A New Scale of the U.S. Alcohol Policy Environment and Its Relationship to Binge Drinking

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Background: Of outcomes related to excessive drinking, binge drinking accounts for approximately half of alcohol-attributable deaths, two thirds of years of potential life lost, and three fourths of economic costs. The extent to which the alcohol policy environment accounts for differences in binge drinking in U.S. states is unknown.

Purpose: The goal of the study was to describe the development of an Alcohol Policy Scale (APS) designed to measure the aggregate state-level alcohol policy environment in the U.S. and assess the relationship of APS scores to state-level adult binge drinking prevalence in U.S. states.

Methods: Policy efficacy and implementation ratings were developed with assistance from a panel of policy experts. Data on 29 policies in 50 states and Washington DC from 2000–2010 were collected from multiple sources and analyzed between January 2012 and January 2013. Five methods of aggregating policy data to calculate APS scores were explored; all but one was weighted for relative policy efficacy and/or implementation. Adult (aged ≥ 18 years) binge drinking prevalence data from 2001–2010 was obtained from the Behavioral Risk Factor Surveillance System surveys. APS scores from a particular state-year were used to predict binge drinking prevalence during the following year.

Results: All methods of calculating APS scores were significantly correlated ($r > 0.50$), and all APS scores were significantly inversely associated with adult binge drinking prevalence. Introducing efficacy and implementation ratings optimized goodness of fit in statistical models (e.g., unadjusted beta$=-3.90$, $p < 0.0001$, $R^2=0.31$).

Conclusions: The composite measure(s) of the alcohol policy environment have internal and construct validity. Higher APS scores (representing stronger policy environments) were associated with less adult binge drinking and accounted for a substantial proportion of the state-level variation in binge drinking among U.S. states.

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Background

Excessive alcohol consumption is a leading cause of morbidity, mortality, social problems, and economic costs in the U.S.[1–5] Of outcomes related to excessive drinking, binge drinking accounts for approximately half of alcohol-attributable deaths, two thirds of years of potential life lost, and three fourths of economic costs.[5,6] Alcohol policies, which comprise the laws, regulations, and practices designed to reduce excessive alcohol use and related harm, can reduce excessive alcohol consumption and related problems at the population level.[1,7,8] Alcohol consumption patterns, including binge drinking, and alcohol policies vary substantially

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across U.S. states.[9,10] It is unknown, however, whether or to what degree the combined effects of multiple concurrent alcohol policies account for differences in alcohol consumption patterns in the U.S.

Many alcohol policy studies examine single policies, taking advantage of natural experiments that occur when a policy is introduced, modified, or withdrawn.[11–15] However, the distribution, sale, and consumption of alcohol are affected by multiple policies in all U.S. states. To determine the extent to which these policies are related to a particular alcohol-related outcome, it is crucial to assess the strength of the *alcohol policy environment*, conceptualized as the combined effect of multiple concurrent policies and operationalized as composite policy measures. Understanding the effect of the policy environment is important to determining the effect of alcohol policies in relation to other factors that contribute to excessive drinking and to understanding the relative effectiveness of particular policies or combinations of policies.

Composite policy measures have been used to characterize the policy environment in other areas of public health, such as tobacco use[16–18] and weight and obesity.[19,20] In these areas, the policy environment has been shown to be correlated with health behavior and related outcomes in U.S. states.[16,19,20] For alcohol, prior research has explored aggregating the alcohol policy environment by creating a simple score that is the sum across a set of policies of whether a policy exists or not.[21–24] However, this approach does not account for the relative efficacy of each policy compared with other policies, nor does it account for the degree to which each policy is designed or implemented.[25]

In an international context, Brand and colleagues developed a country-specific "alcohol policy index" that accounted for relative policy efficacy and policy implementation.[26] Each policy was assigned a relative weight of low, medium, or high based on a comparative efficacy analysis developed by the WHO.[1] Policies in country-years were given full or partial credit based on the stringency of implementation. The Alcohol Policy Index score was inversely associated with per capita consumption across 30 countries; its relationship to youth drinking has also been assessed.[27,28]

To date, we are not aware of any composite measures to operationalize the alcohol policy environment in U.S. states. The purpose of this paper is to describe the processes and methods used to develop "Alcohol Policy Scale" (APS) scores for U.S. states, and to characterize the association between APS scores and binge drinking prevalence in U.S. states.

Methods

Policy Panelists

Because there was no "gold standard" by which to develop composite variables to operationalize the policy environment, a panel of ten alcohol policy experts were engaged, using a modified Delphi approach. The policy experts assisted with three tasks: (1) nominating and selecting existing alcohol policies; (2) rating the relative efficacy of those policies; and (3) developing implementation ratings for each policy. The names, affiliations, and areas of expertise of the panelists are summarized in Appendix A (available at www.ajpmonline.org).

Policy Selection, Policy Efficacy Ratings

After de-duplication, 47 unique alcohol policies were initially nominated by panelists. Investigators then developed standardized, idealized descriptions of each policy. Panelists then independently rated the efficacy of each policy for reducing binge drinking based on a 5-point Likert scale (1=low efficacy, 5=high efficacy; see also Appendix B, available at www.ajpmonline.org). Each panelist rated each policy in the context of four distinct outcome domains: reducing binge drinking among adults, reducing impaired driving among adults, reducing binge drinking among underage youth, and reducing impaired driving among youth. Because the goal was to relate the policy scale to binge drinking prevalence among adults, efficacy ratings (ERs) for reducing binge drinking among adults were used for these analyses. Additional detail about the efficacy rating process and average efficacy scores for each policy are summarized in a separate publication.[29]

Because this was a study of state policy environments, federal policies or those that did not vary across states were excluded. Also, policies that did not exist in the U.S. and those without reliable cross-state data were excluded. Examples of excluded policies were blood alcohol concentration (BAC) 0.05 laws (do not exist in the U.S.); restrictions on mass media advertising (not promulgated at the state level); public intoxication laws (no variance at the state level); and mandatory substance abuse assessment for DUI offenders (absence of reliable data). Policies excluded because of inadequate or missing data tended to have low efficacy ratings (of 47 policies, the median rank was 32 based on efficacy to reducing binge drinking among the general population). Ultimately, 29 policies met inclusion criteria.

Implementation Ratings

In consultation with panelists with expertise in particular policies, an implementation rating (IR) was developed for each policy based on provisions or characteristics of a particular policy. Factors informing the implementation rating were typically based on a policy's statutory design (i.e., provisions making the policy broadly applicable, effective, or enforceable). The IR scales were reviewed by all panelists and revised by the investigators after reviewing the panelist feedback; any revisions typically involved re-weighting an IR scale metric based on panelist opinion about the relative importance of particular provisions. For all policies, the IR scale score by state and year could range from 0.0 (no policy) to 1.0 (full implementation; Appendix B, available at www.ajpmonline.org). Although IR scores varied by state-year, the scoring criteria applied to each policy were uniform across state-years.

Aggregating Policy Data to Calculate Alcohol Policy Scale Scores

Five methods were tested of aggregating policy data into APS scores for each state-year. Method 1 was based on a summation of

one point for each existing policy. Method 2 involved summing the ERs of all existing policies. Method 3 involved summing the IRs of all existing policies.

Methods 4 and 5 involved summing the products of policy ERs and IRs of all existing policies. In Method 4, the ERs were determined directly by rescaling the Likert-scale ratings (i.e., [ER–1]/4); in Method 5, the ERs were transformed by taking the inverse of their ER rank relative to other policies. For Methods 4 and 5, the purpose of rescaling the ERs was to ensure that the maximum possible ER was 1, in order to make the ERs and IRs of comparable magnitude so that when combined they could contribute approximately equally to the APS scores.

The approach for Methods 4 and 5 is a commonly utilized aggregation technique in the composite indicator literature that involves summing weighted and normalized subindicators.[30] It was hypothesized that either Method 4 or 5 would be the best way to operationalize the policy environment. The general formula to calculate the APS scores for Methods 4 and 5 is:

$$APS\ score_{jh} = \sum_{k=1}^{n=29}(ER_k * IR_{kjh}),$$

where j=state, h=year, k=policy, ER=efficacy rating, and IR=implementation rating.

Data Sources

For policy data sources, only sources with data for all 50 states that used uniform ascertainment methods across states were included (Appendix C, available at www.ajpmonline.org). The primary policy data source was the Alcohol Policy Information System (APIS).[25] APIS was a source for 14 of the 29 policies and was the primary source for 13 of these policies. Additional data sources were used to collect and code data about policies and provisions that were not included in APIS.

Investigators reviewed the data for each policy to identify missing or inconsistent data and to identify data that changed briefly before returning to their original form. When multiple data sources were available for a particular policy, data sources were cross-checked for consistency. Discrepancies were resolved by a public health lawyer using the legal research database WestlawNext. For six policies with missing data from 2000 to 2008, the research team used WestlawNext to conduct historical reviews to identify policy changes during that period. Policy data were collected and reviewed from January 2011 to July 2012.

State-level adult binge drinking prevalence during 2001–2010 came from the Behavioral Risk Factor Surveillance System (BRFSS) survey. Extensive detail about the BRFSS and its methods are available at www.cdc.gov/brfss. The BRFSS is a state-based random-digit-dial telephone survey of people aged ≥18 years, which is conducted monthly in all states, the District of Columbia, and three U.S. territories. Binge drinking was defined as consuming ≥5 (men) or ≥4 (women) drinks on one or more occasions in the past 30 days. Data were weighted to be representative of state populations.

Comparing Methods of Calculating the Scores

The five methods were used to calculate a policy environment score for each of the 50 U.S. states and Washington DC for each year from 2000 to 2010, resulting in 561 state-years for each method. Pearson correlations were calculated to compare pairwise association among the policy scores for the five methods.

Assessing the Relationship between the Scores and Binge Drinking

For all state-year strata, linear regression was conducted using state-year APS scores of each scoring method to predict state-level binge drinking prevalence. Goodness of fit was evaluated in the form of R-squared. A 1-year lag between the APS exposure variable and binge drinking prevalence outcome was assessed (e.g., APS scores in Year X were associated with binge drinking prevalence in Year X+1). The same analyses were also performed using 0- and 3-year lag periods. To adjust for the clustering of repeated measures of the same state, generalized estimating equations, as well as a longitudinal analysis, were employed to compare to results based on linear regression. Linear regressions were also performed on the relationship between APS scores and binge drinking prevalence for individual years (versus all years combined) using a 1-year lag between the APS scores and binge drinking prevalence outcomes. Analyses were conducted during January 2012–January 2013.

Results

Correlation among Methods

When comparing the various methods of calculating APS scores relative to Method 1 (the method of simply summing the number of present policies for all state-years of data), all correlation coefficients were $r > 0.5$ and were significant (Table 1). Method 1 demonstrated the weakest correlation compared with Methods 4 and 5, which weighted existing policies according to both their efficacy and implementation ratings.

Table 1. Correlation of five different methods of calculating the Alcohol Policy Scale scores, U.S. states, 2000–2010

Method	1[a]	2[b]	3[c]	4[d]
1[a]	—	—	—	—
2[b]	**0.886**	—	—	—
3[c]	**0.802**	**0.713**	—	—
4[d]	**0.692**	**0.746**	**0.927**	—
5[e]	**0.504**	**0.609**	**0.752**	**0.899**

Note: Boldface indicates significance. For all values, $p<0.0001$.
[a]Method 1 was calculated by summing one point for each existing policy in a particular state-year.
[b]Method 2 was calculated by summing the efficacy ratings of all existing policies in a particular state-year.
[c]Method 3 was calculated by summing the implementation ratings of all existing policies in a particular state-year.
[d]Method 4 was calculated by summing the products of implementation and efficacy ratings in a particular state-year. The ERs were determined directly by rescaling the Likert scale ratings, that is, (ER−1)/4.
[e]Method 5 was calculated by summing the products between implementation and efficacy. Efficacy ratings were transformed by taking the inverse of their ER rank relative to other policies.

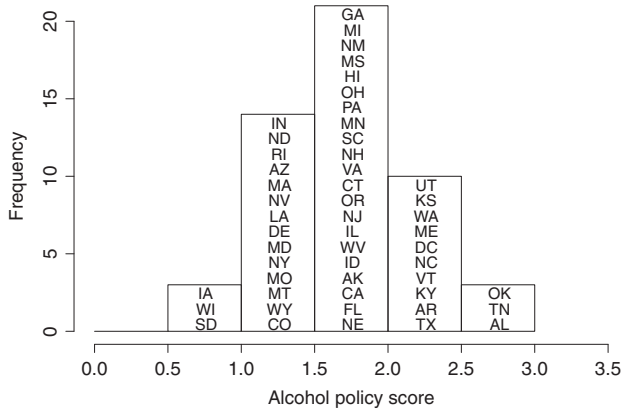

Figure 1. Distribution of Alcohol Policy Scale scores, 2008

State Variation in Scores

The policy environment differed across U.S. states. Using 2008 as an example, Figure 1 shows the distribution of APS scores for all 50 U.S. states and Washington DC using Method 5. The scores appear to be normally distributed. South Dakota had the lowest APS score, and Oklahoma had the highest score.

Relationship between Scores and Binge Drinking Prevalence

All five methods for calculating the APS score were significantly associated with lower binge drinking prevalence among adults (e.g., Method 5 beta=−3.90, $p<0.0001$; Table 2). The simple summative scale (Method 1) explained the least variance of adult binge drinking (R^2=0.12) in bivariate models. Introducing either ERs (Method 2) or IRs (Method 3) improved the goodness of fit compared with Method 1 (Method 2 R^2=0.15, Method 3 R^2=0.18). Combining efficacy ratings and implementation ratings in Methods 4 and 5 further improved goodness of fit (Method 4 R^2=0.25, Method 5 R^2=0.31).

Findings stratified by year of outcome from 2001–2010 were similar to pooled results (range for R^2 based on Method 5 using a 1-year lag = 0.26–0.38, mean=0.32, median 0.33). In pooled analyses using linear regression models, using 0- and 3-year lags between APS scores and binge drinking prevalence did not meaningfully affect the results.

Based on Method 5, controlling for selected state-level covariates including age, gender, race/ethnicity, religious composition, median household income, urbanization, police officers per capita, region, and year further increased the goodness of fit in a simple linear regression model of the relationship between the APS score and adult binge drinking prevalence (beta=−1.90, $p<0.0001$, R^2=0.61).

Assessing the relationship between APS scores and adult binge drinking prevalence using other regression methods yielded similar results. Based on GEE method adjusting for clustering (e.g., first-order autoregressive covariance structure) of repeated measures of states over the study period, the alcohol policy score was inversely correlated with binge prevalence (beta=−1.84, SE=0.61, $p<0.001$; Table 3). Longitudinal analysis yielded consistent unadjusted and adjusted (with covariates) effects of APS (Method 5) scores on binge drinking prevalence (unadjusted beta=−2.41, $p<0.001$; adjusted beta=−1.40, p=0.03, respectively).

Based on Method 5, the median state binge drinking in ascending quartiles of APS scores were 17.4%, 15.8%, 15.6%, and 13.0%. After adjusting for the state covariates and clustering for repeated measures, having an above-median APS score was associated with reduced odds of having a state binge drinking prevalence in the top quartile (AOR=0.28, 95% CI=0.10, 0.82; data not shown).

As an example from a single comparison period, Figure 2 shows the unadjusted relationship between state APS scores in 2008 and state-level binge drinking prevalence in 2009 (r=−0.54, $p<0.001$). The six states with the highest APS scores (Washington, Kansas, Utah, Alabama, Tennessee, Oklahoma) fell below the median in terms of binge drinking prevalence and the six states with the lowest APS scores (South Dakota, Wisconsin, Iowa, Colorado, Wyoming, Montana) had prevalences above the median binge drinking prevalence.

Table 2. Relationship between Alcohol Policy Scale scores and binge drinking prevalence[a] among adults, U.S. states, 2000–2010[b]

APS score method	Beta	SE	*p*-value	R^2
1[c]	−0.455	0.055	<0.0001	0.119
2[d]	−1.308	0.137	<0.0001	0.153
3[e]	−0.592	0.056	<0.0001	0.179
4[f]	−1.633	0.126	<0.0001	0.250
5[g]	−3.901	0.256	<0.0001	0.314

[a]BRFSS binge drinking prevalence was obtained from BRFSS surveys and was defined as ≥1 occasions of consuming ≥4 drinks for women or ≥5 drinks for men in the past 30 days.
[b]APS scores were associated with binge drinking outcomes using a 1-year lag between APS scores and binge drinking outcomes (e.g., APS scores in 2008 were associated with binge drinking prevalence in 2009).
[c]Method 1 was calculated by summing one point for each existing policy.
[d]Method 2 was calculated by summing the efficacy ratings of all existing policies in a particular state-year.
[e]Method 3 was calculated by summing the implementation ratings of all existing policies in a particular state-year.
[f]Method 4 was calculated by summing the products of implementation and efficacy ratings of all existing policies in a particular state-year after rescaling the efficacy ratings, that is, (ER−1)/4.
[g]Method 5 was calculated by summing the products of implementation ratings and the inverse of the efficacy rating ranks of all existing policies in a particular state-year.
APS, Alcohol Policy Scale

Table 3. Relationship between Alcohol Policy Scale score[a] and binge drinking prevalence[b] among adults for the generalized estimating equations model, U.S. states, 2000–2010[c]

State-level predictor	Beta	SE	*p*-value
APS score	−1.844	0.606	<0.001
Adult (aged ≥21 years) proportion	0.002	0.004	0.046
Male proportion	0.189	0.207	0.362
Non-Hispanic white proportion	−0.029	0.012	0.012
Non-Hispanic black proportion	−0.008	0.030	0.800
Non-Hispanic others proportion	−0.002	0.031	0.958
Hispanic proportion	ref		
Level of urbanization	−0.040	0.073	0.579
Median household income	0.037	0.028	0.179
Religious (Catholic) per 1000	0.007	0.004	0.046
Police officers per 1000	0.280	0.331	0.396
Northeast region	0.108	1.239	0.930
Midwest region	2.652	0.853	0.002
South region	−1.153	0.931	0.216
West region	ref		
Year (as a continuous variable)	−0.003	0.057	0.954

[a]APS scores were calculated by summing the products of implementation ratings and the inverse of the efficacy rating ranks of all existing policies in a particular state-year.
[b]BRFSS binge drinking prevalence was obtained from BRFSS surveys and was defined as ≥1 occasions of consuming ≥4 drinks for women or ≥5 drinks for men in the past 30 days.
[c]APS scores were associated with binge drinking outcomes using a 1-year lag between APS scores and binge drinking outcomes (e.g., APS scores in 2008 were associated with binge drinking prevalence in 2009) adjusting for state-level covariates and for clustering among repeated measures of the same state across the study period using Generalized Estimating Equations method.
APS, Alcohol Policy Scale

Discussion

Policy environments differed widely across U.S. states over time. This analysis found that higher APS scores were strongly inversely associated with adult binge drinking before and after adjusting for a variety of potential confounders. Further, the alcohol policy environment explained a substantial proportion of the variation between state binge drinking prevalence. These findings suggest that the alcohol policy environment is an important determinant of drinking behaviors at the population level, and provide new evidence that population-based policies are an effective, modifiable means by which to reduce excessive drinking.

To our knowledge, the Alcohol Policy Scale represents the first effort to develop and validate a composite measure to operationalize the alcohol policy environment in U.S. states. This work is important to determine whether, or to what extent, the policy environment is associated with binge drinking, which is a leading preventable cause of death in the U.S.[31] Further, characterizing the policy environment may lead to a better understanding of the relative importance of policies and in the context of other factors as possible risk or protective factors for excessive drinking. Finally, characterizing the policy environment could lead to a better understanding of the relative effectiveness of individual policies or combinations of policies and could contribute to future efforts to modify the policy environment in order to achieve public health objectives related to excessive drinking.

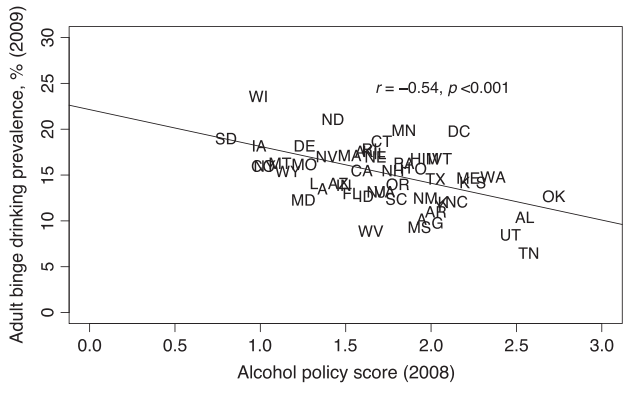

Figure 2. The Alcohol Policy Scale score for each state during 2008 and corresponding unadjusted adult binge drinking prevalence during 2009

Findings were similar when using different lag periods between the policy environments and drinking outcomes, were consistent in individual years as well as for all years combined, and were consistent when using statistical models that account for clustering of repeated measures of the same state over time. Although it is possible that public opinion supporting more restrictive alcohol policies is associated with lower levels of drinking and a stronger policy environment, comprehensive reviews of effective alcohol policies have been based primarily on longitudinal analyses in which the effect of policy is assessed after the

policy is enacted, thus controlling for prevalent attitudes that led to adoption of those policies in the first place.[32–36]

All the methods of aggregating the policies into APS scores were correlated with one another, suggesting that the approach was robust with respect to characterizing the policy environment across several related methodologies. In terms of construct validity, APS scores that were based on policies after weighting for their relative efficacy as well as their degree of implementation best predicted adult binge drinking outcomes in states. This supported the hypothesis that the mix of prevalent policies, as well as their relative efficacy and degree of implementation, are all important factors when operationalizing the policy environment as an exposure variable.

Limitations

This study is subject to caveats and limitations. The purpose of this study was to determine if varying policy environments accounted for differences in binge drinking across U.S. states. Potentially effective policies that have not been adopted in the U.S. were not assessed (e.g., 0.05% BAC laws). The policy scales did not include policies that are promulgated at the national, county, or local levels (e.g., alcohol marketing in mass media, county-level alcohol taxes). In addition, some policies nominated as effective did not have reliable cross-state data about their presence or provisions and were therefore not included in the APS scoring system. Further, the efficacy ratings and implementation ratings for any given policy may be informed by an incomplete and limited evidence base, and a different group of investigators or policy panelists might have differing opinions about what constitutes key provisions of a given policy.[30]

Enforcement is a theoretically important component of policy implementation for some policies,[37] but there are no reliable, publicly available cross-state data about enforcement, even for specific policies. This limitation was addressed by including policy provisions that made particular policies enforceable, by including the number of Alcoholic Beverage Control officials with enforcement capability as an alcohol policy in our scales, and by controlling for the number of police officers per capita as a state-level control variable. However, all limitations related to the imprecision of the exposure or outcome variables may have biased the results towards the null hypothesis, particularly because the methods used here for policy ascertainment, policy scoring systems, and determining binge drinking prevalence were uniform across states. BRFSS estimates are subject to survey noncoverage and nonresponse biases, but are reliable for comparisons across states,[38,39] which was the focus of the current analyses.

Conclusion

Development of the APS establishes the groundwork for further studying the effect of the alcohol policy environment in the U.S. and for subsequently assessing the relative impacts of combinations of related policies for reducing binge drinking or other alcohol-related outcomes such as youth drinking, impaired driving, alcohol use disorders, alcohol-related economic costs, and alcohol-attributable mortality. Although efficacy ratings specific to adult binge drinking were used in this analysis, the collection of several context-specific efficacy ratings (e.g., efficacy for reducing drinking and driving among youth) from the expert panelists potentiates such future analyses.

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Appendix

Supplementary Data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.amepre.2013.07.015.