, Sheets V. A comparison of methods to test mediation and other intervening variable effects. *Psychol Methods*. 2002;7(1):83–104

41. Sobel ME. Asymptotic confidence intervals for indirect effects in structural equation models. In: Lienhart S, ed. *Psychological Methods*. San Francisco, CA: Jossey-Bass; 1982:290–312

42. Brand DA, Saisana M, Rynn LA, Pennoni F, Lowenfels AB. Comparative analysis of alcohol control policies in 30 countries. *PLoS Med*. 2007;4(4):e151

43. Gilligan C, Kuntsche E, Gmel G. Adolescent drinking patterns across countries: associations with alcohol policies. *Alcohol Alcohol*. 2012;47(6): 732–737

44. Elder RW, Lawrence B, Ferguson A, et al; Task Force on Community Preventive Services. The effectiveness of tax policy interventions for reducing excessive alcohol consumption and related harms. *Am J Prev Med*. 2010;38(2):217–229

45. Hahn RA, Kuzara JL, Elder R, et al; Task Force on Community Preventive Services. Effectiveness of policies restricting hours of alcohol sales in preventing excessive alcohol consumption and related harms. *Am J Prev Med*. 2010; 39(6):590–604

46. Campbell CA, Hahn RA, Elder R, et al; Task Force on Community Preventive Services. The effectiveness of limiting alcohol outlet density as a means of reducing excessive alcohol consumption and alcohol-related harms. *Am J Prev Med*. 2009;37(6):556–569

47. Hahn RA, Middleton JC, Elder R, et al; Community Preventive Services Task Force. Effects of alcohol retail privatization on excessive alcohol consumption and related harms: a community guide systematic review. *Am J Prev Med*. 2012;42(4):418–427

48. Nardo M, Saisana M, Saltelli A, Tarantola S, Hoffman A, Giovannini E. *Handbook on Constructing Composite Indicators: Methodology and User Guide*. Paris, France: OECD Publishing; 2005

49. Ritter A. Comparing alcohol policies between countries: science or silliness? *PLoS Med*. 2007;4(4):e153

50. Hingson RW, Heeren T, Winter MR. Age at drinking onset and alcohol dependence: age at onset, duration, and severity. *Arch Pediatr Adolesc Med*. 2006;160(7): 739–746

51. Dawson DA, Goldstein RB, Chou SP, Ruan WJ, Grant BF. Age at first drink and the first incidence of adult-onset DSM-IV alcohol use disorders. *Alcohol Clin Exp Res*. 2008;32(12):2149–2160

52. Viner RM, Taylor B. Adult outcomes of binge drinking in adolescence: findings from a UK national birth cohort. *J Epidemiol Community Health*. 2007; 61(10):902–907

APPENDIX Unadjusted Relationship of a 10 Percentage Point Change in State APS Scores With State-Level Youth Drinking and Binge Drinking Prevalence in US States, YRBS, Biennial Years 1999–2011

Alcohol Policy Scale[a] Method	Youth Drinking[b]			Youth Binge Drinking		
	β	P	R^2	β	P	R^2
1[c]	−3.49	<.0001	0.19	−3.17	<.0001	0.22
2[d]	−3.09	<.0001	0.15	−2.85	<.0001	0.18
3[e]	−4.45	<.0001	0.29	−3.78	<.0001	0.29
4[f]	−4.17	<.0001	0.26	−3.55	<.0001	0.26
5[g]	−3.26	<.0001	0.21	−2.58	<.0001	0.18

[a] State APS scores were used to predict same-year state prevalence of youth drinking and binge drinking prevalence. Regression coefficient (β) is based on absolute 10 percentage point increase of APS score.

[b] Youth drinking was defined as ≥1 d of consuming alcohol during the past 30 d. Binge drinking was defined as ≥1 d of having ≥5 drinks of alcohol "in a row, that is, within a couple of hours" during the past 30 d.

[c] Method 1 was calculated by summing present policies for each state-year.

[d] Method 2 was calculated by summing efficacy scores of present policies for each state-year.

[e] Method 3 was calculated by summing implementation scores of present policies for each state-year.

[f] Method 4 was calculated by summing the products between implementation and efficacy ratings of present policies for each state-year.

[g] Method 5 was calculated by summing the products between implementation and the inverse of efficacy rank for each state-year.

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