Associations Between COVID-19 Alcohol Policy Restrictions and Alcohol Sales in British Columbia: Variation by Area-based Deprivation Level

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Indication of grant support:

This work was supported by a UKRI UK-Canada Globalink doctoral exchange scheme grant (NE/V009826/1) awarded to J.M.C, T.N. and T.S. The funders had no role in study design, data analysis, data interpretation, writing of the report, or the decision to submit for publication.

Word count of manuscript: 4,182

Number of Tables: 1; Number of Figures: 4.

Word count of abstract: 250

Abstract

Objective. Government alcohol sales data were used to investigate associations between estimates of per capita age 15+ alcohol consumption, policy restrictiveness, and area-level deprivation.

Method. We analysed weekly consumption data (expressed as per capita age 15+ Canadian standard drinks [13.45g of pure ethanol]), collected from all 89 Local Health Areas in British Columbia, Canada, between April 2017 and April 2021. Our analyses were stratified by outlet type (total, on-premise and off-premise). Our intervention was alcohol policy restrictiveness (operationalized by the Restrictiveness of Alcohol Policy Index), and our moderator was area-level deprivation (Canadian Index of Multiple Deprivation). The Restrictiveness of Alcohol Policy Index included hours of trading, the number of people permitted on site for on-premise venues), the proportion of outlets in operation, and the extent of permissible home delivery.

Results. Higher policy restrictiveness was associated with decreased consumption across all outlet types ($p_s < .001$): when the most restrictive policies were implemented, consumption was reduced by 9% and 100% in off- and on-premise outlets, respectively. Area-based deprivation level modified the effect of policy restriction on PCAC ($p_s < 0.007$): for total and off-premise consumption, the decrease was greatest among more economically deprived areas ($p < 0.001_s$); for on-premise outlets, areas with a high proportion of racial and ethnic minorities increased their consumption ($p_s < 0.001$).

Conclusions. Alcohol-specific policy restrictions implemented in response to the COVID-19 pandemic were associated with reduced consumption. However, the magnitude and direction of change was moderated by area-based deprivation level, albeit inconsistently across various deprivation measures.

Keywords: COVID-19; Alcohol; Policy; Deprivation; Public Health; SES

Introduction

Those most at risk of alcohol-related harm tend to be those who are disadvantaged (i.e., lower socioeconomic status [SES]), despite these groups typically consuming lower quantities of alcohol than their more privileged counterparts. This phenomenon is commonly referred to as the alcohol-harm paradox (Bellis et al., 2016; Lewer et al., 2016) and is reflected by greater mortality and morbidity rates among lower SES groups (Mackenbach et al., 2008; Probst et al., 2020). One explanation may be that deprivation is linked to greater exposure to stressors, such as: financial concerns, unemployment, issues with personal relationships, discrimination, and isolation (Baum et al., 1999; Lantz et al., 2005). This is further supported by biological evidence which shows that SES is inversely related to stress hormone levels (Cohen et al., 2006). Therefore, alcohol may represent pleasure and relaxation; a way to regulate mood (Lantz et al., 2005; Wilkinson, 2002). Thus, as the link between stress and health is well established (Thayer et al., 2012), the negative health consequences of alcohol consumption on health may be compounded in more disadvantaged areas. Another reason for the alcohol-harm paradox is that living in a more deprived area is typically associated with poorer access to essential services, including health care (Butler et al., 2013). Put differently, those suffering with alcohol-related health conditions in more deprived areas may be unable to receive help. Finally, binge drinking, which is known to be more harmful than spreading the consumption of the same quantity of alcohol over several drinking sessions, may be more prevalent in these populations (Bellis et al., 2016; Probst et al., 2020). Despite this, we have an incomplete understanding of how alcohol policy interventions may affect more deprived areas. A better understanding will assist policymakers in making decisions that result in reduced alcohol-related harm.

The COVID-19 pandemic resulted in severe policy changes across the world, such as national 'lockdowns' (orders to remain at home and socially isolate); the closure of restaurants, bars, and nightclubs; border closures; and 'mask mandates' (being required to wear cloth face coverings in public spaces) (Anderson et al., 2020). However, the sale of alcohol intended for off-premise consumption (i.e., places where alcohol is sold but cannot be consumed on-site) was deemed 'essential' by Canadian policymakers (Hobin and Smith, 2020), despite drinking being a risk factor for the spread of the disease through (for example) reduced social distancing (Gurrieri et al., 2021). Therefore, during the pandemic, drinking habits likely changed for many; from spending time drinking on-premise with others to predominantly drinking at home and/or alone. This is of particular concern when considering a substantial number of people reported 'drinking to cope' with distress brought about by the pandemic in Canada and elsewhere (Gadermann et al., 2021; Rodriguez et al., 2020; Wardell et al., 2020). For instance, a recent meta-analysis suggests that solitary drinking and the tendency to 'drink to cope' with negative affect are precursors for future alcohol-related problems (Skrzynski and Creswell, 2020).

Public health restrictions were enforced in British Columbia (BC) March 2020 and rapidly changed over the course of the pandemic (CTV News, 2021). Previous work has attempted to assess the impact of these policies on alcohol consumption through self-report surveys (Shield et al., 2021) or by conducting interrupted time series analysis (ITSA) on sales (dollar value) data (MacKillop et al., 2021; Myran et al., 2021). Both approaches are limited. Self-report surveys have been consistently shown to under-estimate true consumption due to social desirability bias, or a poor memory of drinking episodes, or due to low coverage, especially among heavy drinkers (Northcote and Livingston, 2011). Meanwhile, dollar values do not represent absolute consumption (due to geographical price differences for example) and ITSA does not allow for the true variation in policy restrictiveness to be evaluated (i.e., the variation reflected in ITSA is less nuanced). Measures such as the University of Oxford's stringency index (Hale et al., 2021) aim to rectify the latter point by providing a continuous measure which captures variation in policy change to enable researchers to investigate the effect of *general* lockdown policies.

No work investigating the impact of *alcohol specific* policy change has been published nor has any on the effect of deprivation in this context, using population-level data. Therefore, we first present the Restrictiveness of Alcohol Policy Index (RAPI) which was designed to capture time-varying *alcohol-specific* policy changes, including: hours of trading, the number of people permitted on-site, outlet density, and the extent of take-out/home deliveries. We then take advantage of detailed (weekly) sales data from BC to assess how absolute alcohol use (litres) changed as a function of policy restrictiveness. Finally, we considered whether changes in alcohol use differed between sub-groups stratified by area-based deprivation. We hypothesised that increased alcohol policy restrictions would be negatively associated with PCAC. Furthermore, based on previous work that evaluated the effect of minimum unit pricing as a function of income (Zhao and Stockwell, 2017), we hypothesised that the negative relationship between alcohol policy restrictions and drinking would be stronger in more deprived areas.

Method

Design

Analyses of time-series-cross-section data (Beck, 2001) were designed to investigate associations between weekly per capita alcohol consumption (PCAC, the dependent variable) and alcohol-specific policy changes (RAPI scores, the independent variable) across 89 Local Health Areas (LHAs) of BC during the COVID-19 pandemic. The 89 LHAs are nested within 16 Health Service Delivery Areas (HSDAs), within 5 Health Authorities (HAs). As previously described, this data structure helps to control for and reduce spatial autocorrelation effects (Stockwell et al., 2013). The moderator variable was level of deprivation, described below. We controlled for pandemic severity using the rate of new COVID-19 infections (per 100,000) as it was assumed that the infection rate would be associated with alcohol use. For instance, someone experiencing COVID-19 symptoms may consume less alcohol due to feeling unwell or fear of infection. Alternatively, when on-premise alcohol was available, individuals who were fearful of infection may be less likely to frequent on-premise venues.

Data sources

Population denominator data

Population data for each Local Health Area (LHA) were estimated and projected by BC Stats (BC Stats, 2021). We used the Spline method (McNeil et al., 1977) via *PROC EXPAND* in SAS (version 9.4) to estimate the weekly total populations and populations aged 15 years or older in each LHA for the study period.

Alcohol consumption

Weekly retail alcohol sales in litres of pure alcohol were provided by the BC Ministry of Public Safety and Solicitor General Liquor Distribution Branch (LDB). The LDB regulate the distribution, importation, and retailing of beverage alcohol in BC. Litres of pure alcohol were converted to weekly PCAC data, expressed as standard drinks (1 standard drink = 17.05mL or 13.45g of pure ethanol), using the population data, i.e., aged 15 years or older. Although data for government owned stores reflected purchases made directly by the consumer, data for privately-owned outlets (stores, bars, restaurants) reflected when they purchased alcohol from the government monopoly distributor.

Canadian Index of Multiple Deprivation (CIMD)

The CIMD is a geographically-based index of deprivation and marginalisation that was created by Statistics Canada to allow analysts to better understand the effect of inequality (Statistics Canada, 2019). Briefly, several potential indicators of deprivation were collected at the deprivation area (DA) level. A DA is a small and stable geographical unit, typically made up of 400 to 700 individuals. Each indicator was analysed by Statistics Canada using factor analysis to allow the complex patterns of relationships between each variable to be interpreted simply. Separate national and regional indexes were created as indicators of deprivation may vary between-geographic areas. This allows for a nuanced understanding of deprivation in each place. Ultimately, four factors were extracted for each area: Residential Instability (e.g., the tendency for residential populations to fluctuate overtime), Economic Dependency (e.g., reliance on income other than that gained through employment), Ethno-cultural Composition (e.g., recently immigrating or belonging to a minority group), and Situational Vulnerability (e.g., sociodemographic differences in, for example: housing, income and education). Here, we used the CIMD index for BC by aggregating DA data to LHA level by taking the median score as the median is less sensitive to skew than the mean (von Hippel, 2005). A sensitivity analysis was conducted by calculating Spearman's correlation coefficients between scores derived using both the median method and the mean for each dimension. This indicated that there were no substantive differences between either method as the correlations were positive, strong, and statistically significant, average $r_s = 0.92$, range = 0.85 to 0.98, $p_s < .001$. As per the User Guide (Statistics Canada, 2019), quintiles (1 = least deprived: 5 = most deprived) were used in analyses and we considered whether a composite index could be created by calculating Spearman's correlation coefficients between each individual dimension (see the Supplemental Material). Ultimately, each factor was modelled separately.

Restrictiveness of Alcohol Policy Index (RAPI)

The RAPI is a bespoke tool designed to be a continuous measure of the restrictiveness of *alcohol-specific* policy (restriction here refers to the physical availability of alcohol); additional details about RAPI are included in the Supplementary Material. The RAPI uses information compiled by the Canadian Centre on Substance Use and Addiction and the Canadian Institute for Substance Use Research to quantify daily changes in four domains of alcohol-specific policy, including: the number of hours of trading (both on and off-premise venues), the number of people permitted on-site (on-premise venues only), outlet density (both on and off-premise venues), and the extent of permissible alcohol take-out/home delivery (both on and off-premise venues). Each domain was informed by the authors' substantive knowledge; the World Health Organization's 'best buy' policy recommendations for reducing the impact of noncommunicable diseases (World Health Organization, 2017); and the evidence which underpins the Canadian Alcohol Policy Evaluation project (Stockwell et al., 2019).

In summary, each domain was given a score between one and five for food-primary, liquor-primary, government liquor stores, and private liquor stores, where higher scores reflected greater restrictions. Domain-level scores were then combined to create overall scores which represented the amount of restriction observed in both on-premise ($RAPI_{on}$) and off-premise ($RAPI_{off}$) venues. As the contribution of each outlet type to the total amount of alcohol consumed is known to vary (e.g., alcohol sales tend to be greater from liquor primary outlets vs. food primary outlets), RAPI scores were weighted at this step to allow for more accurate coverage and greater generalisability. Next, a score representing the total level of restriction ($RAPI_{total}$) was calculated by combining

$RAPI_{on}$ and $RAPI_{off}$ scores. Again, scores were weighted before combining. Finally, $RAPI_{on}$, $RAPI_{off}$ and $RAPI_{total}$ scores were rescaled to a 0 to 100 scale, where higher scores represented more restriction. The internal consistency was excellent, Cronbach's $\alpha = 0.84$, average inter-item correlation (r_s) = 0.33, and there was a moderate correlation between $RAPI_{total}$ and University of Oxford's stringency index (Hale et al., 2021), $r_s = .43$, $p < .001$, 95% CI = 0.41 to 0.44.

COVID-19 infections

COVID-19 infection data was sourced from the BC Centre for Disease Control (BC Centre for Disease Control, 2021) and were available at the Health Authority (HA) level. Therefore, we assigned the HA data to each corresponding LHA. We used the Spline method (McNeil et al., 1977) via *PROC EXPAND* in SAS (version 9.4) to estimate weekly total population in HAs and further calculate weekly rates per 100,000 new infections for each HA to match the weekly PCAC data.

Statistical analysis

[INSERT FIGURE 1 ABOUT HERE]

Descriptive statistics (means, standard deviation, range and the proportion of missing data) were calculated for alcohol sales and for each of the key study variables. Our data were hierarchical (see Figure 1), with repeated PCAC measurements nested in LHAs, LHAs nested in Health Service Delivery Areas (HSDA), and HSDAs nested in HAs. Therefore, linear mixed effects models (LMM) (Hox et al., 2017) were used to: (1) estimate whether alcohol policy restrictions (RAPI score) was associated with reduced PCAC and (2) investigate whether the effect size of RAPI score was moderated by deprivation measures. LMMs are flexible, allowing researchers to specify statistical models with both fixed and random effects, thus facilitating for the analysis of clustered or nested data (Hox et al., 2017). For instance, it is assumed that repeated-measurements from the same person, or same area, are more highly correlated than those from separate individuals or areas. Therefore, LMMs are commonly used in the analysis of both longitudinal and time-series data (Curran et al., 2010) and data collected in ecology studies (Bolker et al., 2009). The seasonal index method was used to deseasonalise the PCAC data (Anderson et al., 2016). Natural log transformations were applied to PCAC data to correct the distribution of model residuals and to make the variance of the dependent variable stationary. All continuous predictor variables, except RAPI scores and pre-COVID trend, were grand mean centered to aid interpretation and reduce potential collinearity. Models were calculated using Maximum Likelihood estimation. The appropriate random effects and covariance structures were selected by sequentially adding individual parameters to our models and assessing goodness-of-fit (GOF) by selecting the model with the lowest Bayesian information criterion (BIC)[1] value that showed no sign of convergence issues (Hox et al., 2017). GOF statistics are reported in the Supplemental Material. Overall, models were adjusted for the potentially confounding effect of the rate of new COVID-19 infections at the HA level, pre-COVID trend, non-stationarity variance (by analyzing natural log-transformed rates), seasonality using the seasonal index method, and where appropriate AR and MA terms. To identify whether deprivation modified the impact of policy restriction (RAPI score) on PCAC, we compared the least deprived (quintile 1), intermediate deprived (quintile 3), and most deprived (quintile 5) groups. We restricted our analyses to these subgroups to reduce the risk of false-positive results due to multiple testing (Burke et al., 2015; Turner et al., 2020). All statistical analyses were conducted using Stata IC (Version 16.1). A p-value < 0.05 was assumed to indicate statistical significance.

Results

Descriptive Statistics for key variables

Descriptive statistics are presented in the Table 1 and Figure D1. Due to the small proportion of missing data and large sample size, listwise deletion is inconsequential (Schafer, 1999).

[INSERT TABLE 1 ABOUT HERE]

Was alcohol policy restrictiveness associated with reduced PCAC?

Alcohol policy restrictions were associated with decreased PCAC. It was estimated that a ten-unit increase in the RAPI was associated with a 0.12% standard drink reduction in both total (95% CI = 0.09 to 0.15, $p < .001$) and off-premise PCAC (95% CI = 0.09 to 0.13, $p <.001$). Meanwhile, for on-premise PCAC, a ten-unit increase in the RAPI was associated with a decrease of 0.43% (95% CI = 0.42 to 0.43, $p < .001$) standard drinks. Put differently, when considering the full range of policy restrictions measured during the study period, the most restrictive policies observed (i.e., RAPI = 100) for both on and off-premise outlets were associated with a 9% decrease in off-premise PCAC and a 100% decrease (i.e., total closure) in on-premise PCAC, compared to baseline (i.e., RAPI = 0).

Was the alcohol policy restrictiveness-PCAC relationship moderated by deprivation?

[INSERT FIGURES 2, 3, AND 4 ABOUT HERE]

Figures 2-4 present the policy restriction (RAPI) by deprivation (CIMD) interactions. Overall, there was strong evidence to suggest that deprivation level modified the effect of policy restrictions on PCAC ($\chi^2 > 9.89$, $p < .007$ for each CIMD dimension). These results were followed by pairwise comparisons of marginal linear predictions (*z*-tests) between the least deprived, intermediate deprived, and most deprived areas.

Total and off-premise PCAC followed a similar pattern, whereby greater policy restrictions were associated with decreased PCAC (i.e., were negatively associated). However, stronger negative associations were observed among areas that were more deprived in terms of situational vulnerability ($z > 4.72$, $p < .001$ in each case) and economic dependency ($z > 6.45$, $p < .001$ in each case) compared to those who were least deprived; approximately -0.3 standard drinks per week, on average, per ten-point increase in RAPI vs. no significant change. Meanwhile, areas which had greater instability with regards to housing tended to consume the same amount of alcohol compared to before the restrictions ($z = 0.58$, $p = .56$), while the strongest associations, of approximately -0.2 standard drinks per week, on average, per ten-point increase in RAPI, were observed in intermediate deprived areas ($z > 2.02$, $p < .04$, in each case, except total PCAC: least deprived vs. most deprived [$z = 1.58$, $p = .11$]).

The key exception here was areas that may be more marginalised due to the ethno-cultural composition as they tended to consume more alcohol (around +0.1 standard drinks per week, on average, per ten-point increase in RAPI) from off-premise venues as restrictions increased ($z > 6.59$, $p < .001$ in each case). When considering changes to on-premise PCAC, there was a negative relationship between increased restrictions and alcohol use in all areas (up to approximately -0.4 standard drinks per week, on average, per ten-point increase in RAPI). In particular, stronger associations tended to be observed in areas which were most deprived compared to the least deprived areas ($z > 2.87$, $p < .005$ in each case), except for the situational vulnerability dimension, where the opposite was observed ($z = 6.89$, $p < .001$).

Discussion

PCAC was negatively associated with tightening restrictions for policies pertaining to both on- and off-premise alcohol availability. This was particularly pronounced for on-premise (e.g., bars, restaurants, nightclubs) outlets, where the greatest restrictions were implemented due to the clear public health risks associated with attending these venues (e.g., mixing in crowds) (Gurrieri et al., 2021; Saengow et al., 2020). In contrast, there were several possible mechanisms for the relatively weaker association between policy stringency and alcohol use observed in off-premise outlets. First, off-premise liquor retailers were classified as 'essential' by policymakers (Hobin and Smith, 2020). Second, it is typically cheaper to purchase alcohol from off-premise retailers compared to on-premise venues (Morrison et al., 2015). Third, regulations were modified in response to the pandemic to permit home delivery by some retailers (Stockwell et al., 2021). Therefore, taken together, both the financial and physical availability of alcohol from off-premise retailers was likely considerably greater during, compared to before, the COVID-19 pandemic.

There was strong evidence that area-based deprivation modified the impact of alcohol specific policy restrictions. In line with our hypotheses, areas with high situational vulnerability and economic dependency (reflecting greater disadvantage) saw larger reductions (i.e., stronger associations) in off-premise alcohol use compared to the least deprived areas. As both the situational vulnerability (i.e., sociodemographic differences in, for example: housing, income and education) and economic dependency (e.g., reliance on income other than that gained through employment) dimensions of the CIMD broadly concern income (or lack thereof) (Statistics Canada, 2019), this finding corroborates previous literature which suggests that alcohol policy interventions - such as minimum unit pricing (MUP) - may be most effective among populations with lower income (Jiang et al., 2016, 2017; Zhao and Stockwell, 2017). It is likely that any policy change that limits the financial affordability of alcohol is most effective among those with low income, although further research is needed to confirm this. Similarly, significantly larger (vs. least deprived) reductions in alcohol use were observed for on-premise outlets in the most deprived areas, except for the situational vulnerability dimension. However, as this dimension of the CIMD reflects income (Statistics Canada, 2019), it may be that individuals in these areas were choosing to purchase their alcohol from the cheaper off-premise outlets instead (Morrison et al., 2015).

In areas which were most deprived in terms of residential instability, the negative association between alcohol policy restrictions and off-premise alcohol use was dampened. In other words, off-premise PCAC, typically did not change as a function of alcohol policy restriction in areas of high residential instability. This was unexpected. However, findings from a recent review, on contextual correlates of changes in alcohol use during the COVID-19 pandemic, suggest that living with others during the pandemic-induced social isolation was associated increased drinking, while living alone was linked to no change (Acuff et al., 2021). Therefore, as the residential instability dimension speaks to those who live alone in rented accommodation, this finding makes sense. Finally, the only place where increased policy restrictions were associated with increased PCAC was from off-premise outlets in areas which may face more marginalisation due to the ethno-cultural composition (e.g., the number of immigrants, linguistic isolation, belonging to a minority ethnic group). This finding is somewhat difficult to interpret. For instance, in BC, many of the areas with a high proportion of people who identify with an ethnic 'minority' group are also areas which have a high cost of living, such as Vancouver (Statistics Canada, 2017). Therefore, these areas may not be deprived in the traditional sense, in terms of income, which may help to explain our findings. Nevertheless, this finding is in-line with previous work. For instance, in the same review, Acuff et al., (2021) find that non-White participants in North America were more likely to increase the quantity of alcohol consumed, the frequency of binge drinking, and the occurrence of solitary drinking compared to pre-pandemic levels. This is particularly concerning as previous work indicates that minority ethnic groups tend to be disproportionately affected by alcohol-related harm, yet research in this area is lacking (Zemore et al., 2018).

We acknowledge several limitations in our study. First the alcohol sales data were not quite complete. However, due to the small proportion of missing data, listwise deletion is unlikely to bias results (Schafer, 1999). Second, data for home-made alcohol and travelers' imports go unrecorded and so were unavailable to us. However, as these data were unavailable throughout the timeseries, and are likely small in magnitude (due to our data having almost full population coverage, unlike representative samples), they are unlikely to bias our results. Third, due to data availability restrictions, we had to estimate weekly population numbers and new COVID-19 infections. Conceivably, this may have increased our statistical power artificially and may have also increased measurement error in the variables that used population size during construction. However, the only other option, to aggregate the sales data to a monthly or yearly intervals, would have resulted in a dramatic decrease in statistical power and nuance; likely beyond the degree to which power and measurement error was affected by our decision. Fourth, the CIMD data was created following the last census in Canada, in 2016. Arguably, therefore, the data may not precisely reflect area-level deprivation in the present day. Nevertheless, the most up to date data available was utilised here and previous research indicates that area-level deprivation is relatively stable over time. For instance, when comparing the 2015 (IMD2015) and 2019 (IMD2019) iterations of the English Indices of Deprivation, 88% of areas that were classified as 'most deprived' according to IMD2019 were given the same classification as IMD2015, as were 84% of the least deprived areas (Ministry of Housing, Communities & Local Government, 2019). Fifth, the RAPI, like most measures, has imperfect construct validity in terms of both the measures included in the scale and the ones not included. For instance, information about policy change that may also be related with increased alcohol use, such as school closures (Huhn et al., 2022), were not captured. However, we chose the policies included in the RAPI based on evidence that similar policy changes have been previously identified as having a large effect on alcohol consumption (Stockwell et al., 2019; World Health Organization, 2017). Similarly, we assumed that each component of the RAPI could be combined additively. While this may be correct, future research should test this assumption. Sixth, there is a possibility that privately owned outlets stocked up or stocked out during the pandemic, thus shifting sales to an earlier or later time. This may have caused some measurement error. However, we attempted to account for this by testing whether models including AR or MA terms were appropriate. Seventh, there are other potential confounding factors that were not accounted for here, such as pandemic-related stress (Clay and Parker, 2020), as this data was not available. Finally, as our analysis was isolated to BC, we cannot be sure that our results generalise to the rest of Canada or elsewhere.

Conclusions

Increased alcohol policy restrictions (e.g., reduced hours of trading; less people permitted in on-premise venues; and a reduction in the number of outlets) were associated with decreased PCAC during the COVID-19 pandemic. Furthermore, the strength of this relationship was modified by area-level deprivation. Specifically, restricting the physical availability (e.g., through reduced hours of trading) of alcohol tended to be associated with decreased alcohol use most greatly in poorer areas. Thus, this work provides further evidence that similar policies which restrict the availability of alcohol, such as MUP (albeit a restriction on financial affordability in this case), may be most beneficial to those most at risk of harm (i.e., people with relatively low income). Troublingly, we found evidence of higher off-premise PCAC levels in areas with a high proportion of minority ethic people. Thus, future research efforts should focus on better understanding this phenomenon.

References

Acuff, S. F., Strickland, J. C., Tucker, J. A., & Murphy, J. G. (2021). Changes in alcohol use during COVID-19 and associations with contextual and individual difference variables: A systematic review and meta-analysis. Psychology of Addictive Behaviors. doi:10.1037/adb0000796 Medline.

Anderson, D. R., Sweeney, D. J., Williams, T. A., Camm, J. D., & Cochran, J. J. (2016). *Statistics for business & economics*. Cengage Learning.

Anderson, R. M., Heesterbeek, H., Klinkenberg, D., & Hollingsworth, T. D. (2020). How will country-based mitigation measures influence the course of the COVID-19 epidemic?[Elsevier.]. Lancet, *395*(10228), 931–934. doi:10.1016/S0140-6736(20)30567-5. Medline

Baum, A., Garopalo, J. P., and Yali, A. M. (1999). Socioeconomic Status and Chronic Stress: Does Stress Account for SES Effects on Health? *Annals of the New York Academy of Sciences, 896*(1), 131–144. Wiley/Blackwell (10.1111). doi: 10.1111/j.1749-6632.1999.tb08111.x

BC Centre for Disease Control. (2021). BC COVID-19 Data. Retrieved from http://www.bccdc.ca/health-info/diseases-conditions/covid-19/data

Stats, B. C. (2019). *Health Boundaries*. Retrieved from https://www2.gov.bc.ca/gov/content/data/geographic-data-services/land-use/administrative-boundaries/health-boundaries

Stats, B. C. (2021). British Columbia - Population Estimates & Projections. Retrieved from https://bcstats.shinyapps.io/popApp/

Beck, N. (2001). Time-series–cross-section Data. Statistica Neerlandica, *55*(2), 111–133. doi:10.1111/1467-9574.00161.

Bellis, M. A., Hughes, K., Nicholls, J., Sheron, N., Gilmore, I., & Jones, L. (2016). The alcohol harm paradox: using a national survey to explore how alcohol may disproportionately impact health in deprived individuals. BMC Public Health, *16*(1), 111. doi:10.1186/s12889-016-2766-x. Medline

Bolker, B. M., Brooks, M. E., Clark, C. J., Geange, S. W., Poulsen, J. R., Stevens, M. H. H., & White, J.-S. S. (2009). Generalized linear mixed models: a practical guide for ecology and evolution. Trends in Ecology & Evolution, *24*(3), 127–135. doi:10.1016/j.tree.2008.10.008. Medline

Burke, J. F., Sussman, J. B., Kent, D. M., & Hayward, R. A. (2015). Three simple rules to ensure reasonably credible subgroup analyses. *BMJ, 351*, h5651. British Medical Journal Publishing Group. doi: 10.1136/bmj.h5651

Butler, D. C., Petterson, S., Phillips, R. L., & Bazemore, A. W. (2013). Measures of social deprivation that predict health care access and need within a rational area of primary care service delivery. Health Services Research, *48*(2 Pt 1, 2pt1), 539–559. doi:10.1111/j.1475-6773.2012.01449.x. Medline

Clay, J. M., and Parker, M. O. (2020). Alcohol use and misuse during the COVID-19 pandemic: a potential public health crisis? *The Lancet Public Health, 5*(5), e259. The Author(s). Published by Elsevier Ltd. This is an Open Access article under the CC BY 4.0 license. doi: 10.1016/S2468-2667(20)30088-8

Cohen, S., Doyle, W. J., & Baum, A. (2006). Socioeconomic status is associated with stress hormones. Psychosomatic Medicine, *68*(3), 414–420. doi:10.1097/01.psy.0000221236.37158.b9. Medline

CTV News. (2021, January 28). Scroll through this timeline of the 1st year of COVID-19 in B.C. Retrieved January 9, 2022, from https://bc.ctvnews.ca/scroll-through-this-timeline-of-the-1st-year-of-covid-19-in-b-c-1.5284929

Curran, P. J., Obeidat, K., & Losardo, D. (2010). Twelve frequently asked questions about growth curve modeling. Journal of Cognition and Development, *11*(2), 121–136. doi:10.1080/15248371003699969. Medline

Gadermann, A. C., Thomson, K. C., Richardson, C. G., Gagné, M., McAuliffe, C., Hirani, S., & Jenkins, E. (2021). Examining the impacts of the COVID-19 pandemic on family mental health in Canada: findings from a national cross-sectional study. BMJ Open, *11*(1), e042871. doi:10.1136/bmjopen-2020-042871. Medline

Gurrieri, L., Fairbairn, C. E., Sayette, M. A., & Bosch, N. (2021). Alcohol narrows physical distance between strangers. *PNAS, 118*(20). National Academy of Sciences. doi: 10.1073/pnas.2101937118

Hale, T., Angrist, N., Goldszmidt, R., Kira, B., Petherick, A., Phillips, T., et al. (2021). A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker). Nature Human Behaviour, *5*(4), 529–538. doi:10.1038/s41562-021-01079-8. Medline

von Hippel, P. T. (2005). Mean, Median, and Skew: Correcting a Textbook Rule. *Journal of Statistics Education, 13*(2), null. Taylor & Francis. doi: 10.1080/10691898.2005.11910556

Hobin, E., & Smith, B. (2020). Is another public health crisis brewing beneath the COVID-19 pandemic? Canadian Journal of Public Health, *111*(3), 392–396. doi:10.17269/s41997-020-00360-z. Medline

Hox, J. J., Moerbeek, M., & van de Schoot, R. (2017). *Multilevel Analysis: Techniques and Applications* (3rd ed.). New York: Routledge. doi: 10.4324/9781315650982

Huhn, A. S., Strain, E. C., Jardot, J., Turner, G., Bergeria, C. L., Nayak, S., & Dunn, K. E. (2022). Treatment Disruption and Childcare Responsibility as Risk Factors for Drug and Alcohol Use in Persons in Treatment for Substance Use Disorders During the COVID-19 Crisis. Journal of Addiction Medicine, *16*(1), e8–e15. doi:10.1097/ADM.0000000000000813. Medline

Jiang, H., Callinan, S., Livingston, M., & Room, R. (2017). Off-premise alcohol purchasing in Australia: Variations by age group, income level and annual amount purchased. Drug and Alcohol Review, *36*(2), 210–219. doi:10.1111/dar.12402. Medline

Jiang, H., Livingston, M., Room, R., & Callinan, S. (2016). Price elasticity of on- and off-premises demand for alcoholic drinks: A Tobit analysis. Drug and Alcohol Dependence, *163*, 222–228. doi:10.1016/j.drugalcdep.2016.04.026. Medline

Lantz, P. M., House, J. S., Mero, R. P., and Williams, D. R. (2005). Stress, Life Events, and Socioeconomic Disparities in Health: Results from the Americans' Changing Lives Study. *Journal of Health and Social Behavior, 46*(3), 274–288. SAGE PublicationsSage CA: Los Angeles, CA. doi: 10.1177/002214650504600305

Lewer, D., Meier, P., Beard, E., Boniface, S., & Kaner, E. (2016). Unravelling the alcohol harm paradox: a population-based study of social gradients across very heavy drinking thresholds. BMC Public Health, *16*(1), 599. doi:10.1186/s12889-016-3265-9. Medline

Mackenbach, J. P., Stirbu, I., Roskam, A.-J. R., Schaap, M. M., Menvielle, G., Leinsalu, M., & Kunst, A. E. (2008). Socioeconomic Inequalities in Health in 22 European Countries. *New England Journal of Medicine, 358*(23), 2468–2481. Massachusetts Medical Society. doi: 10.1056/NEJMsa0707519

MacKillop, J., Cooper, A., & Costello, J. (2021). National Retail Sales of Alcohol and Cannabis During the COVID-19 Pandemic in Canada. JAMA Network Open, *4*(11), e2133076. doi:10.1001/jamanetworkopen.2021.33076. Medline

McNEIL, D. R., Trussell, T. J., & Turner, J. C. (1977). Spline interpolation of demographic data. Demography, *14*(2), 245–252. doi:10.2307/2060581. Medline

Ministry of Housing. Communities & Local Government. (2019). *The English Indices of Deprivation 2019*.

Morrison, C., Ponicki, W. R., & Smith, K. (2015). Social disadvantage and exposure to lower priced alcohol in off-premise outlets. Drug and Alcohol Review, *34*(4), 375–378. doi:10.1111/dar.12256. Medline

Myran, D. T., Smith, B. T., Cantor, N., Li, L., Saha, S., Paradis, C., et al. (2021). Changes in the dollar value of per capita alcohol, essential, and non-essential retail sales in Canada during COVID-19. BMC Public Health, *21*(1), 2162. doi:10.1186/s12889-021-12226-1. Medline

Northcote, J., & Livingston, M. (2011). Accuracy of self-reported drinking: observational verification of 'last occasion' drink estimates of young adults. Alcohol and Alcoholism (Oxford, Oxfordshire), *46*(6), 709–713. doi:10.1093/alcalc/agr138. Medline

Probst, C., Kilian, C., Sanchez, S., Lange, S., and Rehm, J. (2020). The role of alcohol use and drinking patterns in socioeconomic inequalities in mortality: a systematic review. *The Lancet Public Health, 5*(6), e324–e332. Elsevier Ltd. doi: 10.1016/S2468-2667(20)30052-9

Rodriguez, L. M., Litt, D. M., & Stewart, S. H. (2020). Drinking to cope with the pandemic: The unique associations of COVID-19-related perceived threat and psychological distress to drinking behaviors in American men and women.[Elsevier.]. Addictive Behaviors, *110*, 106532. doi:10.1016/j.addbeh.2020.106532. Medline

Saengow, U., Assanangkornchai, S., & Casswell, S. (2021). Alcohol: a probable risk factor of COVID-19 severity. Addiction (Abingdon, England), *116*(1), 204–205. doi:10.1111/add.15194. Medline

Schafer, J. L. (1999). Multiple imputation: a primer.[Sage Publications Sage CA: Thousand Oaks, CA.]. Statistical Methods in Medical Research, *8*(1), 3–15. doi:10.1177/096228029900800102. Medline

Shield, K. D., Chrystoja, B. R., Ali, S., Sohi, I., Rehm, J., Nigatu, Y. T., Elton-Marshall, T., et al. (2021). Changes in Alcohol Consumption in Canada During the COVID-19 Pandemic: Associations With Anxiety and Self-Perception of Depression and Loneliness. *Alcohol and Alcoholism (Oxford, Oxfordshire)*, agab055. doi: 10.1093/alcalc/agab055

Skrzynski, C. J., & Creswell, K. G. (2020). Associations between solitary drinking and increased alcohol consumption, alcohol problems, and drinking to cope motives in adolescents and young adults: a systematic review and meta-analysis. Addiction (Abingdon, England), *115*(11), 1989–2007. doi:10.1111/add.15055. Medline

Statistics Canada. (2017). *Vancouver [Census metropolitan area], British Columbia and British Columbia [Province] (table)*. Census Profile. Ottawa, Ont. Retrieved from https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CMACA&Code1=933&Geo2=PR&Code2=59&Data=Count&SearchText=vancouver&SearchType=Begins&SearchPR=01&B1=All&TABID=1

Statistics Canada. (2019). *The Canadian Index of Multiple Deprivation: User Guide*.

Stockwell, T., Andreasson, S., Cherpitel, C., Chikritzhs, T., Dangardt, F., Holder, H., et al. (2021). The burden of alcohol on health care during COVID-19. Drug and Alcohol Review, *40*(1), 3–7. doi:10.1111/dar.13143. Medline

Stockwell, T., Wettlaufer, A., Vallance, K., Chow, C., Giesbrecht, N., April, N., et al. (2019). *Strategies to Reduce Alcohol-Related Harms and Costs in Canada: A Review of Provincial and Territorial Policies*. Victoria, BC: Canadian Institute for Substance Use Research, University of Victoria.

Stockwell, T., Zhao, J., Martin, G., Macdonald, S., Vallance, K., Treno, A., Ponicki, W., et al. (2013). Minimum Alcohol Prices and Outlet Densities in British Columbia, Canada: Estimated Impacts on Alcohol-Attributable Hospital Admissions. *American Journal of Public Health, 103*(11), 2014–2020. American Public Health Association. doi: 10.2105/AJPH.2013.301289

Stoica, P., & Selen, Y. (2004). Model-order selection: a review of information criterion rules. *IEEE Signal Processing Magazine, 21*(4), 36–47. Presented at the IEEE Signal Processing Magazine. doi: 10.1109/MSP.2004.1311138

Thayer, J. F., Åhs, F., Fredrikson, M., Sollers, J. J., III, & Wager, T. D. (2012). A meta-analysis of heart rate variability and neuroimaging studies: implications for heart rate variability as a marker of stress and health. Neuroscience and Biobehavioral Reviews, *36*(2), 747–756. doi:10.1016/j.neubiorev.2011.11.009. Medline

Turner, S., Mackay, D., Dick, S., Semple, S., & Pell, J. P. (2020). Associations between a smoke-free homes intervention and childhood admissions to hospital in Scotland: an interrupted time-series analysis of whole-population data. The Lancet. Public Health, *5*(9), e493–e500. doi:10.1016/S2468-2667(20)30178-X. Medline

Wardell, J. D., Kempe, T., Rapinda, K. K., Single, A., Bilevicius, E., Frohlich, J. R., et al. (2020). Drinking to Cope During COVID-19 Pandemic: The Role of External and Internal Factors in Coping Motive Pathways to Alcohol Use, Solitary Drinking, and Alcohol

Problems. Alcoholism, Clinical and Experimental Research, *44*(10), 2073–2083. doi:10.1111/acer.14425. Medline

Wilkinson, R. G. (2002). *Unhealthy Societies*. Routledge. doi: 10.4324/9780203421680

World Health Organization. (2017). *'Best buys' and other recommended interventions for the prevention and control of noncommunicable diseases*.

Zemore, S. E., Karriker-Jaffe, K. J., Mulia, N., Kerr, W. C., Ehlers, C. L., Cook, W. K., et al. (2018). The future of research on alcohol-related disparities across US racial/ethnic groups: A plan of attack.[Rutgers University.]. Journal of Studies on Alcohol and Drugs, *79*(1), 7–21. doi:10.15288/jsad.2018.79.7. Medline

Zhao, J., & Stockwell, T. (2017). The impacts of minimum alcohol pricing on alcohol attributable morbidity in regions of British Colombia, Canada with low, medium and high mean family income. Addiction (Abingdon, England), *112*(11), 1942–1951. doi:10.1111/add.13902. Medline

Tables

Table 1. Descriptive Statistics for Key Study Variables

Measure	*N*	Mean	SD	Min.	Max.	% Miss.
Estimated Age 15+ PCAC						
Total	18,218	13.31	7.54	0.01	527.44	2.06
Off-premise	18,182	11.92	7.07	0.07	526.19	2.25
On-premise	17,839	1.45	1.76	0.00	34.48	4.10
RAPI						
Total	18,601	34.73	12.51	0.00	100.00	0.00
Off-premise	18,601	34.64	16.47	0.00	100.00	0.00
On-premise	18,601	34.35	15.27	0.00	100.00	0.00
CIMD						
Ethno-cultural Composition	18,601	2.94	1.41	1.00	5.00	0.00
Situational Vulnerability	18,601	2.83	1.49	1.00	5.00	0.00
Economic Dependency	18,601	2.85	1.50	1.00	5.00	0.00
Residential Instability	18,601	2.82	1.29	1.00	5.00	0.00
Weekly rate of COVID-19 Infection per 100,000 population						
Total	18,601	7.76	23.98	0.00	181.38	0.00

Note: N = the number of data points between April 2017 to April 2021; Descriptive statistics (mean, SD [standard deviation], min [minimum], max [maximum], % miss [the percentage of missing data]) were calculated across the entire time period. PCAC = Age 15+ Per Capita Alcohol Consumption (Standard Drinks); RAPI = Restrictiveness of Alcohol Policy Index; CIMD = Canadian Index of Multiple Deprivation.

Captions for Figures

Figure 1. Map of Administrative Health Boundaries in British Colombia alongside which study variables map to which level of the nested hierarchy: 89 Local Health Areas (LHA) aggregate to 16 Health Service Delivery Areas (HSDA), which aggregate to 5 Health Areas (HA). Adapted from (BC Stats, 2019). Adapted under the Open Government Licence – British Columbia. RAPI = Restrictiveness of Alcohol Policy Index; PCAC = age 15+ per capita alcohol consumption; CIMD = Canadian Index of Multiple Deprivation.

Figure 2. Total consumption: Average change in age 15+ per capita alcohol consumption (standard drinks) per 10-point increase in the Restrictiveness of Alcohol Policy Index (RAPI) by four dimensions of area-based deprivation (Canadian Index of Multiple Deprivation). Large numbers at the bottom indicate the test of the overall significance (*p*-value) of the interactions. Smaller numbers at the top show the significance corresponding to pairwise comparisons (least deprived, intermediate deprived, most deprived). Error bars represent 95% confidence intervals. 1 standard drink = 17.05mL or 13.45g of pure ethanol.

Figure 3. Off-premise consumption: Average change in age 15+ per capita alcohol consumption (standard drinks) per 10-point increase in the Restrictiveness of Alcohol Policy Index (RAPI) by four dimensions of area-based deprivation (Canadian Index of Multiple Deprivation). Large numbers at the bottom indicate the test of the overall significance (*p*-value) of the interactions. Smaller numbers at the top show the significance corresponding to pairwise comparisons (least deprived, intermediate deprived, most deprived). Error bars represent 95% confidence intervals. 1 standard drink = 17.05mL or 13.45g of pure ethanol.

Figure 4. On-premise consumption: Average change in age 15+ per capita alcohol consumption (standard drinks) per 10-point increase in the Restrictiveness of Alcohol Policy Index (RAPI) by

four dimensions of area-based deprivation (Canadian Index of Multiple Deprivation). Large numbers at the bottom indicate the test of the overall significance (*p*-value) of the interactions. Smaller numbers at the top show the significance corresponding to pairwise comparisons (least deprived, intermediate deprived, most deprived). Error bars represent 95% confidence intervals. 1 standard drink = 17.05mL or 13.45g of pure ethanol.

Figures

Figure 1

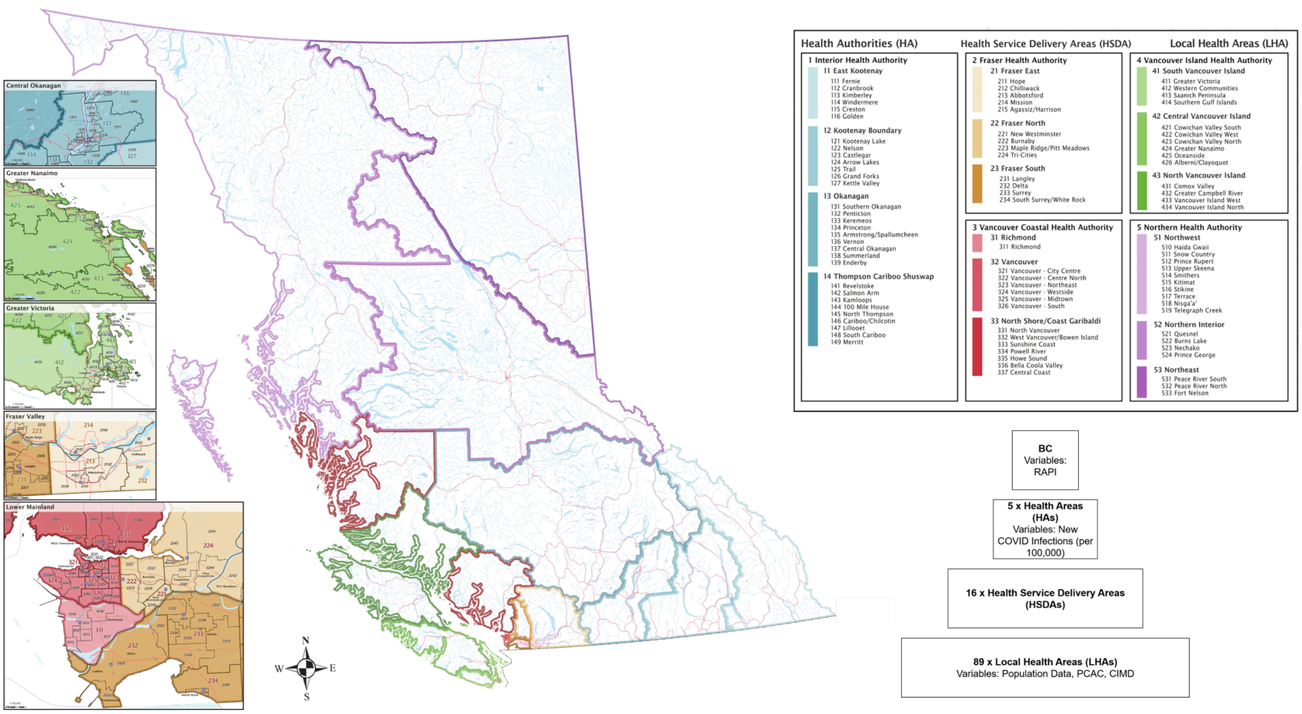


Figure 2

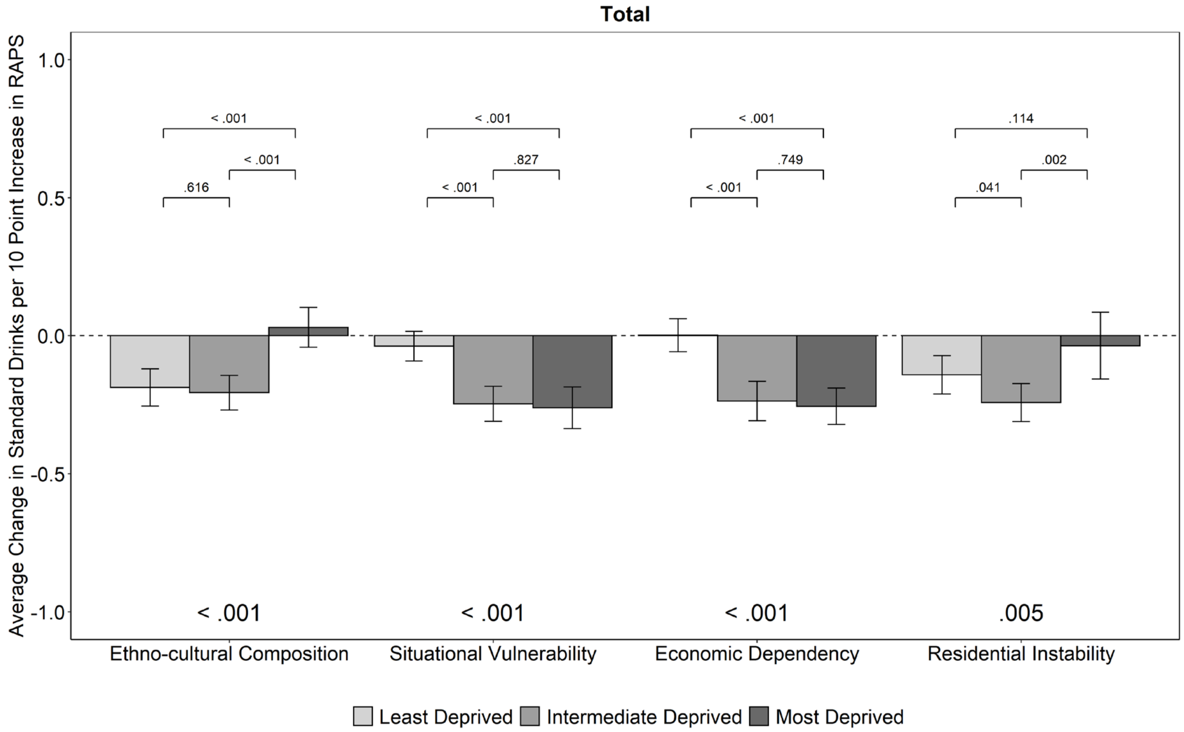


Figure 3

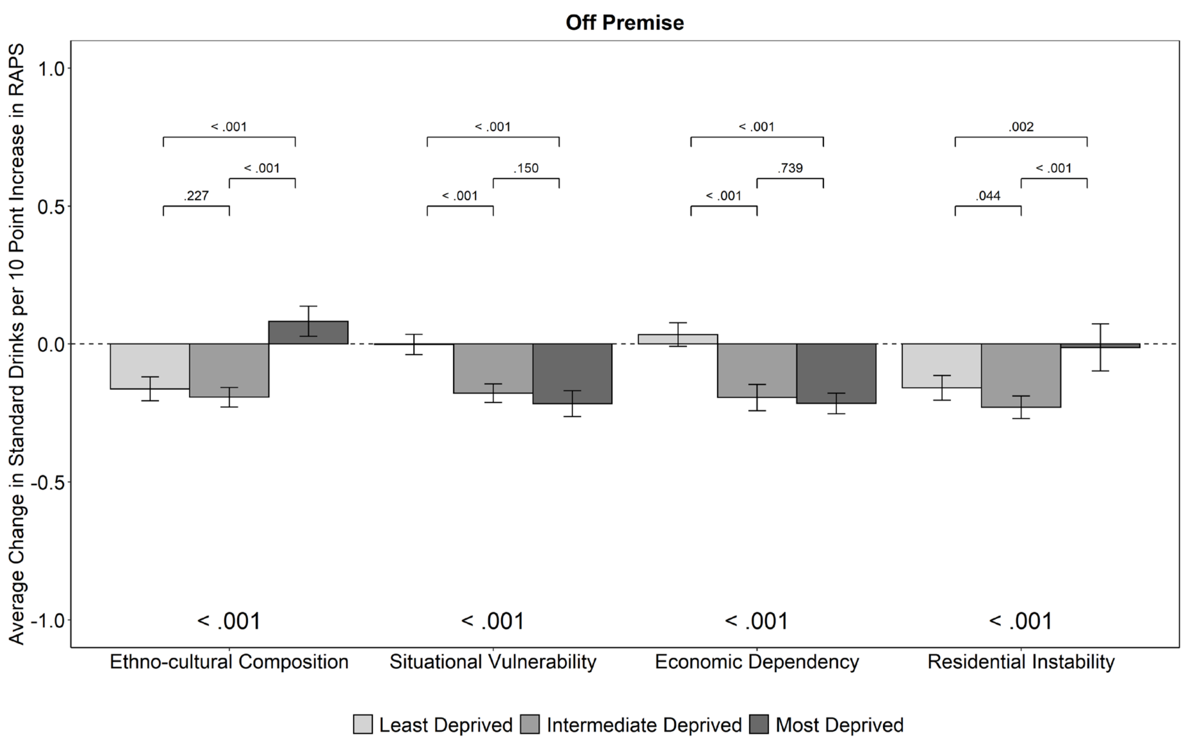
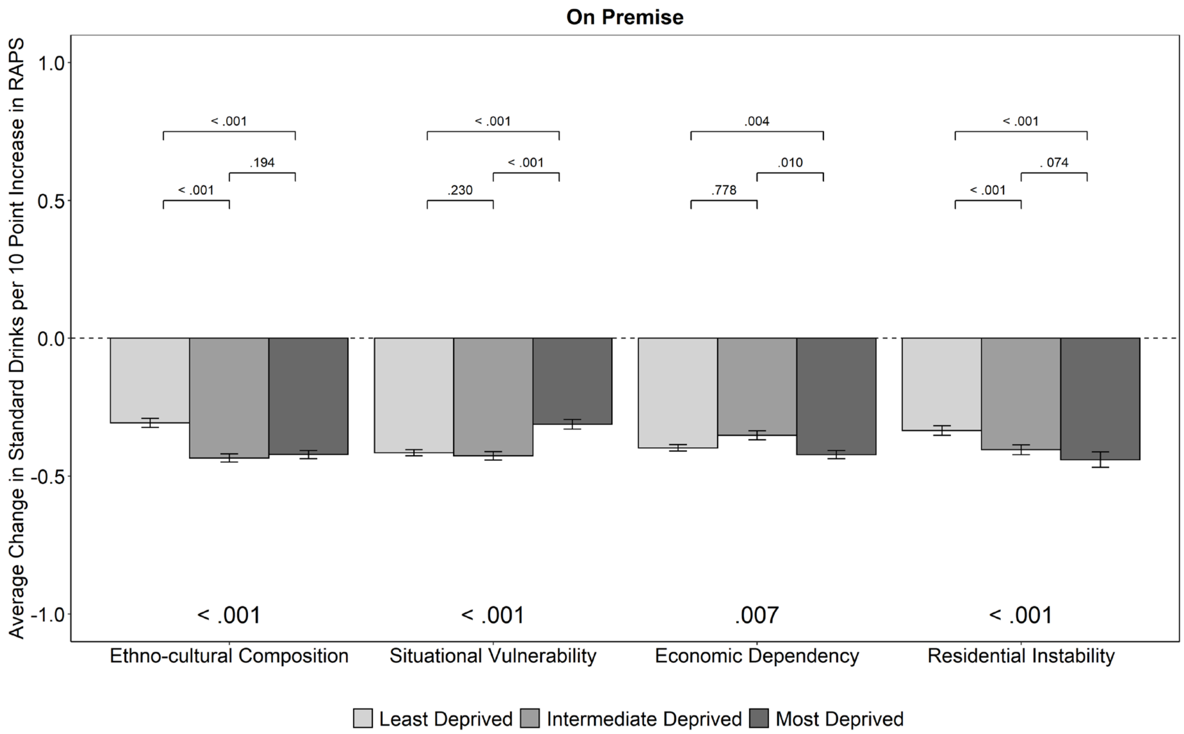


Figure 4


On Premise
Average Change in Standard Drinks per 10 Point Increase in RAPS
1.0
0.5
0.0
-0.5
-1.0
< .001
.194
< .001
< .001
< .001
.230
.004
.010
.778
< .001
. 074
< .001
< .001
< .001
.007
< .001
Ethno-cultural Composition
Situational Vulnerability
Economic Dependency
Residential Instability
Least Deprived
Intermediate Deprived
Most Deprived

Supplemental Material

Supplement to:

Associations Between COVID-19 Alcohol Policy Restrictions and Alcohol Sales in British Columbia: Variation by Area-based Deprivation Level

Appendix A: Canadian Index of Multiple Deprivation Correlations

Table A1. *Spearman's Correlation Coefficients between Canadian Index of Multiple Deprivation Indices for BC.*

	1	2	3	4
1. Ethno-cultural Composition	-			
2. Situational Vulnerability	-0.67*	-		
3. Economic Dependency	-0.37*	0.34*	-	
4. Residential Instability	0.65*	-0.46*	-0.21	-

Note: * $p < .05$

Appendix B: Restrictiveness of Alcohol Policy Index (RAPI)

Overview

The RAPI is a bespoke tool that was designed to quantify week-by-week changes in the alcohol policy landscape in Canada during the COVID-19 pandemic. Daily alcohol policy changes were monitored by Canadian Centre on Substance Use and Addiction and the Canadian Institute for Substance Use Research. The policy domains included in the RAPI were:

1. The number of hours of trading (for both on-premise and off-premise retailers).
2. The number of people permitted on site compared to before the pandemic (on-premise retailers only)
3. The proportion of outlets in operation compared to before the pandemic (for both on-premise and off-premise retailers).
4. The extent of home delivery (for both on-premise and off-premise retailers).

Each policy domain was informed by the World Health Organization's (WHO) 'best buy' policy recommendations for reducing the impact of noncommunicable diseases (World Health Organization, 2017); the evidence which underpins the Canadian Alcohol Policy Evaluation (CAPE) Project (Stockwell et al., 2019); and the authors' substantive knowledge. For instance, the WHO recommend "enacting and enforcing restrictions on the physical availability of retailed alcohol", which encompasses a reduction in hours of sale, reduced outlet density, home delivery, and restrictions on the capacity of alcohol retailers; all of which are incorporated in the RAPS. Similarly, CAPE has identified the four domains included in the RAPS as important measures to impact alcohol consumption, based on comprehensive reviews on the available literature. Therefore, it was theorised that changes in these policy domains would have a large effect on alcohol consumption.

Domain scoring

As summarised in Table B1, each of the four domains were assigned a score from one to five, with higher scores reflecting greater restrictiveness (i.e., more stringency).

Table B1. Summary of RAPI Domains.

Domain	Venue (Abbreviation)	Domain Scoring
Hours of trading compared to the maximum allowed number of hours before the pandemic	Both on (H_{on}) and off premise (H_{off})	1 = 88% to 100% 2 = 63% to 87% 3 = 38% to 62% 4 = 13% to 37% 5 = 0% to 12%.
Number of people permitted on site compared to before the pandemic	On premise only (P_{on})	
Proportion of outlets in operation compared to before the pandemic	Both on (O_{on}) and off premise (O_{off})	
The extent of home delivery	Both on (D_{on}) and off premise (D_{off})	On premise 1= unrestricted home deliveries; 2 = third-party home deliveries with restricted quantity; 3 = direct home deliveries with restricted quantity; 4 = curb-side pickup; 5 = no delivery or curbside pickup. Off premise 1= unrestricted home deliveries; 2 = home delivery with quantity or food restrictions; 3 = unrestricted pick up or take away; 4 = pick up or take away alongside food; 5 = no delivery or curbside pickup.

For hours of trading, the number of people permitted on site, and the proportion of outlets in operation, the following scoring system was used: 1 = 88-100%, 2=63-87%, 3=38-62%, 4=13-37%, 5=0-12%. The scoring system was developed so that there would be a smaller likelihood of domain scores that were either most stringent (i.e., a score of 5) or least stringent (i.e., a score of 1) so that more weight was given to middling values. This system was agreed within the research team and discussed with several subject area experts.

The number of hours of trading

RAPI scores were determined for the number of hours of trading for both on (H_{on}) and off premise (H_{off}) venues. Here, the opening hours of a given venue type, for a given week, was divided by the maximum weekly number of opening hours permitted before the pandemic, and then multiplied by 100 to produce a percentage value.

The number of people permitted on site compared to before the pandemic

RAPI scores representing the number of people permitted on-site were calculated for on-premise venues only (P_{on}). Here, the percentage of people permitted on-site was derived from official documentation. For example, the province of British Colombia mandated that business owners implement and follow a "COVID-19 Safety Plan", such as allowing no more that 50% of the usual capacity of patrons to be present at one time.

The proportion of outlets in operation compared to before the pandemic

The number of outlets in operation were normalised using population data through conversion to a rate (per 100,000). We then divided the weekly rate by the maximum rate observed prior to the pandemic, before multiplying by 100 to produce a percentage value. Finally, we converted the percentage values into RAPI scores for both on (O_{on}) and off premise (O_{off}) venues.

The extent of home delivery

RAPI scores for the extent of home delivery were calculated separately for both on (Don) and off premise (Doff) venues. For off premise retailers, policies with unrestricted home deliveries and curbside pick-up from the retailer or any third-party delivery services received a score of 1 (least stringent). Policies which did not allow for delivery or curbside pick-up of alcohol received a score of 5 (most stringent). As home deliveries were judged as a more convenient method of access to alcohol compared to physically picking up one's alcohol in-person, policies which allowed for only curbside pick-up of alcohol, but no home deliveries received a score of 4. With fewer options (and less availability) to purchase alcohol for delivery directly through the retailer, home deliveries from retailer only with a cap on the quantity of alcohol purchased received a score of 3, whilst home deliveries from any third-party services with a cap on the alcohol purchased received a score of 2. For on premise retailers, policies with unrestricted home deliveries received a score of 1, whilst policies which did not allow for deliveries, pick-up, or take-away of alcohol received a score of 5. Policies which did not allow for home delivery but allowed pick-up or take-away of alcohol with purchase of food received a score of 4, whist policies which did not allow for home delivery, but allowed for unrestricted pick-up or take-away of alcohol (no food purchase required) received a score of 3. Policies which allowed for home delivery of alcohol but with quantity or food restrictions received a score of 2.

Combining domain-level scores

On-premise sales can be further subdivided into food-primary (e.g., restaurants) and liquor-primary (e.g., bars) outlets. Off-premise venues can be broken down into government-owned liquor stores (GLS) and privately-owned liquor stores (PLS). The contribution of each of these outlet types to the absolute amount of alcohol sold and consumed is known to vary. Therefore, we weighted RAPI scores to allow for more accurate coverage and better generaliseability. Weights were calculated as the absolute amount of alcohol sold by a venue type divided by the total amount of alcohol sold in that domain.

On-premise

PCAC for on-premise consumption was calculated by summing the PCAC from food-primary and liquor-primary venues:

$$\mathrm{PCAC_{On}} = \mathrm{PCAC_{food}} + \mathrm{PCAC_{liqour}}$$

The weight for food-primary venues was calculated by dividing the total PCAC from food-primary venues by the total on-premise PCAC:

$$\mathrm{W_{food}} = \frac{\mathrm{PCAC_{food}}}{\mathrm{PCAC_{on}}}$$

The weight for liquor-primary venues was calculated by dividing the total PCAC from liquor-primary venues by the total on-premise PCAC:

$$\mathrm{W_{liquor}} = \frac{\mathrm{PCAC_{liquor}}}{\mathrm{PCAC_{on}}}$$

RAPI scores for food-primary and liquor-primary venues were calculated by multiplying the weight by the sum of the domain scores for the maximum allowed number of hours before the pandemic (H); the number of people permitted on site compared to before the pandemic (P); the proportion of outlets in operation compared to before the pandemic (O); and the extent of home delivery (D):

$$\mathrm{RAPI_{food}} = (\mathrm{H_{food}} + \mathrm{P_{food}} + \mathrm{O_{food}} + \mathrm{D_{food}}) \times \mathrm{W_{food}}$$

$$\mathrm{RAPI_{liquor}} = (\mathrm{H_{liquor}} + \mathrm{P_{liquor}} + \mathrm{O_{liquor}} + \mathrm{D_{liquor}}) \times \mathrm{W_{liquor}}$$

The RAPI score for on-premise consumption was calculated by summing the RAPI scores for food-primary and liquor-primary venues:

$$\mathrm{RAPI_{on}} = \mathrm{RAPI_{food}} + \mathrm{RAPI_{liquor}}$$

Off-premise

PCAC for off-premise consumption was calculated by summing the PCAC from GLS and PLS venues:

$$\mathrm{PCAC_{On}} = \mathrm{PCAC_{GLS}} + \mathrm{PCAC_{PLS}}$$

The weight for GLS venues was calculated by dividing the total PCAC from GLS venues by the total off-premise PCAC:

$$\mathrm{W_{GLS}} = \frac{\mathrm{PCAC_{GLS}}}{\mathrm{PCAC_{off}}}$$

The weight for PLS venues was calculated by dividing the total PCAC from PLS venues by the total off-premise PCAC:

$$\mathrm{W_{PLS}} = \frac{\mathrm{PCAC_{PLS}}}{\mathrm{PCAC_{off}}}$$

RAPI scores for GLS and PLS venues were calculated by multiplying the weight by the sum of the domain scores for the maximum allowed number of hours before the pandemic (H); the proportion of outlets in operation compared to before the pandemic (O); and the extent of home delivery (D):

$$\mathrm{RAPI_{GLS}} = (\mathrm{H_{GLS}} + \mathrm{O_{GLS}} + \mathrm{D_{GLS}}) \times \mathrm{W_{GLS}}$$

$$\mathrm{RAPI_{PLS}} = (\mathrm{H_{PLS}} + \mathrm{O_{PLS}} + \mathrm{D_{PLS}}) \times \mathrm{W_{PLS}}$$

The RAPI score for off-premise consumption was calculated by summing the RAPI scores for GLS and PLS venues:

$$\mathrm{RAPI_{off}} = \mathrm{RAPI_{GLS}} + \mathrm{RAPI_{PLS}}$$

Total

Total PCAC was calculated by summing the PCAC from on-premise and off-premise outlets:

$$\mathrm{PCAC_{total}} = \mathrm{PCAC_{on}} + \mathrm{PCAC_{off}}$$

The weight for on-premise outlets was calculated by dividing the total PCAC from on-premise venues by the total PCAC:

$$\mathrm{W_{on}} = \frac{\mathrm{PCAC_{on}}}{\mathrm{PCAC_{total}}}$$

The weight for off-premise outlets was calculated by dividing the total PCAC from on-premise venues by the total PCAC:

$$\mathrm{W_{off}} = \frac{\mathrm{PCAC_{off}}}{\mathrm{PCAC_{total}}}$$

A total RAPI score was calculated by summing the product of the separate RAPI scores for on- and off-premise outlets and their respective weights:

$$\mathrm{RAPI_{total}} = (\mathrm{RAPI_{on}} \times \mathrm{W_{on}}) + (\mathrm{RAPI_{off}} \times \mathrm{W_{off}})$$

Rescaling

$RAPI_{on}$, $RAPI_{off}$, and $RAPI_{total}$ scores were rescaled to a 0 to 100 scale using the *scales::rescale()* command in R.

Reliability

To test the reliability of the RAPI, we calculated the average inter-item correlation between each of the domains and the Cronbach's alpha for the scale. Both values were found to be acceptable: $\alpha = 0.84$, average $r_s = 0.33$, suggesting that the RAPI was internally consistent.

We also calculated the correlation between the RAPI and University of Oxford's stringency index (Hale et al., 2021) as it plausible that both measures of *general* and *alcohol specific* policy changes are related, though distinct. A Spearman's rank correlation revealed a moderate positive relationship between RAPI and the University of Oxford's stringency index, $r_s = .43$, $p < .001$, 95% CI = 0.41 to 0.44.

Appendix B References

Hale, T., Angrist, N., Goldszmidt, R., Kira, B., Petherick, A., Phillips, T., Webster, S., Cameron-Blake, E., Hallas, L., Majumdar, S., & Tatlow, H. (2021). A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker). *Nature Human Behaviour*, *5*(4), 529–538. https://doi.org/10.1038/s41562-021-01079-8

Stockwell, T., Wettlaufer, A., Vallance, K., Chow, C., Giesbrecht, N., April, N., Asbridge, M., Callaghan, R. C., Cukier, S., Davis-MacNevin, P., Dube, M., Hynes, G., Mann, R., Solomon, R., Thomas, G., & Thompson, K. (2019). *Strategies to Reduce Alcohol-Related Harms and Costs in Canada: A Review of Provincial and Territorial Policies*. Canadian Institute for Substance Use Research, University of Victoria.

World Health Organization. (2017). *'Best buys' and other recommended interventions for the prevention and control of noncommunicable diseases*.

Appendix C: Goodness-of-fit Statistics

Table C1. Goodness-of-fit statistics

	Total				Off Premise				On Premise			
	LL	*df*	AIC	BIC	LL	*df*	AIC	BIC	LL	*df*	AIC	BIC
Random Effect Structure												
Model 1A	8419	5	-16828	-16789	8851	5	-17693	-17654	-16910	5	33831	33870
Model 1B	*Convergence issues*											
Model 1C	9129	6	-18245	-18199	9076	6	-18140	-18093	-16838	6	33688	33735
Model 1D	8595	6	-17178	-17131	8899	6	-17786	-17739	-16902	6	33816	33863
Model 1E	9133	7	-18252	-18198	9078	7	-18143	-18088	-16838	7	33690	33744
Time Polynomials												
Model 1F	9202	7	-18390	-18335	9365	7	-18716	-18661	-16633	7	33279	33334
Model 1G	9214	7	-18415	**-18360**	9378	7	-18743	**-18688**	-16546	7	33106	**33160**
Residuals												
Model 1H	*Convergence issues*											
Model 1I	*Convergence issues*											

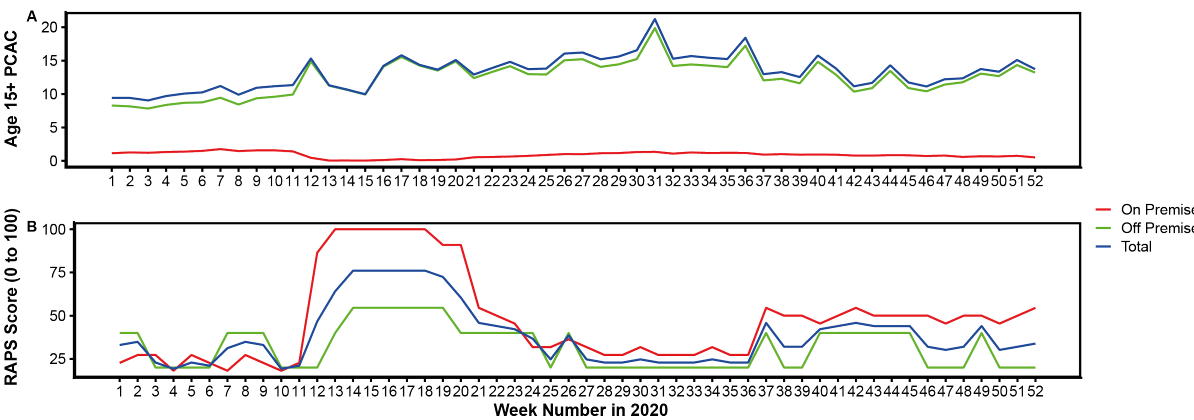
Note: LL = Log Likelihood; AIC = Akaike Information Criteria; BIC = Bayesian Information Criteria. Time (i.e., week number) was included as a continuous fixed effect in all models. Boldface font denotes the model with the lowest BIC value.

Model A = Random intercepts for each LHA and HA.
Model B = Random Intercepts for each LHA, HSDA and HA.
Model C = Model A + random slopes for each LHA.

Model D = Model A + random slopes for each HA.
Model E = Model A + random slopes for each LHA and HA.
Model F = Model C + quadratic time term.
Model G = Model C + cubic time term.
Model H = Model G + AR(1).
Model I = Model G + MA(1)

Appendix D: Descriptive Statistics

Figure D1. Weekly age 15+ per capita alcohol consumption (PCAC) (A) and Restrictiveness of Alcohol Policy Scale (RAPS) scores (B) in 2020.



[1] The BIC is a model selection criterion which penalises the number of parameters included in a model, and therefore model complexity, thus facilitating parsimony and minimising the risk of overfitting (Stoica and Selen, 2004).