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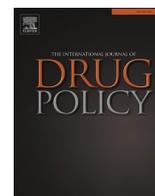
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Research Paper

Restrictive and permissive alcohol policies during the COVID-19 pandemic and their association with alcohol consumption in the United States

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ABSTRACT

Background: Early in the COVID-19 pandemic, alcohol researchers anticipated that psychological distress and changes in alcohol availability would impact alcohol consumption patterns. While psychological distress was expected to increase alcohol use, particularly among vulnerable groups, restrictive alcohol policies might have led to reduced consumption. This study examined the complex relationship between psychological distress, alcohol policies, alcohol consumption, and their interactions with sociodemographic factors during the COVID-19 pandemic in the US.

Methods: We used 2020–21 US Behavioral Risk Factor Surveillance System Survey (BRFSS, $N = 726,962$ adults) data to analyze associations between psychological distress, alcohol policy scores, and alcohol consumption, considering age, sex, education, race and ethnicity, and COVID-19 government response as covariates in a zero-inflated multi-level regression. State-level monthly alcohol policy scores derived from Alcohol Policy Information System data reflect the restrictiveness and permissiveness of alcohol policies implemented during the COVID-19 pandemic.

Results: Psychological distress and exposure to restrictive policies increased the likelihood of abstaining from alcohol in the past month, although the observed effects were small. Among past-month drinkers, distress and restrictive policies were associated with slightly higher average daily consumption in pure alcohol grams/day. Younger respondents were more likely to abstain from alcohol when exposed to restrictive policies, while permissive policies correlated with higher drinking prevalence and heavy episodic drinking occurrence among those with higher education.

Conclusion: Alcohol policies and psychological distress during the COVID-19 pandemic were linked to both lower and higher alcohol consumption in different population subgroups. Restrictive and permissive policies had diverging associations with consumption patterns across subgroups. While effect sizes were modest, they could translate into meaningful changes in alcohol consumption at the population level, especially during prolonged times of crisis.

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Early in the COVID-19 pandemic, alcohol researchers suggested two potential mechanisms for the pandemic's global impact on alcohol use based on evidence from previous public health crises (Rehm et al., 2020; de Goeij et al., 2015). The first mechanism postulates that increased psychological distress—triggered by financial difficulties, reduced social contact, and uncertainty about the future—may worsen patterns of alcohol use and increase related harm (Rehm et al., 2020; Rodriguez et al., 2020). There is now ample evidence from the United States (US) supporting this hypothesis, including a spike in psychological distress (McGinty et al., 2022; Ernst et al., 2022; Dragiotti et al., 2022; Czeisler et al., 2020), alongside increased levels of alcohol consumption (Acuff et al., 2022; Patrick et al., 2022), and rising alcohol-attributable mortality during the COVID-19 pandemic (White et al., 2022; Yeo et al., 2022). For example, the US National Institute on Alcohol Abuse and Alcoholism (NIAAA) recorded a 5.5 % increase in US per capita alcohol consumption from 2019 to 2021, the largest two-year increase since 1969 (Slater & Alpert, 2023).

Some changes in alcohol use also mirror differential stress responses across population subgroups. Studies show that psychological distress was more pronounced among women (compared to men) (Dragiotti et al., 2022; Leung et al., 2022), racialized minority groups in the US (compared to non-Hispanic White individuals) (Czeisler et al., 2020; Thomeer et al., 2023), young adults (compared to older adults) (McGinty et al., 2022; Dragiotti et al., 2022; Czeisler et al., 2020) and in individuals with lower income (compared to individuals with higher income) (McGinty et al., 2022; Leung et al., 2022). Correspondingly, studies found significant increases in drinking and alcohol use disorder prevalence among women and African Americans (Rodriguez et al., 2020; Barbosa et al., 2021; Kerr et al., 2022), reduced drinking and heavy drinking prevalence among men and White respondents in 2020 and 2021 (Kerr et al., 2022), and increased drinking frequency among young (Patrick et al., 2022) and middle-aged respondents (Patrick et al., 2022; Kerr et al., 2022).

In contrast, based on insights from alcohol control policy research, a second mechanism predicts reductions in alcohol use and some related problems (e.g., violence in public places) during the pandemic as a result of changes in alcohol availability and affordability (Rehm et al., 2020; Sherk et al., 2018; Popova et al., 2009; Campbell et al., 2009). Restrictions on alcohol access during the COVID-19 pandemic—such as the closing of on-premises consumption sites (Lemp et al., 2023)—could decrease overall alcohol consumption (Rehm et al., 2020). In addition, job loss and reduced working hours during crises like the COVID-19 pandemic may make alcohol less affordable (de Goeij et al., 2015). Evidence from the first year of the pandemic supports this, with global alcohol consumption decreasing by 10.3 % (World Health Organization, 2024), particularly in poorer countries. Together, these two mechanisms are expected to lead to a polarization of drinking in the general population (Rehm, 2024).

The US is one of the few high-income countries for which overall alcohol consumption increased during COVID-19 (World Health Organization, 2024). This may be, in part, due to the relaxation of alcohol control measures curtailing alcohol home delivery and “to-go” alcohol sales to provide economic relief to establishments and retailers—thereby counteracting the effects of alcohol access restrictions. Many of these permissive measures have since become permanent post-pandemic, raising concerns about long-term increases in alcohol availability (Sherk et al., 2018, Lemp et al., 2023; Noel & Rosenthal, 2023). Notably, early evidence suggests that individuals who had alcohol delivered reported higher consumption compared to people who obtained alcohol through other methods (Grossman et al., 2022; Trangenstein et al., 2023; Huckle et al., 2020).

While these mechanisms were proposed as early as April 2020 (Rehm et al., 2020), no study has yet investigated the unique associations of psychological distress and restrictive versus permissive alcohol policies with alcohol consumption during the COVID-19 pandemic in the US. To fill this research gap, we developed two alcohol policy scores to capture

temporary restrictive and permissive policy measures implemented during COVID-19. Using monthly data from the Behavioral Risk Factor Surveillance System (BRFSS), we analyzed the association between these scores' associations and alcohol consumption.

Guided by the literature, we proposed a causal pathway model (Fig. 1) and formulated several hypotheses: a positive association between psychological distress and alcohol consumption (H1), a negative association between stringency of restrictive policy measures and alcohol consumption (H2), and a positive association between permissive policy measures and alcohol consumption (H3). Given that the decision to drink or abstain differs fundamentally from the decision to drink more or less—each driven by distinct sets of motives—and that increases in alcohol use during the COVID-19 pandemic seem to be primarily driven by greater drinking frequency and volume (Kerr et al., 2022), we evaluate these associations separately for drinking prevalence (any drinking vs. none) and the level of alcohol consumption among those who drink. The latter, in particular, may be more strongly influenced by circumstantial factors including changes in alcohol availability.

Recognizing potential differential impacts of the pandemic across population groups, we also tested three interaction hypotheses. First, we hypothesized that women reported higher alcohol use (compared to men) in association with psychological distress (H4). Women appear to have experienced greater psychological distress during the pandemic, due to their predominance in the healthcare workforce (Connor et al., 2020; Brooks et al., 2020) and additional caregiving and domestic responsibilities (Acuff et al., 2022; Connor et al., 2020). Further, the pandemic's disruption of access to emotional and instrumental social support (Tamres et al., 2002; Spataro et al., 2016)—coping mechanisms commonly used by women—may have contributed to their increased alcohol consumption in response to additional stressors.

Second, we hypothesized that younger respondents reported lower alcohol use (compared to older respondents) when exposed to more restrictive measures (H5). Young adults' alcohol consumption patterns are heavily influenced by social motives and their social environment (Schulenberg & Maggs, 2002; Kuntsche et al., 2005). It has been hypothesized that reductions in drinking and heavy drinking seen among young adults may reflect reduced opening hours, closures, and other restrictions placed on bars and restaurants, nightclubs, parties, and other events (Patrick et al., 2022; Kerr et al., 2022). These contexts are most commonly utilized by younger drinkers and might not have been fully replaced by home drinking (White et al., 2020).

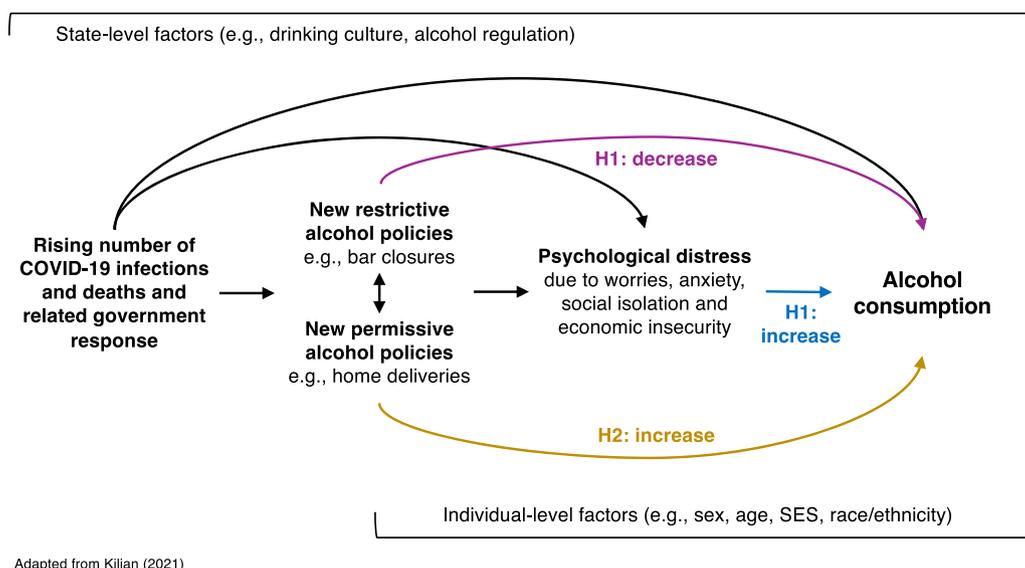
Lastly, our final interaction hypothesis is that respondents with high socioeconomic status (SES) reported higher alcohol use (compared to respondents with low SES) when exposed to more permissive measures (H6). Although evidence on the demographic differences in the effects of alcohol availability policies is limited (Kilian et al., 2023), existing studies suggest that people with higher SES are more likely to make use of alcohol delivery services (Trangenstein et al., 2023). This may be due to lifestyle factors, affordability, and/or greater availability in urban-/more affluent areas.

Methods

Study population

Our study comprised respondents from the BRFSS in the years 2020 and 2021. The BRFSS is an annual repeated cross-sectional survey using a multistage-cluster sampling design. It collects data, representative at the state and national level, from non-institutionalized US residents in 50 states plus Washington DC. We included individual-level data from 726,962 adults (18 years and older) with complete reports on relevant variables. Missingness is reported in Supplemental Table S1. A sample description by year is available in Supplemental Table S2.

BRFSS data collection was not substantially impacted by pandemic-related disruptions due to its telephone survey format (Office of Science



Adapted from Kilian (2021)

Fig. 1. Hypothesized causal pathway model adapted from Rehm et al. (2020) and Kilian (2021). H1: Total effect of psychological distress on alcohol consumption adjusted for COVID-19 government response and alcohol control policies. H2: Direct effect of restrictive alcohol policies on alcohol consumption, isolated from the effect mediated through psychological distress. H3: Direct effect of permissive alcohol policies on alcohol consumption, isolated from the effect mediated through psychological distress.

& Data Policy, 2021). Response rates for BRFSS are determined by dividing the number of respondents who completed the survey by the total number of eligible and likely-eligible people, which follows standards set by the American Association for Public Opinion Research (AAPOR) (The American Association for Public Opinion Research, 2023). The median survey response rate across all states, territories and Washington, DC, in 2020 was 47.9 and ranged from 34.5 to 67.2 and in 2021 was 44.0 and ranged from 23.5 to 60.5. The BRFSS's reliance on telephone surveys may introduce sampling biases by excluding individuals without phone access or those less likely to answer unknown calls, despite mitigation efforts like Random Digit Dialing (RDD) and dual-frame sampling. We analyzed the distribution of interviews by month and US region (Northeast, Midwest, South, West) to ensure there were enough observations at each period across the two years (Supplemental Fig. S1). This time-specific data linkage procedure prevented us from applying usual survey weights. However, since our main objective was to test hypotheses regarding specific associations, weighting was not deemed necessary (Groves, 2004).

Study measures

Drinking measures

The main outcome variable was the average grams of pure alcohol consumed per day (GPD). This was calculated based on the reported alcohol frequency and quantity consumed per occasion in the past 30 days. With BRFSS data, it is not possible to identify past-year or lifetime abstainers, as the alcohol use variables only relate to a 30-day timeframe. Therefore, respondents who did not report any alcohol consumption in the past month were assigned zero GPD and classified as abstainers. As a secondary outcome, we performed parallel analyses for the count of days with heavy episodic drinking (HED, which the BRFSS defines as 4+ drinks for women/5+ drinks for men on a single occasion) in the past month (range 0–30). The gender-specific threshold for HED aligns with US clinical guidelines based on studies indicating that women experience alcohol-related problems at a lower threshold compared to men (National Institute on Alcohol Abuse & Alcoholism, 2019; Dawson et al., 2005).

Alcohol policy measures

The NIAAA's Alcohol Policy Information System (APIS) recorded

date-specific information on alcohol-related legislation from January 1, 2020, to December 31, 2021 (National Institute on Alcohol Abuse & Alcoholism, 2022). BRFSS data includes the exact date each interview was conducted allowing us to link each respondent's answers to alcohol use and psychological distress questions to the existing policy environment at that time (i.e., the past 30 days). All processing was done using R version 4.3.1 and the *lubridate* package (version 1.9.3) to handle time data. Table 1 details which policies we included in the restrictive and permissive policy score, respectively, and presents the final scoring system. In short, we applied a two-step weighting procedure to alcohol-related policies before combining them into their respective sum score: First, we assigned points to each policy indicating its expected impact on alcohol consumption, relative to other policies in its category (restrictive or permissive). Given the paucity of empirical evidence relating to the impact of specific policies during the pandemic, these points were assigned based on an iterative consensus-building approach. Specifically, the lead authors (JML, CP) proposed a scoring system, which was then refined through multiple rounds of feedback from co-author alcohol policy experts (see Methods S1 for details). Second, we calculated for how many days each policy was in place in the 30 days prior to each interview date and weighted the exposure to each policy accordingly at the individual level. Consequently, each respondent received two policy scores (a restrictive and a permissive score) based on their state and interview date, with a higher policy score indicating a more restrictive or more permissive alcohol policy environment, respectively. The policy scores, ranging from 0 to 10, were centered around their mean before being entered into our regression models to test hypotheses.

Sociodemographic factors, psychological distress, and COVID-19 government response stringency

Self-reported sex (men, women), age (18 to 29, 30 to 59, 60 to 90), education level (low: high school diploma or less, medium: some college but no bachelor's degree, high: bachelor's degree or more), and race and ethnicity (collapsed categories: Hispanic, Non-Hispanic Black, Non-Hispanic Other, Non-Hispanic White; more details in Supplemental Table S2) were categorical variables.

Psychological distress was measured by one question asking the respondents how many days in the past month they experienced poor mental health ("Now thinking about your mental health, which includes

Table 1
Components and scoring of individual alcohol-related measures for policy scores.

Description		Points
Restrictive policy score (total available points: 10)		
<i>Restaurants</i>		
Closed	All restaurants throughout the state are closed to customers and can only be open for curbside pickup/takeout or delivery, if at all.	5
<i>If open:</i>		
Capacity	Number of customers allowed in the establishment at one time is capped, either by total percentage or total number	0.5
Food	Alcoholic beverage sales tied in restaurants are tied to food service	0.5
Hours	Alcoholic beverage sales only during a particular time window, and this time window is reduced compared to before the pandemic	0.5
Outdoor	Indoor dining banned, re-opened or open for outdoor dining only	0.5
<i>Bars</i>		
Closed	All bars throughout the state are closed to customers and can only be open for curbside pickup/take-out or delivery, if at all	5
<i>If open:</i>		
Capacity	Number of customers allowed in the establishment at one time is capped, either by total percentage or total number	0.5
Food	Alcoholic beverage sales tied in bars are tied to food service	0.5
Hours	Alcoholic beverage sales only during a particular time window, and this time window is reduced compared to before the pandemic	0.5
Outdoor	Indoor dining banned, re-opened or open for outdoor dining only	0.5
Permissive policy score (total available points: 10)		
<i>Restaurants</i>		
Takeout	Restaurants are permitted to sell alcoholic beverages to customers for takeout or curbside pickup	1
Delivery	Restaurants are permitted to deliver alcoholic beverages to customers, either directly or through a third-party delivery service	2
<i>Bars</i>		
Takeout	Restaurants are permitted to sell alcoholic beverages to customers for takeout or curbside pickup	1
Delivery	Restaurants are not permitted to deliver alcoholic beverages to customers, either directly or through a third-party delivery service	2
<i>Off-premises retailers</i>		
Delivery	Some or all off-premises establishments are permitted to deliver alcoholic beverages to consumers' homes, either directly or through a third-party delivery service	4

Note: A higher policy score indicates a more restrictive or more permissive alcohol policy environment, respectively. Given a lack of detailed information about partial restrictions and respondents' precise location, the weight applied is halved if the restrictions are in place in some jurisdictions of the state. See Methods S1 for details on policy score development.

stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?"

To control for the relationship between lockdown/state response and alcohol use, thereby isolating the effect of alcohol-related policies, we also considered the stringency score from the Oxford Government Response Tracker (Hale et al., 2021). The stringency score is based on nine metrics including, stay-at-home requirements, cancellation of public events etc (Hale et al., 2021). We tested for multicollinearity using variance inflation factors (VIF) with VIFs for the main regression model indicating low multicollinearity (see Methods S2).

Statistical analysis

Multi-level zero-inflated negative binomial regression analysis

As detailed above, with BRFSS data, it is not possible to identify past-year or lifetime abstainers, as the alcohol use variables only relate to a

30-day timeframe. However, individuals who abstain completely from alcohol have been found to exhibit distinct characteristics compared to light alcohol users (Mugavin et al., 2020; Vaughn et al., 2011) and their decision to abstain is likely driven by different considerations compared to the decision how much alcohol someone consumes when drinking. To account for these distinct processes, we fitted zero-inflated mixed models with a negative binomial distribution (ZINB) using the *glmmTMB* package (version 1.1.8) (Brooks et al., 2017). ZINB models simultaneously evaluate two different distributions of data (Hu et al., 2011): The logistic part of the model estimates a binary outcome (likelihood of being an excess zero, i.e., not consuming any alcohol/not reporting any HED in the past month) among all respondents. Results are reported as an Odds Ratio. The count part of the model estimates GPD among those who consumed any alcohol in the past month, including only the proportion of zeros that would be expected in a negative binomial distribution with the given sample mean and variance (Miller et al., 2019). Similarly, for HED, the count part estimates the number of HED days in the past month among those who reported any HED. Results are reported as Incidence Rate Ratios (IRRs). IRRs indicate by how much the average number of GPD would be expected to decrease (< 1) or increase (> 1) for a one unit increase in the predictor, given the other variables are held constant in the model.

The theoretically driven decision to select a ZINB model was empirically supported by model fit statistics (including likelihood-ratio tests and the Akaike information criterion), where ZINB outperformed other regression models including standard and zero-inflated Poisson models. While results from Hurdle models performed equivalently in terms of model fit, we limit our reporting to the ZINB model given almost identical results.

We did not preregister our hypotheses. To assess the total effect of psychological distress on alcohol use (H1), we fitted a mixed ZINB model adjusted for age, sex, education, and race and ethnicity as well as government response stringency and alcohol policies (restrictive and permissive policy score) whereby the latter account for upstream confounding in our causal pathway model (Fig. 1). To assess the direct effect of restrictive and permissive alcohol policies, respectively (H2 and H3), we fitted a mixed ZINB model adjusted for age, sex, education, race and ethnicity, government response stringency, psychological distress, and the counterpart alcohol policy score. We adjusted for the counterpart alcohol policy score (i.e., permissive alcohol policy score when assessing the effect of restrictive policies on alcohol use and vice versa) as they may offset one another. We also adjusted for psychological distress since we were primarily interested in the isolated effect of alcohol control policies on alcohol use (and not a potential mediating effect through psychological distress).

To investigate differential effects by sex, age, and education, we fitted three additional models where, in addition to adjusting for the aforementioned covariates, we included an interaction term of psychological distress with sex, the restrictive policy score with age, and the permissive policy score with education level.

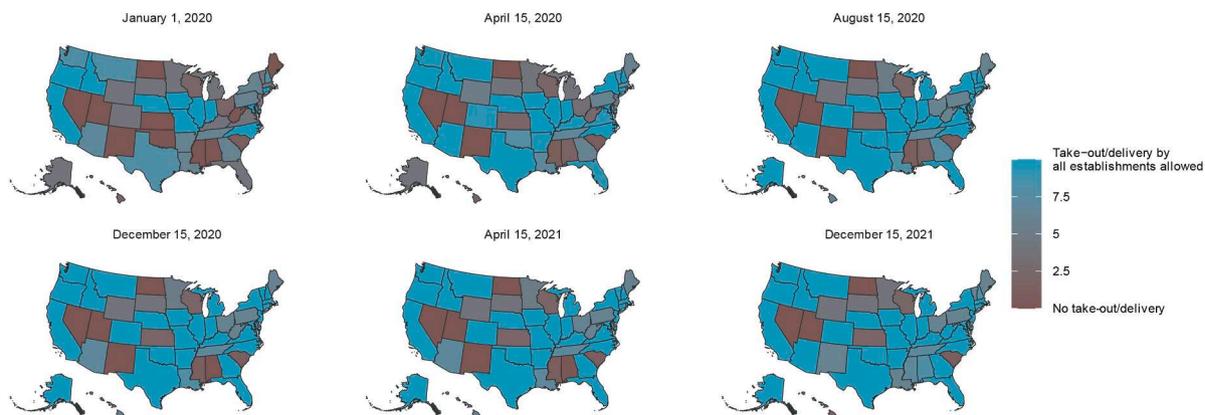
In all regression models, the state variable was included as random intercept to account for unobserved heterogeneity and variations in baseline alcohol use across states that are not captured by the policy environment. To facilitate interpretation of our results, in particular to illustrate interaction effects and gauge the magnitude of the effect, we computed estimated marginal means using the R package *ggeffects* (version 1.5.2) (Lüdtke, 2018).

Results

Policy scores

Fig. 2 shows the variation in permissive and restrictive policy scores by time and state. In most states (n = 34), off-premises retailers like breweries and liquor stores could already deliver alcoholic beverages before spring 2020 (Lemp et al., 2023). However, on-premises retailers

A: Permissive Policy Score



B: Restrictive Policy Score

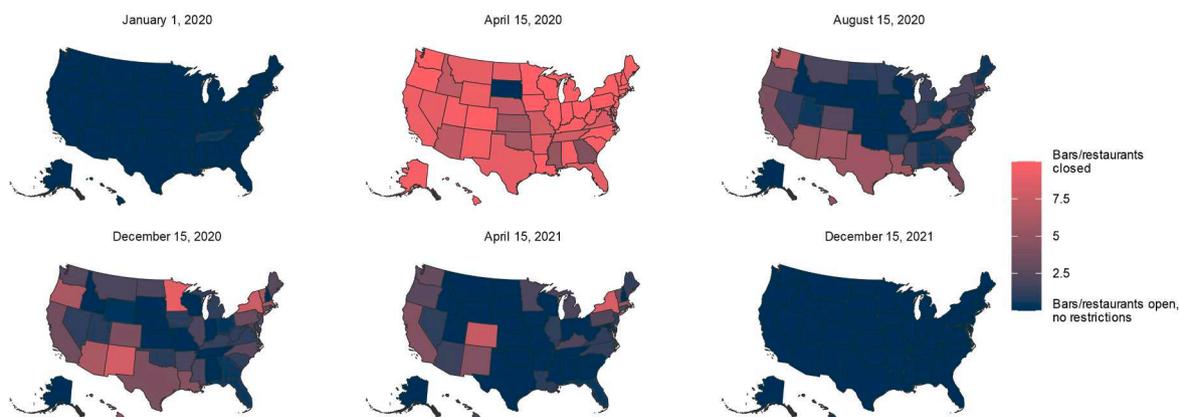


Fig. 2. Permissive and restrictive policy scores at different timepoints in 2020 and 2021 across the United States. Note that a higher policy score indicates a more restrictive or more permissive alcohol policy environment, respectively.

(bars or restaurants) were prohibited from offering alcohol delivery or take-out/curbside pick-up sales in 25 states. By the end of 2021, only 5 states maintained this prohibition. Most restrictive policy measures were introduced in spring 2020, but some continued for two years, with the last capacity restrictions lifted in Hawaii on December 1st, 2021.

Regression results

The effects of interest from the regression models for GPD are shown in [Table 2](#). In relation to psychological distress, experiencing more days with poor mental health in the past month was associated with higher odds of abstaining from alcohol in this period. However, among past-month alcohol users, psychological distress was associated with more GPD consumed in the past month. Likewise, a higher restrictive policy score (i.e., more stringent restrictions were in place in the past month) was associated with higher odds of abstaining altogether in the full sample but also with higher GPD among those who drank in the past month. The permissive policy score was neither associated with the odds of abstaining from alcohol nor with GPD in the past month ([Table 2](#)). When excluding the government response stringency score as a covariate, results for psychological distress remained unchanged, whereas opposing effects for the restrictive policy score slightly increased (count model part: 1.009, 95 % CI: 1.007–1.011; logistic model part: 1.013, 95 % CI: 1.010–1.017) and the permissive policy score was positively associated with GPD in the past month (count model part: 1.004, 95 % CI: 1.000–1.007; logistic model part: 1.001, 95 % CI: 0.994–1.008).

The negative binomial distribution follows a Type II specification with variance = $\mu + (\mu^2)/k$, where μ is the mean and k is the over-dispersion parameter. The dispersion parameter for all models is 0.37.

Results from regression models with number of HED days as the outcome show similar associations with policy scores: a higher restrictive policy score was associated with higher odds of *not engaging* in HED while it was associated with a higher number of HED days among those who engaged in HED at least once in the past month. The permissive policy was neither associated with the odds of engaging in HED nor with HED days in the past month. Higher psychological distress was associated with higher odds of engaging in HED as well as a higher number of HED days ([Table S3](#)).

In the first interaction model (H4), the inverse association between odds of abstaining from alcohol in the past month and psychological distress was weaker for women compared to men ([Table 3](#), [Fig. 3-I-B](#)). Put differently, women had higher odds of continuing to drink (rather than abstain) when exposed to high levels of distress compared to male counterparts and compared to levels with low distress. Women and men did not differ in their reported GPD consumed in the past month as a function of psychological distress. Note that the estimated marginal means from the count part of the model are informed by increasing rates for GPD, and the steeper absolute increase for men does not reflect a statistically significant interaction effect but is a result of higher baseline alcohol consumption ([Fig. 3-I-C](#)). In relation to HED, women and men did not differ in their odds of engaging in HED as a function of psychological distress, but women reported a relatively larger increase in

Table 2

Main results (H1-H3) from mixed-effects zero-inflated negative binomial regression models for average daily grams of pure alcohol in the past month.

Model effect	Logistic model part OR of past-month abstinence (95 % CI) ¹	Count model part IRR of past-month alcohol GPD (95 % CI) ²
Psychological Distress (H1) <i>Total effect (adjusted for sociodemographic variables,³ restrictive policy score, permissive policy score, and government response stringency)</i>	1.012 (1.011, 1.013)	1.018 (1.017, 1.018)
Restrictive Policy Score (H2) <i>Direct effect (adjusted for sociodemographic variables, psychological distress, permissive policy score, and government response stringency)</i>	1.010 (1.005, 1.015)	1.004 (1.002, 1.006)
Permissive Policy Score (H2) <i>Direct effect (adjusted for sociodemographic variables, psychological distress, restrictive policy score, and government response stringency)</i>	0.999 (0.991, 1.006)	0.999 (0.996, 1.003)

Note. N = 726,962. 95 % Wald-type confidence intervals indicated in brackets. GPD = grams of pure alcohol per day. Random intercept: US state.

¹ OR (Odds Ratio) indicates the ratio of odds for abstaining from alcohol in the past month ('zero probability').

² IRR (Incidence Rate Ratio) indicates the ratio of average grams of pure alcohol consumed per day.

³ Sociodemographic variables include sex, age, education, and race and ethnicity. A one-unit increase in psychological distress equals one additional day that respondents experience poor mental health in the past month. A higher policy score indicates a more restrictive or more permissive alcohol policy environment, respectively.

number of HED days in the past month with increasing psychological distress compared to men (Table S3).

In line with our second interaction hypothesis (H5), respondents in the youngest (18 to 29) and mid-age group (30 to 59) had higher odds of abstaining from alcohol in the past month when exposed to restrictive policies compared to respondents in the oldest age group (60 to 90) (Table 3). Comparing scenarios with no restrictions vs. bar and restaurant closures in full effect (Fig. 3-II-B), there was a 4.6 percentage point decrease in drinking prevalence in the past month (1 minus past-month abstinence) for the youngest age group, compared to a 2.2 percentage point decrease in the mid-age group and a 1.4 percentage point decrease in the oldest age group. Those who consumed alcohol in the youngest age group did not differ in their past-month reported GPD compared to older respondents as a function of the restrictive policy environment; both age groups showed a small increase in GPD with higher restrictions. Conversely, respondents in the mid-age group reported lower GPD compared to older respondents when faced with more restrictions. As can be seen in Fig. 3-II-A, the opposing effects of past-month abstinence and average daily consumption offset each other in estimated marginal means that integrate both parts of the model. When considering HED, respondents in the youngest (18 to 29) and mid-age group (30 to 59) had higher odds of *not engaging* in HED when exposed to restrictive policies compared to respondents in the oldest age group (60 to 90; Table S3). There were no differences between age groups in the number of HED days with increasingly restrictive policy measures (Table S3).

In the third interaction model (H6), greater exposure to permissive policies in the past month was associated with a higher drinking prevalence (1 minus past-month abstinence) among respondents with higher education levels (Fig. 3-III-B). Specifically, compared to a scenario with no permissive policies in place, the drinking prevalence increased by 9.6 percentage points among respondents with high education when delivery as well as take-out was permitted from all establishments (the

Table 3

Interaction results (H4-H6) from mixed-effects zero-inflated negative binomial regression models for average daily grams of pure alcohol in the past month.

Model effect	Logistic model part OR of past-month abstinence (95 % CI) ¹	Count model part IRR of past-month alcohol GPD (95 % CI) ²
Interaction: Gender X Psychological Distress (H4)		
Gender: women (ref: men)	1.675 (1.641, 1.711)	0.508 (0.503, 0.513)
Psychological Distress	1.017 (1.015, 1.019)	1.018 (1.017, 1.019)
Interaction Gender: women (ref: men) X psychological distress	0.993 (0.990, 0.995)	1.000 (0.999, 1.001)
Interaction: Age X Restrictive policy score (H5)		
Age: 18 to 29 (ref: 60 to 90)	0.307 (0.295, 0.319)	1.081 (1.063, 1.099)
Age: 30 to 59 (ref: 60 to 90)	0.380 (0.371, 0.389)	1.115 (1.103, 1.127)
Restrictive Policy Score		
Interaction Age: 18 to 29 (ref: 60 to 90) X restrictive policy score	1.026 (1.014, 1.038)	1.000 (0.995, 1.006)
Interaction Age: 30 to 59 (ref: 60 to 90) X restrictive policy score	1.008 (1.000, 1.015)	0.995 (0.992, 0.999)
Interaction: Education X Permissive policy score (H6)		
Education: medium (ref: low)	0.438 (0.428, 0.449)	0.855 (0.843, 0.866)
Education: high (ref: low)	0.140 (0.134, 0.146)	0.784 (0.774, 0.794)
Permissive policy score	1.025 (1.017, 1.033)	0.996 (0.991, 1.000)
Interaction Education: medium (ref: low) X permissive policy score	0.973 (0.967, 0.979)	1.003 (0.999, 1.007)
Interaction Education: high (ref: low) X permissive policy score	0.888 (0.880, 0.896)	1.000 (0.998, 1.004)

Note. N = 726,962. 95 % Wald-type confidence intervals indicated in brackets. GPD = grams of pure alcohol per day. Ref: reference. Random intercept: US state. Each interaction model is adjusted for sociodemographic variables including sex, age, education, and race and ethnicity. In addition, H4 is adjusted for government response stringency, permissive policy score and restrictive policy score. H5 is adjusted for government response stringency, psychological distress and permissive policy score. H6 is adjusted for government response stringency, psychological distress and restrictive policy score.

¹ OR (Odds Ratio) indicates the ratio of odds for abstaining from alcohol in the past month ('zero probability').

² IRR (Incidence Rate Ratio) indicates the ratio of average grams of pure alcohol consumed per day.

maximum permissive policy score). In contrast, drinking prevalence remained nearly unchanged for those with medium education and decreased by 6.0 percentage points for those with low education in the most permissive environments. Respondents' reported GPD in the past month did not significantly differ between education levels as a function of the permissive policy environment.

Results from regression models for HED prevalence confirm this pattern: respondents with high education and medium education have higher odds of engaging in *any* HED when being in a highly permissive policy environment vs. in an environment with no permissive policies, compared to respondents with low education (Table S3). Among respondents who engage in HED, the number of HED days did not significantly differ between education levels as a function of the permissive policy environment.

Discussion

In this study, we provide novel evidence on the associations between newly implemented alcohol policies, psychological distress, and differential patterns of alcohol consumption during the COVID-19 pandemic. In line with our hypothesis, restrictive policy measures were associated with a lower overall prevalence of drinking and HED in the past month. However, restrictive policy measures were also associated with higher average daily consumption in GPD among past-month drinkers and an increased number of HED days among those who engaged in HED at least once in the past month. A similar pattern was observed for

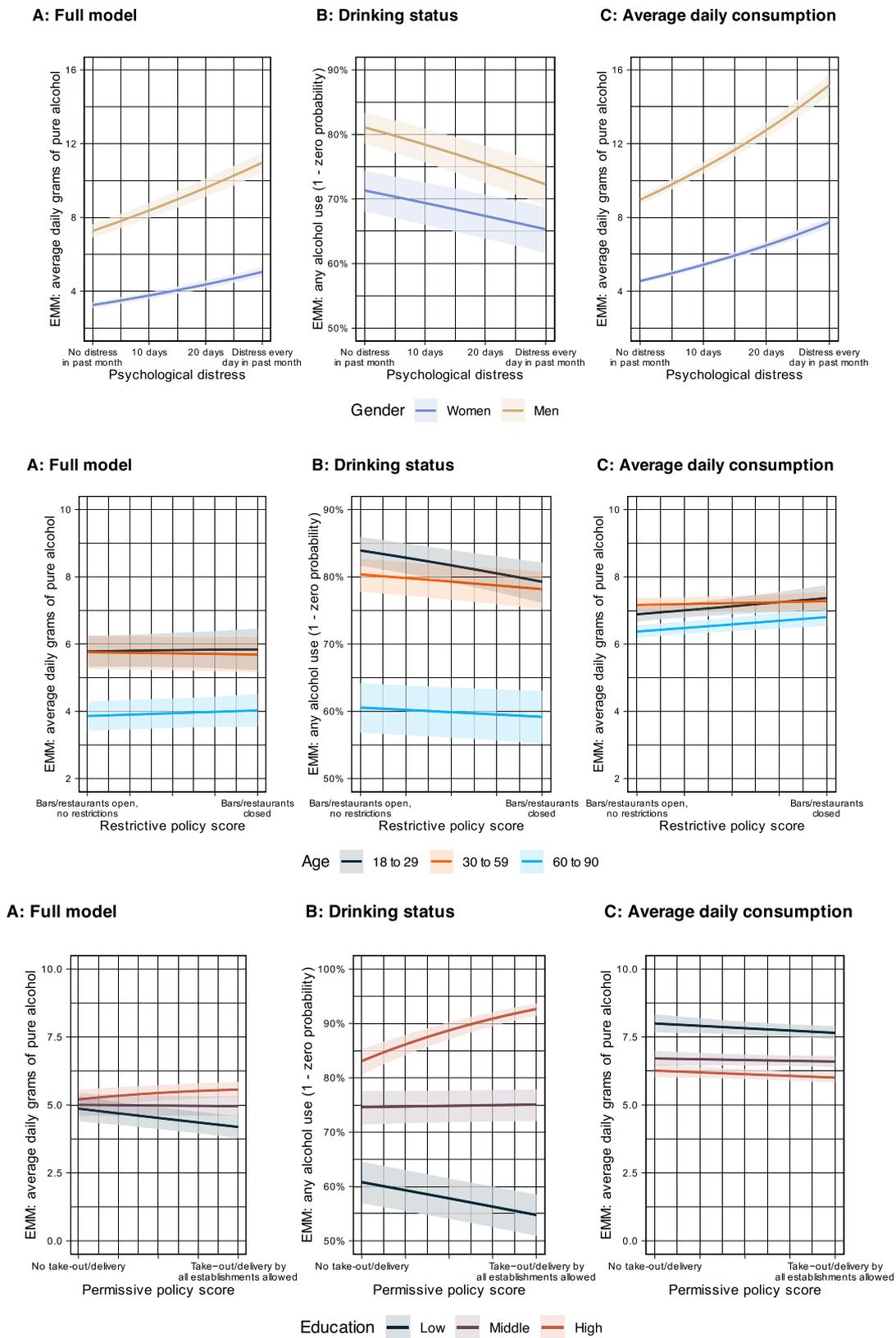


Fig. 3. Estimated marginal means (EMM) by (i) sex and psychological distress, (ii) age group and restrictive policy score, and (iii) education group and permissive policy score.

A, average daily drinking levels estimated from full model integrating counts and zero inflation, B, average daily drinking levels estimated from count model only, and C, drinking status by subtracting estimated zero probability from 1. Shaded area represents the 95 % Wald-type confidence intervals. Low: high school diploma or less, Middle: some college but no bachelor's degree, High: bachelor's degree or more. Shaded area represents the 95 % Wald-type confidence intervals.

psychological distress: higher psychological distress was associated with a lower drinking prevalence (in contrast to our hypothesis) but higher daily alcohol consumption, greater odds of engaging in HED, and more HED days in the past month (in line with our hypothesis). These patterns likely contributed to the observed increases in alcohol consumption among certain subgroups during the pandemic. Although the effect sizes were generally small, they remain important to consider: While modest reductions or increases in individual alcohol consumption may seem minor, their cumulative impact across entire populations could result in substantial public health benefits. Given the high prevalence of drinking and the number of health outcomes causally linked to alcohol use, small shifts in consumption patterns can meaningfully reduce alcohol-related harm at the population level.

Our findings are in line with a proposed polarization of alcohol consumption during the COVID-19 pandemic¹: While some people have decreased or even stopped drinking alcohol temporarily in 2020 and 2021, drinking levels have escalated in others (Acuff et al., 2022; Rossow et al., 2021). Recent literature suggests that tension-reduction theories of distress predicting alcohol use may be most applicable to heavier-drinking populations, whereas responses among lighter drinkers appear more nuanced (Wolkowicz et al., 2022). Indeed, the most pronounced increases in alcohol consumption levels were observed in those with the highest alcohol consumption prior to the pandemic (Rossow et al., 2021), mirrored by a significant increase in alcohol-related mortality. In the US, deaths due to alcohol use disorder increased by 24.8 % and 22.0 % in 2020 and 2021, respectively (Yeo et al., 2022), and alcohol-related liver mortality likewise increased by 23.4 % from 2019 to 2020 (Kulkarni et al., 2023). Our research adds to the existing body of research that newly implemented alcohol policies and psychological distress may have contributed to these developments.

An increase in daily alcohol consumption among past-month alcohol users in a restrictive policy environment may be explained by a shift from on-premises drinking to drinking at home. At home, the opportunity costs associated with alcohol use—such as price, effort, and time—are lower compared to drinking at restaurants and bars (Acuff et al., 2021). Additionally, new opportunities to work from home eliminated the commute to work, decreased the time required to get ready for work, and extended the time available for sleep (e.g., after a night of heavy drinking). These new opportunities and its associated “benefits” are also likely more available to those working in office/white-collar jobs rather than essential workers.

Our interaction analysis supports this explanation: individuals with high education were more likely to use delivery and “to-go” services, as indicated by increased drinking and HED prevalence when these options were available. This is in line with prior findings from the National Alcohol Survey (Trangenstein et al., 2023). At the same time, we observed a negative association between permissive policy measures and drinking prevalence in the low education group, that is, respondents with lower education were more likely to abstain from alcohol in the past month when delivery and “to-go” services were available. Although our models of permissive policy effects accounted for potential confounding by restrictive policy measures, it is possible that this counterintuitive effect may have been driven by the unique timing of permissive policy changes during peak pandemic phases (Lemp et al., 2023). During this period, individuals with low SES were particularly vulnerable to being infected with the coronavirus and were less likely to work from home compared to those with high SES (Backer et al., 2022).

Additionally, given physical distancing guidelines, drinking competed with fewer other leisure activities. However, people who primarily drink in social contexts may have stopped drinking due to limited opportunities for in-person activities (Acuff et al., 2021). This is in line with our finding that restrictive policy measures were most associated with a decrease in drinking and HED prevalence in the youngest age group, whose alcohol consumption patterns are heavily influenced by social motives (Schulenberg & Maggs, 2002; Kuntsche et al., 2005).

Finally, during the pandemic, women bore the brunt of caregiving and domestic duties such as homeschooling, exacerbating the gender imbalance in the division of labor and contributing to increased mental health symptoms among women (Dragioti et al., 2022; Leung et al., 2022; Hahm et al., 2023). Our findings highlight that albeit women did not categorically drink more in response to higher psychological distress compared to men, the relative increase in HED days, which is considered one of the riskiest forms of alcohol consumption, was higher in women when experiencing high psychological distress.

Limitations

Our study had some limitations. First, no causal conclusions can be drawn from the results of our study given the cross-sectional data and chosen methodology. In addition, we did not account for pre-pandemic levels and differences between groups, and the lack of pre-pandemic policy information limited our possible analytical time window. However, interview date information from the BRFSS allowed us to directly relate APIS information on restrictive and permissive policy measures to each individual’s policy environment, and using data from 50 US states across two years ensured a wide variety of policy environments.

Second, given limited evidence about the impact of individual policy measures and laws during the pandemic, our scoring system should be deemed preliminary.

Third, there were limitations in the data used. Drinking measures were based on self-reported alcohol consumption data from the BRFSS, which is generally prone to underreporting and self-reporting biases (Stockwell et al., 2014). However, these distortions would have affected our results only if there were systematic differences in these biases across our sociodemographic groups or across survey months or years, for which there is limited evidence (Kilian et al., 2020). Likewise, psychological distress was measured as self-perceived poor mental health and not diagnosed by a health professional. Additionally, as a telephone-based survey, BRFSS is subject to potential selection bias since nonrespondents may differ systematically from respondents, potentially limiting generalizability (Zhao et al., 2009). While BRFSS response rates in 2020 and 2021 ranged from 23.5 % to 67.2 % depending on the state, these rates are consistent with similar large-scale surveys (Behavioral Risk Factor Surveillance System, 2022).

Fourth, it is plausible that the factors influencing the decision to drink at all (excess zero) differ from those shaping the decision of how much to drink (count process). BRFSS data did not include a number of variables that likely influence individuals’ decisions to abstain from alcohol entirely, beyond the investigated covariates. Factors such as cultural and religious norms surrounding alcohol abstinence or personal drinking histories were not accounted for, potentially limiting the explanatory power of the zero-inflation part of our model. This omission may have contributed to the relatively small effects observed for drinking prevalence. At the same time, the variables included in both parts of our model—psychological distress and restrictive and permissive alcohol policies—may exert opposing influences depending on the context. For example, psychological distress might lead some individuals to abstain from alcohol (e.g., due to aggravating effects of alcohol on psychological well-being, or due to worries about personal expenses at a time of widespread job loss), while prompting others to drink more as a coping mechanism. Indeed, our results suggest that psychological distress and restrictive policies were associated with higher odds of complete abstinence (excess zero), yet among past-month drinkers, these same factors were linked to increased consumption (count process). This highlights that while the same covariates appear in both parts of the model, their effects may operate through distinct mechanisms.

Finally, we acknowledge that the observed associations may have been driven by unique effects during the COVID-19 pandemic that we did not account for when adjusting for government response stringency index. For example, while the widespread rollout of COVID-19 vaccines

in 2021 likely influenced the COVID-19 government response and restrictive alcohol policies, this association precedes the key variables in our causal pathway. However, vaccination may have reduced risk perception among vaccinated individuals, potentially affecting psychological distress and alcohol consumption behaviors (Sepucha et al., 2024).

Conclusion

Our findings underscore that newly implemented policies during the pandemic were associated with alcohol use, with variations across different population groups and drinking patterns. Understanding how population groups may respond differently to policy measures and stressors can inform the development of targeted interventions and policies in future pandemics. For example, availability restrictions may reduce alcohol consumption and prevent health burden, in particular in younger age groups; however, there seem to be sizable groups of people (e.g., with higher SES) whose consumption appears to increase by shifting drinking off-premises and into homes.

Given the modest effect sizes and high psychological burden in the population, and among women in particular, restrictive policy measures are insufficient to curb harmful alcohol consumption. Knowing which population groups are more vulnerable to increased alcohol use during public health crises can help prioritize resources. For example, our findings on a gendered association between psychological distress and number of HED days, combined with evidence that middle-aged women experienced significant increases in high-acuity alcohol-related complications during the pandemic (Shuey et al., 2024), indicate a need for increased attention to alcohol use disorder (AUD) risk factors, drinking patterns and related health effects in this population. Populations vulnerable to increased psychological distress or elevated consumption levels require targeted interventions, including those specific to alcohol (e.g., alcohol screening and brief intervention), as well as measures to mitigate financial pressures, childcare responsibilities, and work-related stress in times of crisis.

Ethics approval

The authors declare that the work reported herein did not require ethics approval because it did not involve animal or human participation.

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CRedit authorship contribution statement

Julia M. Lemp: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **Carolin Kilian:** Writing – review & editing, Supervision, Investigation, Conceptualization. **Sophie Bright:** Writing – review & editing, Investigation. **William C. Kerr:** Writing – review & editing, Investigation, Funding acquisition, Conceptualization. **Laura Llamosas-Falcón:** Writing – review & editing, Investigation. **Nina Mulia:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Jürgen Rehm:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Charlotte Probst:** Writing – review & editing, Supervision, Project administration, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Charlotte Probst reports financial support was provided by National Institute on Alcohol Abuse and Alcoholism. William Kerr reports a relationship with National Alcoholic Beverage Control Association that includes: funding grants and travel reimbursement. William Kerr reports a relationship with Office of the Illinois Attorney General that includes: paid expert testimony. William Kerr reports a relationship with Office of the Indiana Attorney General that includes: paid expert testimony. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

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