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DOI: https://doi.org/10.1016/j.drugpo.2019.01.014

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Abstract

Background: A basic, yet untested tenet underlying alcohol control policies is that they should affect both light and heavy drinking, thereby shifting the entire population in a favourable direction. The aim of this study was to test this assumption in young Swiss men.

Methods: Cross-sectional self-reported data — from 5755 young Swiss men participating in the Cohort Study on Substance Use Risk Factors (C-SURF), a large cohort study on young men living within 21 jurisdictions across Switzerland — were analysed via nested logistic regression. With this approach, a set of increasingly-heavy drinking patterns was broken down into a set of nested regression models, each one estimating the probability of heavier drinking, conditional on the lighter drinking pattern. Drinking patterns relating to heavy episodic drinking (HED), heavy volume drinking (HVD) on weekends, and workweek drinking, as well as alcohol use disorder (AUD) were examined. The explanatory variable was a previously-used alcohol policy environment index (APEI) reflecting the number of alcohol control policies implemented in each jurisdiction. Conventional and multilevel logistic regression models were tested, adjusted for age, education, linguistic region, urban/rural status, attention-deficit/hyperactivity disorder, depression, sensation seeking, antisocial personality disorder, and unobserved heterogeneity between jurisdictions.

Results: For HED, weekend HVD, and AUD, negative relationships with the APEI were found, such that with a higher APEI the probability of lighter drinking patterns was increased while the probability of heavier patterns was reduced, including a reduced probability of the heaviest patterns. These relationships were non-linear, however, and tapered off towards the heavy end of the drinking spectrum. No relationship was identified between the APEI and workweek drinking patterns.

Conclusion: Among young Swiss men, stricter alcohol policy environments were associated with a global shift towards lighter drinking, consistent with the basic tenet behind the universal prevention approach.

Key words:

alcohol drinking; alcohol use disorder; alcohol control policy; health policy; young adult

Introduction

Regulating the availability of alcohol has been an enduring target of policy-makers worldwide, since alcohol use was found to be a leading risk factor for increased burden of disease (Hasin, Stinson, Ogburn, & Grant, 2007; Lim et al., 2012; Rehm et al., 2010; Rehm et al., 2009; Rehm, Room, van den Brink, & Jacobi, 2005). Studies indeed indicate that alcohol control policies — like restricting purchasing hours and increasing alcohol taxation — have a protective effect against alcohol use and related harm, both when considering the implementation of individual policies (Campbell et al., 2009; Elder et al., 2010; Gruenewald, 2011; Hahn et al., 2010; Kuo, Heeb, Gmel, & Rehm, 2003; Lavoie et al., 2017; Middleton et al., 2010; Popova, Giesbrecht, Bekmuradov, & Patra, 2009; Scherer, Fell, Thomas, & Voas, 2015; Stockwell, Auld, Zhao, & Martin, 2012; Wagenaar, Salois, & Komro, 2009; Wicki & Gmel, 2011) and when considering the alcohol policy environment, as indicated by the number of alcohol control policies implemented (Bendtsen et al., 2014; Brand, Saisana, Rynn, Pennoni, & Lowenfels, 2007; Foster, Held, Estevez, Gmel, & Mohler-Kuo, 2015; Foster, Held, Gmel, & Mohler-Kuo, 2016; Gilligan, Kuntsche, & Gmel, 2012; Hadland et al., 2017; Naimi et al., 2014; T. F. Nelson, Naimi, Brewer, & Wechsler, 2005; Paschall, Grube, & Kypri, 2009; Xuan, Blanchette, et al., 2015).

The implementation of a stricter alcohol policy environment usually follows a universal prevention approach that targets the entire population. A basic tenet of this approach is that it should be associated with a shift of the entire population towards higher proportions of lighter drinkers and lower proportions of heavier drinkers, thereby shifting the entire population in a favourable direction (Rose, 2001; Rossow, Makela, & Kerr, 2014; Skog, 1999). By reducing alcohol consumption globally, alcohol-related harm might be reduced via two routes. First, as heavy drinking is a strong predictor of various harms (Anderson, Chisholm, & Fuhr, 2009; Danielsson, Wennberg, Hibell, & Romelsjo, 2012; Taylor et al., 2010), cutting down heavy

drinking will help to reduce such harm. Second, alcohol-related harm might be reduced by lowering the consumption of moderate drinkers. The reason for this is that, although heavy drinkers are at the highest risk of alcohol-related harm, moderate drinkers nevertheless experience a substantial portion of the harm at the population level, due to their larger numbers (generating the so-called 'prevention paradox', Danielsson et al., 2012; Rose, 2001; Skog, 1999). This also holds true when considering heavy drinking episodes, rather than heavy drinking habits, because moderate drinkers also produce a substantial portion of total heavy drinking episodes (generating the so-called 'second-order prevention paradox', Gmel, Heeb, Rezny, Rehm, & Mohler-Kuo, 2005; Gmel, Klingemann, Muller, & Brenner, 2001; Skog, 1999). If, on the other hand, population-wide preventive effects are not evident, it is less obvious whether a population-based prevention approach is justified, relative to selective prevention measures that target specific high-risk subpopulations, like heavy drinkers, or specific high-risk situations, like drunk drinking.

Considering the existing studies, however, it is unclear whether a stricter alcohol policy environment exerts any global effect on alcohol consumption. The first issue is that these studies analysed per-capita consumption (Brand et al., 2007) or single drinking patterns (Bendtsen et al., 2014; Foster et al., 2015; Foster et al., 2016; Gilligan et al., 2012; Naimi et al., 2014; T. F. Nelson et al., 2005; Paschall et al., 2009; Xuan, Blanchette, et al., 2015). Single drinking patterns reflected either lighter or heavier drinking and were defined as crossing some threshold; for example, 'drinking at least weekly' or 'having been drunk at least once over the last 30 days'. Modelling these outcomes did not allow for deriving the probability distribution of both light and heavy drinking patterns.

The second issue is that several studies found that the effects of a alcohol policy environment tended to be stronger with lighter than heavier drinking patterns. For example, Gilligan et al.

(2012) detected correlations ranging from -0.48 to -0.77 when examining the prevalence of weekly drinking, whereas the correlations ranged from -0.07 to 0.11 examining the prevalence of lifetime drunkenness. Comparable patterns of differential relationships were found by Bendtsen et al. (2014) and Paschall et al. (2009). Consequently, it remains unclear whether populations living in different alcohol policy environments differ primarily in the prevalence of lighter drinking, or whether a stricter environment is associated with a global shift towards lighter drinking, to include reduced heavy drinking. Only the latter scenario would meet the tenet of the universal prevention approach.

Our current aim was, therefore, to obtain a more complete picture of the association between alcohol policy environments and the probability of lighter and heavier drinking patterns in a cohort of young Swiss men. We had previously discovered a relationship between the environment and drinking in this cohort (Foster et al., 2015; Foster et al., 2016). However, as in the above-cited studies, these analyses were based on single drinking patterns and the relationships tended to be stronger with lighter drinking. As such, in the current study, we specifically examined the hypothesis that the probability of heavier drinking patterns decreases systematically as the strictness of the alcohol policy environment increases; and estimated the probability distribution of light and heavy patterns as a function of the policy environment.

Methods

Study design and sample

Cross-sectional data were analysed from the baseline assessment of the Cohort Study on Substance Use Risk Factors (C-SURF) in Switzerland, collected between September 2010 and

March 2012. More details on the C-SURF study, including sampling methods and non-response bias are published elsewhere (Foster et al., 2015; Foster et al., 2016; Studer, Baggio, et al., 2013; Studer, Mohler-Kuo, et al., 2013). The study protocol was approved by the Ethics Committee for Clinical Research at Lausanne University Medical School (protocol number 15/07). Informed written consent was obtained from all participants.

Of 7563 consenters (57.1%), 5990 (79.2%) completed the baseline survey. Using nearest-neighbour hot-deck imputations (Iacus & Porro, 2007), certain missing responses were replaced for sensation seeking, antisocial personality disorder (ASPD) and attention-deficit/hyperactivity disorder (ADHD) (Foster et al., 2015). Imputations were performed for each of these variables when participants failed to answer no more than two questions. After this imputation process, 235 participants (3.9%) were excluded due to additional missing data among the predictor variables, leading to an analytical sample of 5755. A total of 100 participants within this analytical sample (1.7%) had missing values replaced for the above-mentioned variables, with 96 having one, two having three, and one having six values replaced. For each outcome, additional participants with missing data for the respective outcome were excluded. The number of additionally-excluded participants ranged from 21 to 26.

Outcomes

Heavy episodic drinking (HED): HED was assessed by asking how often participants drank six standard drinks or more on a single occasion over the past 12 months (Gmel et al., 2013). Accompanying each question, pictures of standard drinks containing approximately 10-12 grams of pure alcohol were provided for various beverage types. Answer categories included "never", "less than once monthly", "each month", "each week", and "every day or almost every day", thereby providing a range of increasingly-heavy drinking patterns. We collapsed

"every day or almost every day" with "each week", since the former contained only 68 participants.

Heavy volume drinking on weekends (weekend HVD): Self-reported frequency and usual quantity of alcohol consumption over the preceding 12 months were assessed for weekends (Friday-Sunday). Again, pictures of standard drinks were provided. A usual quantity of "5 or 6" standard drinks was considered heavy drinking. Seven frequency categories were provided, ranging from "never" to "3 days per weekend". We constructed frequency categories comparable to the ones for HED, with two adaptations. First, we collapsed "less than monthly" and "monthly", since only 93 participants were contained in the former category. Second, we additionally differentiated "weekly" from "twice weekly or more".

Drinking during the workweek: Assessment of self-reported frequency and usual quantity were assessed for the workweek (Monday-Thursday) in the same format as for the weekend. However, because heavy drinking during the workweek was very rare (Foster et al., 2016), we analysed the frequency of any drinking at all; i.e., drinking any quantity. The following patterns were analysed: "never", "less than once monthly", "each month", "each week", "twice weekly or more".

Alcohol use disorder (AUD): Self-reported criteria for AUD were asked, as per Knight et al. (2002), additionally including the criterion 'craving'. These criteria correspond to the DSM-5 symptoms of AUD and were assessed for the preceding 12 months, with two answer options (yes/no) for each criterion. The DSM-5 severity categorization was used, consisting of the levels "no AUD", "mild AUD" (2-3 criteria), "moderate AUD" (4-5 criteria), and "severe AUD" (6+ criteria) (Hasin et al., 2013). We collapsed the moderate and severe categories,

since the “severe”-category had a rather low frequency (191 participants) and produced non-converging statistical models (data not shown).

Explanatory variable

Alcohol policy environment index (APEI): Switzerland is a federation of 26 jurisdictions, so-called “cantons”, of which 21 were included in the C-SURF study (Foster et al., 2015; Foster et al., 2016). At the national level, Switzerland is characterized by relatively-liberal alcohol policies, while providing high legislative autonomy to its cantons (Brand et al., 2007; Bundesamt für Gesundheit BAG, 2013). An overview checklist from 2011 was obtained from the Swiss Federal Office of Public Health on the implementation of eight different types of alcohol policy, by cantons. These included 1) restrictions on when alcohol can be sold; 2) restrictions on where alcohol can be sold; 3) restrictions on alcohol advertisements; 4) a special turnover tax for on- and off-premise alcohol venders; 5) the so-called ‘syrup regulation’ stating that on-premise outlets must sell at least one non-alcoholic beverage cheaper than the cheapest alcoholic drink; 6) probes of purchases by underage persons to enforce underage-drinking laws; 7) prohibiting the dissemination of alcohol to underage persons by persons with legal access to alcohol; and 8) special protection measures for adolescents (e.g., restricting the serving of adolescents at on-premise outlets in the evening and at night). As for previous studies, the APEI was created by summing the number of policies implemented within each canton (Foster et al., 2015; Foster et al., 2016; Naimi et al., 2014; T. F. Nelson et al., 2005), producing a continuous score with a theoretical range of zero to eight.

Adjustment variables

We included the same adjustment variables as in our previous studies (Foster et al., 2015; Foster et al., 2016). These included ASPD (“no” versus “yes”, assessed and scored via the

Mini International Neuropsychiatric Interview (Lecrubier et al., 1998)); sensation seeking (continuous, assessed via Brief Sensation Seeking Scale by Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002); adult ADHD (continuous, assessed via the Adult ADHD Self-Report Scale Screener by Kessler et al., 2005; Kessler et al., 2007); major depression ("no" versus "at least mild", assessed via the Major Depression Inventory by Bech, Rasmussen, Olsen, Noerholm, & Abildgaard, 2001; Olsen, Jensen, Noerholm, Martiny, & Bech, 2003); age (continuous); highest achieved education (obligatory school, secondary vocational education, secondary higher school education, tertiary education), linguistic region (French-speaking, German-speaking) and urban/rural status (city, agglomeration, or rural, as defined by the Swiss Federal Statistical Office).

Statistical analysis

To assess the relationship between the APEI and increasingly-heavy drinking patterns, we applied the "nested dichotomies" approach (Fox, 2008). As an example, consider the frequency of HED. This variable can be broken down into several patterns, including 'never', HED less than once a month, monthly HED, and weekly HED. Such a set of increasingly-heavy drinking patterns can be analysed, as summarized in Table 1. With this approach, HED is broken down into a series of independent logistic regression models, one for each dichotomy. In each regression, the probability of one drinking pattern is assessed against all heavier patterns, while excluding all lighter patterns. Dichotomy 1 thereby indicates whether the APEI reduces the risk of being an HED drinker. Among HED drinkers, dichotomy 2 indicates whether a canton's APEI additionally reduces the risk of being a monthly HED drinker. Among the monthly HED drinkers, dichotomy 3 finally indicates whether the APEI additionally reduces the risk of being a weekly HED drinker.

Together, the set of nested dichotomies indicates, for each HED pattern, whether the APEI exerts any additional protective effect beyond the effects already achieved with lighter drinking patterns. Because the dichotomies are nested, they describe the entire probability distribution of the HED variable (Fox, 2008). Hence, the probabilities of all HED patterns can be estimated for cantons with a high versus low APEI.

Contrary to multinomial regression - the approach commonly used for multi-categorical outcomes such as HED - the nested dichotomies approach treats the outcome as ordered categories. It thereby tests for a monotonic relationship between the APEI and the outcome categories. In the above example, this means examining whether moving up on the APEI is associated with gradually transitioning from frequent to less frequent HED.

In the first step of our analysis, we examined whether there was, indeed, a negative monotonic relationship between the APEI and the outcome categories, by plotting the mean of the APEI for each outcome category. These means should be in a consistent order (Harrell Jr, 2015).

Then, we estimated three models for each outcome. Model 1 included the APEI as the only explanatory variable, thereby assessing whether any relationship existed between the APEI and the outcome. In Model 2, multilevel logistic regression models were used, with participants (level 1) nested within cantons (level 2), to control for adjustment variables and random cantonal effects (Foster et al., 2015). This model, thereby, examined whether the APEI's relationships with the outcomes persisted after adjusting for control variables. Random cantonal effects were included to adjust for unobserved cantonal heterogeneity, and because participants were clustered within cantons (Hox, 2002).

In Model 3, we also added an interaction effect between the APEI and ASPD to Model 2. We did this because we had found previously that ASPD and sensation seeking moderated the protective effect of the APEI in young Swiss men (Foster et al., 2015). These results implied that considering only the overall effect of the APEI underestimates its protective effect in those who are low in antisocial behaviours and sensation-seeking, while overestimating it in individuals who are, in fact, unamenable to alcohol legislation (people high in antisocial behaviour and sensation-seeking). Because our present interest was in those amenable to alcohol legislation, we conducted an analysis confined to those without antisocial tendencies, by including the interaction effect between APEI and ASPD. We chose the APEI by ASPD interaction because a) ASPD was the strongest effect modifier, and b) it is a binary variable coded as 0/1. With such a binary predictor, the APEI coefficient and its significance test correspond to the APEI coefficient in the 0-group (i.e., the group amenable to alcohol legislation, Cohen, Cohen, West, & Aiken, 2003). Thus, including the interaction effect allowed for estimating the APEI coefficients, while excluding those already known to be non-responsive to stricter alcohol legislations, due to their personality. For the remainder, we only report the results confined to those without an ASPD (complete results are available in Tables S1-2 of the online supplementary material).

All analyses were conducted using R software (R Core Team, 2016). The add-on package "lme4" was used to perform multilevel logistic regression analysis (Bates, Mächler, Bolker, & Walker, 2015), and the package "effects" to derive predicted probabilities (Fox, 2003). Continuous participant-level variables were centred around their means, whereas the APEI was centred around the mean of cantons (Foster et al., 2015). Odds ratios (OR) with 95% confidence intervals, and p-values for the null hypothesis OR=1.00, were computed for the APEI in all analyses.

Results

Baseline characteristics of the study participants are summarized in Table 2. Figure 1 shows negative monotonic relationships between the APEI and both HED and weekend HVD. The relationships were non-linear, however, and tapered off with the heaviest drinking patterns. Conversely, no systematic relationship was evident for the workweek drinking patterns. Considering AUD — since only three AUD categories exist — it is unclear whether there is a similar negative relationship, as found for HED and weekend HDV, or whether there is actually no clear relationship, as observed with workweek drinking.

The negative monotonic relationships evident in Figure 1 imply a corresponding pattern in the nested regressions, such that statistically-significant effects should be present among the first regression models, but no longer in subsequent models. Such a pattern of results was indeed evident for HED, weekend HVD, and AUD (Table 3). Considering the unadjusted analysis of HED (Model 1), the first of the nested regressions indicated that the APEI was negatively associated with the odds of being an HED drinker (OR=0.85, 95% CI: 0.81-0.90); the second regression indicated that, among HED drinkers, the APEI was additionally associated with reduced odds of being a monthly HED drinker, though this relationship was weaker (OR=0.93, 95% CI: 0.89-0.97); and finally, the APEI exhibited no further relationships among monthly and weekly HED drinkers (OR=0.99, 95% CI: 0.94-1.05). Comparable results were apparent with adjusted analyses.

Considering the unadjusted analysis of weekend HVD, within the first of the nested regression, the APEI was associated with reduced odds of being an HVD drinker (OR=0.89, 95% CI: 0.85-0.93), while no further relationships were evident. The same pattern of results

was found for Model 2. In Model 3, however, the APEI was additionally linked to the odds of being a weekly HVD drinker among HVD drinkers (OR=0.90, 95% CI: 0.82-0.99).

Considering AUD, the APEI was associated with reduced odds of having at least mild AUD across all analyses (odds ratios ranging from 0.91-0.94), but it was no longer associated with the odds of having moderate-to-severe AUD among those with an AUD.

Finally, no relationships were identified between the APEI and workweek drinking patterns. This also is consistent with Figure 1, which indicates no monotonic relationship between the APEI and workweek-drinking patterns.

The predicted probabilities derived from analyses 1 to 3 are summarized in Table 4. In agreement with Table 3, the probabilities of lighter drinking patterns were higher, while the probabilities of heavier drinking patterns were lower in high-APEI cantons, with respect to HED, weekend HVD, and AUD. Crucially, the probabilities of heavy drinking patterns were reduced in high-APEI cantons, indicating a preventive effect against heavy drinking. Also in line with Table 3, workweek drinking patterns had similar probabilities in low- versus high-APEI cantons.

Additional analysis

As noted above, Figure 1 indicates that monotonic relationships might not be present between the APEI and either workweek drinking patterns or AUD. In this case, multinomial regression analysis would be more appropriate. We, therefore, ran multinomial regression models for workweek drinking and AUD. The results of this analysis agreed with the above-reported findings (online supplementary material, Tables S3-4): there was no relationship between the

APEI and workweek-drinking patterns, and a higher APEI was associated with a reduced probability of mild AUD, but not moderate-to-severe AUD.

Discussion

Our aim was to examine the relationship between the alcohol policy environment and various drinking patterns among young Swiss men. Our results can be summarized by three major findings. First, we found negative relationships between the strictness of the alcohol policy environment and drinking patterns relating to episodic drinking, volume drinking on weekends, and alcohol use disorder. These relationships were such that, with stricter alcohol policy environments, the entire probability distribution of drinking patterns was shifted towards lighter drinking. Second, the negative relationships tapered off at the heavier end of the drinking spectrum. Third, we identified no relationship between the alcohol policy environment and drinking during the workweek. We now will discuss each of these findings in turn.

Reduced drinking in stricter alcohol policy environments

That alcohol consumption was reduced in jurisdictions with a stricter alcohol policy environment echoes our previous analyses of the C-SURF sample (Foster et al., 2015; Foster et al., 2016) and is consistent with the international literature on samples of adolescents and adults (Bendtsen et al., 2014; Brand et al., 2007; Gilligan et al., 2012; Naimi et al., 2014; T. F. Nelson et al., 2005; Paschall et al., 2009; Xuan, Blanchette, et al., 2015). Going beyond these studies, our analysis indicates that the effect holds for the entire probability distribution of drinking patterns, ranging from light to heavy drinking. Thus, a stricter alcohol policy environment was associated with "healthier" populations that were shifted towards reduced exposure to the risks of alcohol consumption. This underscores a basic assumption of alcohol

control policies as a universal prevention measure: that they should have a global impact on the entire population, including heavy drinkers.

It is generally assumed that alcohol control policies reduce alcohol consumption by reducing the availability of alcohol (Giesbrecht & Greenfield, 2003; Gruenewald, 2011; Hawkins, Catalano, & Miller, 1992). Indeed, alcohol policies like the ones we studied constrain the physical availability (e.g., where alcohol can be bought), temporal availability (e.g., what days alcohol can be bought), economic availability (i.e., the price of alcohol), and socio-demographic availability (e.g., via underage drinking laws) of alcohol. In addition, stricter alcohol control policies are likely to reduce the "social availability" of alcohol, by conveying social norms and societal attitudes about alcohol consumption (Cooke, Dahdah, Norman, & French, 2016; Hawkins et al., 1992). Collectively, the availability constraints reduce opportunities for alcohol consumption and, consequently, might reduce the probability that someone develops a drinking habit. This is in line with our findings and potentially explains why individuals living in stricter policy environments were less likely to exhibit heavy drinking patterns.

Relationships tapered off

One new insight is that the preventive effect of the alcohol policy environment might taper off at the heavier end of the drinking spectrum. At a population level, the result was nevertheless a "healthier" population with a lower probability of heavy drinking in jurisdictions with a stricter policy environment. However, once the preventive relationships with lighter drinking were taken into account, no additional relationships with heavier patterns were present.

This finding seems to resonate with an observation made repeatedly in the previous literature: that alcohol policy environments had stronger associations with lighter drinking patterns (e.g.,

"any drinking") than with heavier drinking patterns (e.g., "binge drinking", Bendtsen et al., 2014; Gilligan et al., 2012; Paschall et al., 2009). Furthermore, there is strong resemblance to a finding from an ecological study of counties in New York State, reported by Schofield and Denson (2013). These investigators found that longer outlet business hours – a result of corresponding alcohol policies – were associated with first-time drunk-driving, but not with repeat drunk driving. Thus, alcohol policy-related alcohol availability seemed unable to reduce repeat behaviours, though it appeared able to minimize the probability of a behaviour's onset.

Taking these findings together generates an interesting hypothesis: that the protective effect gained by implementing a stricter alcohol policy environment might be achieved by hindering light drinkers from becoming heavy drinkers, but not by impacting heavy drinkers *per se*. If this holds true, it might be necessary to distinguish between two time-scales. In the short run, a policy change that decreases alcohol availability might have a limited impact upon those who already tend towards heavy drinking. However, in the longer run, both current non-heavy drinkers and future generations of potential drinkers might be less likely to develop heavy drinking habits, thereby leading to populations with a reduced prevalence of heavy drinking, as observed in our study. In the long run, the basic tenet of universal prevention would then hold, though it fails to apply in the short run.

There is, indeed, some evidence that agrees with the outlined hypothesis. First, some investigators have found that light and moderate drinkers tend to increase their consumption once alcohol availability increases (Heeb, Gmel, Zurbrügg, Kuo, & Rehm, 2003; Kuo et al., 2003). Second, in the domain of alcohol price and tax policies, evidence implies that heavy drinkers are less affected by policy changes (Gmel, Wicki, Rehm, & Heeb, 2008; J. P. Nelson, 2013, 2015) and less price sensitive than light and moderate drinkers (Aepli, 2014; Manning,

Blumberg, & Moulton, 1995; J. P. Nelson, 2013; Wagenaar et al., 2009). Heavy drinkers might be similarly less responsive to availability changes generated by other policies, and, ultimately, to the entire alcohol policy environment. Finally, it is usually assumed that heavy drinking and alcoholism are processes of maladaptive habit-based learning fuelled by the dependence-producing properties of alcohol, whereby alcohol drinking shifts from a behaviour regulated by goal-directed decision-making to a habitual, automatic behaviour (Barker & Taylor, 2014; Corbit & Janak, 2016; Lannoy, Billieux, & Maurage, 2014; McKim, Shnitko, Robinson, & Boettiger, 2016). Once the shift has taken place, the behaviour is difficult to change, even to the degree that it is maintained despite negative consequences. In addition, heavy chronic alcohol consumption has, itself, a detrimental effect on one's capacity for top-down controlled goal-directed behaviour and self-regulation, thereby accelerating habit formation and maintenance (Ewing, Sakhardande, & Blakemore, 2014; Koob & Volkow, 2016; Lannoy et al., 2014). It consequently seems unsurprising that the availability constraints imposed by alcohol policies have only a limited effect on habitual heavy drinking and severe forms of alcohol use disorder.

More research is clearly needed, however. First, the outlined hypothesis is longitudinal in nature and, hence, requires a longitudinal study to test it. Second, evidence regarding heavy drinkers' responsiveness to tax and price changes is inconclusive (Aepli, 2014; Byrnes, Shakeshaft, Petrie, & Doran, 2016; Elder et al., 2010; Sharma, Etile, & Sinha, 2016; Xuan, Chaloupka, et al., 2015). In addition, the differential impact of policy and availability changes, as a function of baseline drinking, is not well studied beyond price and tax studies. Third, results might differ as a function of whether the effect of a particular policy or of the alcohol policy environment are examined. Finally, Skog's theory of the "collectivity of drinking" provides an alternative mechanism. This theory states that lighter and heavier drinking in a population change in concert, due to mutual influences and interactions among

individuals in the population (Norstrom & Svensson, 2014; Rossow et al., 2014; Skog, 1999). Due to this 'collectivity of drinking', prevention measures that target all individuals shift the entire distribution of drinking patterns downwards. Thus, policy impacts might be mediated by mutual influences among drinkers, rather than by preventing light drinkers from becoming heavy drinkers.

Workweek drinking

Our third finding was that the APEI was not related to drinking during workweeks. This finding extends our previous result: that heavy workweek drinking was not related to the APEI (Foster et al., 2016). Thus, drinking that happened during the workweek appeared to be independent of the alcohol policy environment. Another study has already indicated that workweek drinking in the C-SURF cohort is different than weekend drinking. Studer et al. found that workweek drinking was characterized by coping-drinking motives, whereas weekend drinking was characterized by enhancement-drinking motives (Studer et al., 2014). Thus, an important bulk of workweek drinking was related to downregulating stress and negative emotions. Eventually, this kind of drinking is unamenable to alcohol legislation. Alternatively, workweek drinking might be restrained by next day work and educational duties, thereby leaving less room for an additional effect of the alcohol policy environment.

Future studies should determine to what extent workweek and weekend drinking differ systematically in their responsiveness to alcohol legislation and to prevention measures in general, and whether such differences depend upon underlying drinking motives and educational and work roles. In any case, the cited results and our own collectively suggest that one size does not fit all, when it comes to designing effective prevention measures for workweek versus weekend drinking.

Implications for prevention

Our results support the notion that alcohol legislation works as a universal prevention measure. This, in turn, should reduce alcohol-related harm by reducing the risks associated with heavy drinking, by reducing the risk of alcohol use disorder, and by exploiting the "prevention paradox" (Danielsson et al., 2012; Gmel et al., 2005; Gmel et al., 2001; Rose, 2001; Skog, 1999). Note that population-wide effects as observed in our analysis are not the only justification of universal prevention. For example, if a universal prevention measure is among the most effective measure for cutting down heavy drinking, it may be justified if the burden on lighter drinkers is not too high. Also a universal prevention approach may be justified by alcohol's harm to others (Karriker-Jaffe, Room, Giesbrecht, & Greenfield, 2018).

Our results also imply that alcohol legislation might not be able to tackle all forms of drinking, in particular drinking during workweeks, already-developed heavy drinking, and severe forms of alcohol use disorder. Furthermore, in a previous study, certain personality characteristics were found to constrain the preventive effect of the alcohol policy environment (Foster et al., 2015). Taking these findings also into account implies that complementing a stricter alcohol policy environment with selective prevention measures, which target the above-mentioned aspects of drinking, would be more potent than either approach used alone. Such measures could be, for example, brief interventions and interventions targeting self-regulation for those who already lean towards heavy drinking (Gaume et al., 2014; Jonas et al., 2012; Tang, Posner, Rothbart, & Volkow, 2015; Wachtel & Staniford, 2010; Whitlock, Polen, Green, Orleans, & Klein, 2004), and interventions that are fine-tuned to personality characteristics, as developed by Conrod and co-workers (Conrod, 2016).

Limitations

Our study has several limitations. First, it was cross-sectional and, hence, permits no causal inferences. In particular, reversed causality cannot be ruled out, i.e. that jurisdictions with lighter drinking patterns are also more supportive of stricter alcohol policy environments. Note, however, that evidence from natural experiments suggests a causal effect of alcohol policies on drinking behaviours (Campbell et al., 2009; Elder et al., 2010; Gruenewald, 2011; Hahn et al., 2010; Kuo et al., 2003; Lavoie et al., 2017; Middleton et al., 2010; Popova et al., 2009; Scherer et al., 2015; Stockwell et al., 2012; Wagenaar et al., 2009; Wicki & Gmel, 2011). Second, more sophisticated indices for characterizing the alcohol policy environment have been suggested that take into account empirical effectiveness, enforcement, and/or implementation stringency of the implemented policies (e.g. Brand et al., 2007; Naimi et al., 2014). Third, our results were based upon a sample of young men. Future studies should test how well our results generalize to other populations. Fourth, as in any study based on informed consent, selection bias might have existed in our sample. Whereas no evidence of substantial bias in alcohol use was identified in the C-SURF sample (Studer, Baggio, et al., 2013; Studer, Mohler-Kuo, et al., 2013), we cannot rule out the possibility that consenting men are also more likely to comply with alcohol policies, which would result in an over-estimation of the strength of the relationship between alcohol policy environments and drinking. Fifth, residual confounding at the canton level might have been present, like differences in outlet densities. Note, however, that including the random effects for cantons accounted for unobserved heterogeneity among cantons in outcome variables. Finally, most of our study variables relied on self-reports, possibly introducing recollection or social desirability bias. Note, however, that the explanatory variable – the APEI – was based on third-party data completely independent of the C-SURF cohort and participants' self-reported data. Additionally, previous studies assessing self-report measures of alcohol consumption have indicated them to be valid (Borsari & Muellerleile, 2009; Cooper, Sobell, Sobell, & Maisto, 1981).

Conclusions

Among young Swiss men, stricter alcohol policy environments were associated with a global shift towards lighter drinking, consistent with the basic tenet behind the universal prevention approach. Future studies should test the hypothesis that this preventive effect was achieved by preventing non- and light drinkers from becoming heavier drinkers.

Declaration of interests:

The authors declare that they have no conflicts of interest.

Funding

This work was supported financially by the Swiss National Science Foundation [FN33CS30_139467]. The funder had no role in study design, data collection, data analysis, data interpretation, preparation of the manuscript, or decision to publish.

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Table 1. Illustration of breaking down the frequency of heavy episodic drinking into nested dichotomies.

HED Frequency:	never	less than monthly	monthly	weekly
Dichotomy 1 (first nested regression)	0	1		
Dichotomy 2 (second nested regression)		0	1	
Dichotomy 3 (third nested regression)			0	1

HED: heavy episodic drinking

With the nested dichotomies approach, the HED variable is broken down into a series of independent logistic regression models, each one modelling one of the dichotomies shown in the table. In each regression, the probability of one drinking pattern is assessed against all heavier patterns, while excluding all lighter patterns. Using the alcohol policy environment index (APEI) as predictor, dichotomy 1 (never vs. less than monthly/monthly/weekly) indicates thereby whether the APEI reduces the risk of being an HED drinker. Among HED drinkers, dichotomy 2 (less than monthly vs. monthly/weekly) indicates whether a canton's APEI additionally reduces the risk of being a monthly HED drinker. Among the monthly HED drinkers, dichotomy 3 (monthly vs. weekly) finally indicates whether the APEI additionally reduces the risk of being a weekly HED drinker.

Table 2. Baseline characteristics of study participants.

	N (%)	HED				p-value [a]	Weekend HVD				p-value [a]	Workweek drinking					p-value [a]	AUD			p-value [a]
		Never (%)	*less than monthly (%)*	*monthly (%)*	*weekly (%)*		*never (%)*	*less than monthly-weekly (%)*	*weekly (%)*	*weekly twice or more (%)*		*never (%)*	*less than monthly (%)*	*monthly (%)*	*weekly (%)*	*weekly twice or more (%)*		*No AUD (%)*	*Mild AUD (%)*	*Moderate – severe AUD (%)*	
Age (Mean: 20.0, SD: 1.2)						< 0.0001					< 0.0001						0.012				0.14
Below median	2883 (50.1)	18.8	32.6	24.3	24.2		49.9	9.7	12.8	27.6		37.7	21.8	21.0	10.9	8.7		67.4	22.0	10.6	
Above median	2872 (49.9)	23.5	33.5	22.5	20.5		56.8	7.8	11.0	24.3		36.5	19.2	21.6	12.1	10.7		69.6	19.9	10.5	
Education						0.62					0.00023						< 0.0001				0.76
Obligatory school	2803 (48.7)	20.7	33.2	23.0	23.1		52.0	8.7	13.4	25.9		39.0	21.5	21.1	10.3	8.2		68.1	21.5	10.4	
Secondary vocational	1822 (31.7)	22.3	32.0	23.7	22		53.0	9.1	9.7	28.1		36.5	19.1	19.1	12.8	12.5		69.7	19.7	10.6	
Secondary higher school	1037 (18.0)	20.3	34.0	24.7	21.1		56.4	8.9	11.7	23.0		34.1	20.9	24.9	11.5	8.6		67.4	21.8	10.8	
Tertiary	93 (1.6)	23.7	37.6	18.3	20.4		66.7	3.2	12.9	17.2		23.7	14.0	29.0	21.5	11.8		68.8	22.6	8.6	
Linguistic region						< 0.0001					0.00056						0.0061				0.029
German-speaking	2600 (45.2)	17.8	34.7	24.3	23.2		50.4	9.5	12.8	27.3		35.2	22.2	22.2	11.0	9.5		67.1	21.3	11.6	
French-speaking	3155 (54.8)	24.0	31.7	22.7	21.6		55.8	8.2	11.2	24.8		38.6	19.1	20.5	11.9	9.9		69.7	20.7	9.6	
Rural/urban status						< 0.0001					< 0.0001						0.00010				0.026
City	1230 (21.4)	26.7	31.8	21.6	19.9		58.7	8.5	8.5	24.3		39.6	20.9	19.6	12.2	7.7		68.9	20.5	10.6	
Agglomeration	2643 (45.9)	21.9	33.6	22.6	21.9		52.5	9.4	12.7	25.4		38.3	20.5	21.7	9.8	9.7		70.3	19.7	10	

Rural	1882 (32.7)	16.5	33.1	25.8	24.6		51.0	8.1	13	27.9		33.7	20.3	21.8	13.3	10.9		65.7	23.1	11.2	
Alcohol policy environment index (Mean: 3.5, SD: 1.6)						< 0.0001					< 0.0001						0.079				0.0031
Below median of cantons [b]	1599 (27.8)	16.1	32.4	26.9	24.6		48.1	8.7	13.6	29.7		34.3	21.8	22.2	12.1	9.6		65.7	23.9	10.4	
Above median of cantons	4156 (72.2)	23.1	33.3	22.1	21.5		55.4	8.8	11.3	24.5		38.2	20.0	20.9	11.2	9.7		69.6	19.8	10.6	

HED: Heavy episodic drinking; HVD: Heavy volume drinking; AUD: Alcohol use disorder; SD: Standard deviation.

[a] p-value derived from Pearson's Chi-square test for two-way contingency tables.

[b] The alcohol policy environment index was dichotomized on the median of cantons for this descriptive analysis.

Table 3. Results for heavy episodic drinking, heavy volume drinking at weekends, workweek drinking, and alcohol use disorder predicted by the alcohol policy environment index via nested logistic regressions.

Drinking/severity patterns		**Patterns compared in nested logistic regression** [a]	**Model 1**				**Model 2**				**Model 3**			
			b	*OR*	*95% CI*	*p-value*	*b*	*OR*	*95% CI*	*p-value*	*b*	*OR*	*95% CI*	*p-value*
HED														
1	never	1 vs. 2-4	-0.16	0.85	0.81 - 0.90	<0.00001	-0.11	0.89	0.84 - 0.95	0.00055	-0.11	0.89	0.84 - 0.96	0.00087
2	less than monthly	2 vs. 3-4	-0.07	0.93	0.89 - 0.97	0.0016	-0.08	0.93	0.85 - 1.01	0.071	-0.11	0.90	0.83 - 0.98	0.015
3	monthly	3 vs. 4	-0.01	0.99	0.94 - 1.05	0.80	-0.03	0.97	0.89 - 1.06	0.50	-0.05	0.95	0.86 - 1.04	0.27
4	weekly	--	--	--	--	--	--	--	--	--	--	--	--	--
Weekend HVD														
1	never	1 vs. 2-4	-0.12	0.89	0.85 - 0.93	<0.00001	-0.09	0.91	0.86 - 0.97	0.0047	-0.11	0.90	0.84 - 0.96	0.0009
2	less than monthly-monthly	2 vs. 3-4	-0.06	0.94	0.87 - 1.01	0.10	-0.09	0.92	0.84 - 1.00	0.054	-0.11	0.90	0.82 - 0.99	0.027
3	weekly	3 vs. 4	0.00	1.00	0.93 - 1.07	0.92	0.01	1.01	0.89 - 1.14	0.90	-0.03	0.97	0.86 - 1.10	0.65
4	weekly twice or more	--	--	--	--	--	--	--	--	--	--	--	--	--
Workweek drinking														
1	never	1 vs. 2-5	-0.04	0.96	0.92 - 1.00	0.06	-0.02	0.98	0.92 - 1.04	0.53	-0.03	0.97	0.91 - 1.03	0.35
2	less than monthly	2 vs. 3-5	0.05	1.05	0.99 - 1.11	0.09	0.02	1.02	0.96 - 1.09	0.49	0.00	1.00	0.94 - 1.07	0.91
3	monthly	3 vs. 4-5	0.02	1.02	0.96 - 1.08	0.57	-0.01	0.99	0.91 - 1.09	0.87	-0.04	0.96	0.87 - 1.06	0.41
4	weekly	4 vs. 5	-0.01	0.99	0.90 - 1.07	0.75	-0.02	0.98	0.89 - 1.09	0.76	-0.01	0.99	0.89 - 1.10	0.80
5	weekly twice or more	--	--	--	--	--	--	--	--	--	--	--	--	--
AUD														
1	No AUD	1 vs. 2-3	-0.07	0.93	0.89 - 0.97	0.0015	-0.06	0.94	0.88 - 1.00	0.067	-0.09	0.91	0.85 - 0.98	0.012
2	Mild AUD	2 vs. 3	0.03	1.03	0.96 - 1.11	0.43	0.03	1.03	0.95 - 1.13	0.45	0.03	1.03	0.93 -1.14	0.61
3	Moderate – severe AUD	--	--	--	--	--	--	--	--	--	--	--	--	--

HED: Heavy episodic drinking; HVD: Heavy volume drinking; AUD: Alcohol use disorder; b: logistic regression coefficient; OR: Odds ratio; CI: Confidence interval.

[a] In the nested logistic regression approach, an ordinal outcome is broken down into a set of individual logistic regressions. Each of the logistic regressions compares one drinking/severity pattern with all heavier patterns while excluding all lighter ones. Each row in the table with a coefficient *b* and an odds ratio OR corresponds to one such regression. For each outcome, there are k – 1 separate regressions with k being the total number of drinking/severity patterns.

Model 1 was unadjusted. Model 2 was adjusted for antisocial-personality disorder, sensation-seeking, attention-deficit/hyperactivity-disorder, depression, age, education, linguistic region, urban/rural status and random effects for jurisdictions. Model 3 included all adjustment variables from model 2 and additionally the interaction effect between APEI and antisocial-personality disorder; shown are the coefficients of the group without antisocial-personality disorder (complete results are available in tables S1-2 of the online supplementary material).

Note that the alcohol policy environment index was entered in all models as a sum score with a theoretical range of zero to eight implemented policies. The observed range was zero to six.

Table 4. Probabilities of heavy episodic drinking, heavy volume drinking at weekends, workweek drinking, and alcohol use disorder as predicted by the alcohol policy environment index via nested logistic regressions.

Drinking/severity pattern	**Model 1**		**Model 2**		**Model 3**	
	Lowest APEI	*Highest APEI*	*Lowest APEI*	*Highest APEI*	*Lowest APEI*	*Highest APEI*
HED						
never	0.12	0.25	0.12	0.21	0.13	0.23
less than monthly	0.30	0.33	0.29	0.35	0.28	0.37
monthly	0.29	0.21	0.28	0.23	0.28	0.23
weekly	0.29	0.20	0.30	0.21	0.31	0.18
Weekend HVD						
never	0.40	0.58	0.43	0.57	0.44	0.60
less than monthly-monthly	0.09	0.09	0.08	0.09	0.07	0.09
weekly	0.16	0.11	0.16	0.11	0.15	0.11
weekly twice or more	0.35	0.23	0.33	0.24	0.35	0.21
Workweek drinking						
never	0.33	0.39	0.35	0.37	0.35	0.39
less than monthly	0.25	0.19	0.22	0.20	0.22	0.21
monthly	0.22	0.21	0.21	0.22	0.20	0.21
weekly	0.11	0.12	0.11	0.12	0.13	0.11
weekly twice or more	0.10	0.10	0.10	0.10	0.10	0.08
AUD						
No AUD	0.62	0.71	0.65	0.73	0.66	0.76
Mild AUD	0.27	0.19	0.25	0.18	0.25	0.16
Moderate – severe AUD	0.12	0.10	0.10	0.09	0.09	0.07

HED: Heavy episodic drinking; HVD: Heavy volume drinking; AUD: Alcohol use disorder; APEI: Alcohol policy environment index

Model 1 was unadjusted. Model 2 was adjusted for antisocial-personality disorder, sensation-seeking, attention-deficit/hyperactivity-disorder, depression, age, education, linguistic region, urban/rural status and random effects for jurisdictions. Model 3 included all adjustment variables from

model 2 and additionally the interaction effect between APEI and antisocial-personality disorder; shown are the coefficients of the group without antisocial-personality disorder (complete results are available in tables S1-2 of the online supplementary material).
Note that the APEI represents a sum score from zero to eight implemented policies. The observed range in the data was zero to six, and this range was used to calculate the predicted probabilities.

Figure 1 Descriptive relationships between different drinking patterns and the alcohol policy environment index.

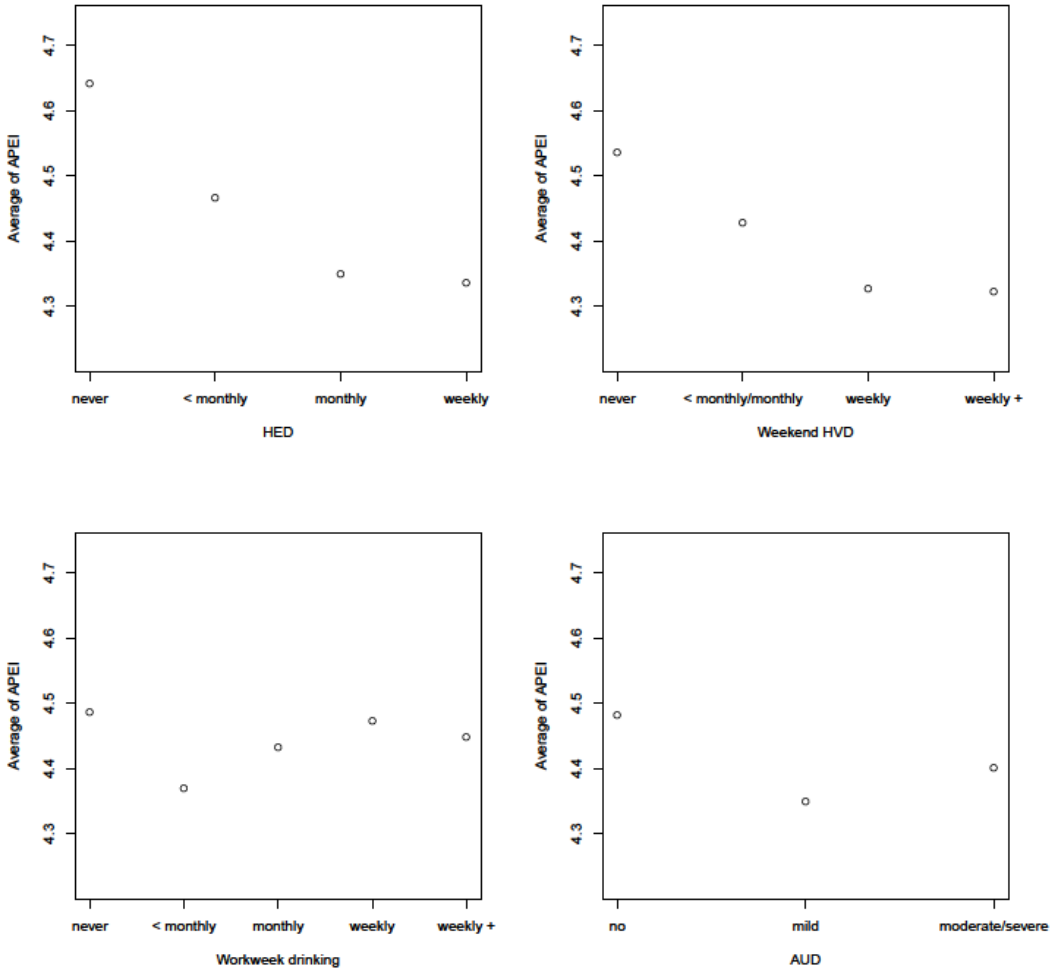

Figure legend: APEI: Alcohol policy environment index; HED: Heavy episodic drinking; HVD: Heavy volume drinking; AUD: Alcohol use disorder.

Note: "< monthly": less than once a month. "weekly +": twice a week or more