Relationships Between Minimum Alcohol Pricing and Crime During the Partial Privatization of a Canadian Government Alcohol Monopoly

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ABSTRACT. Objective: The purpose of this study was to estimate the independent effects of increases in minimum alcohol prices and densities of private liquor stores on crime outcomes in British Columbia, Canada, during a partial privatization of off-premise liquor sales. **Method:** A time-series cross-sectional panel study was conducted using mixed model regression analysis to explore associations between minimum alcohol prices, densities of liquor outlets, and crime outcomes across 89 local health areas of British Columbia between 2002 and 2010. Archival data on minimum alcohol prices, per capita alcohol outlet densities, and ecological demographic characteristics were related to measures of crimes against persons, alcohol-related traffic violations, and non–alcohol-related traffic violations. Analyses were adjusted for temporal and regional autocorrelation. **Results:** A 10% increase in provincial minimum alcohol prices was associated with an 18.81% (95% CI: ±17.99%, $p < .05$) reduction in alcohol-related traffic violations, a 9.17% (95% CI: ±5.95%, $p < .01$) reduction in crimes against persons, and a 9.39% (95% CI: ±3.80%, $p < .001$) reduction in total rates of crime outcomes examined. There was no significant association between minimum alcohol prices and non–alcohol-related traffic violations ($p > .05$). Densities of private liquor stores were not significantly associated with alcohol-involved traffic violations or crimes against persons, though they were with non–alcohol-related traffic violations. **Conclusions:** Reductions in crime events associated with minimum-alcohol-price changes were more substantial and specific to alcohol-related events than the countervailing increases in densities of private liquor stores. The findings lend further support to the application of minimum alcohol prices for public health and safety objectives. (*J. Stud. Alcohol Drugs, 76,* 628–634, 2015)

DURING THE PAST CENTURY, government controls in North America over the sale and distribution of alcohol put in place after the National Prohibition era have been gradually dismantled. At the time of writing, just 18 U.S. states retain some form of control over the sale and distribution of alcohol (Hilton, 2013). In Canada, although all 10 provinces retain a government monopoly on the wholesale distribution of alcohol, only 2 retain a complete monopoly over retail sales for off-premise consumption, 7 permit alcohol sales in both government- and privately owned liquor stores, and 1 (Alberta) has completely privatized retail sales (Giesbrecht et al., 2013; Thomas, 2012). The net effect of this process has usually involved increased numbers of liquor outlets, longer trading hours, and cheaper prices, along with measurable increases in alcohol-related harms (Babor et al., 2010; Holder, 2007).

In some jurisdictions, pricing and taxation measures have been used to offset anticipated increases in adverse public health and safety effects of privatization—and to maintain government revenues. For example, Washington State recently introduced full privatization of alcohol retail sales alongside a substantial increase in alcohol taxes. In neighboring British Columbia (BC), a rapid expansion of private liquor outlets from a low base was permitted between 2002 and 2006. As a result, by 2010 the number of private outlets increased from 543 to 1,045 while government outlets decreased from 212 to 197 (Stockwell et al., 2011). However, with the BC liquor distribution authority fixing wholesale prices only slightly below government liquor store prices (initially 10% lower, rising to 16%) and the imposition of minimum retail prices, private stores typically have sold alcohol at prices between 10% and 15% higher than in government stores—although on any given day, the cheapest alcohol is usually available from private stores (Stockwell et al., 2010).

Evidence has mounted in recent years that alcohol-pricing policies can be highly effective policy tools for reducing

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alcohol-related harms (Babor et al., 2010; Wagenaar et al., 2009a, 2009b). Furthermore, strong theoretical and empirical evidence has emerged to suggest that minimum pricing in particular may be a powerful tool for reducing hazardous consumption (Gruenewald et al., 2006; Holmes et al., 2014; Purshouse et al., 2010) and alcohol-related harm (Stockwell et al., 2013; Zhao et al., 2013). These studies suggest that cheaper products (a) are preferred by hazardous drinkers and (b) display greater price sensitivities than do higher priced alcohol products.

These examples of evolving alcohol policies raise the question as to how effectively price controls can be used to limit possible adverse effects on public health and safety associated with liquor privatization and increased alcohol availability. The present study uses BC as a case study of a jurisdiction where almost simultaneously controls on the physical availability of alcohol have been loosened while government-set minimum prices have been periodically adjusted. Most recently, the government of BC has announced a new approach to liquor policy involving fewer restrictions on the places and times at which alcohol can be sold, along with a comprehensive set of minimum prices to protect both public safety and government revenues (British Columbia Ministry of Justice, 2014). In this study, we analyzed archival data to explore the relative effectiveness of changes to physical availability and minimum alcohol prices as public health policies. In previous studies, there have been indications that minimum alcohol prices may have far stronger effects on rates of alcohol-related hospital admissions (Stockwell et al., 2013) and deaths (Zhao et al., 2013) than do levels of liquor outlet density. In the present study, we explored this question in relation to crime outcomes and compared those identified as, or known to be, alcohol related with those designated as non–alcohol related.

The specific objectives of this study are to investigate the association of alcohol-involved traffic violations, non–alcohol-involved traffic violations, and crimes against persons with alcohol outlet densities and minimum alcohol prices. Here we propose two hypotheses: (a) Changes in the real value of minimum prices will be negatively associated with rates of alcohol-involved traffic violations (but not non–alcohol-involved traffic violations) and crimes against persons. (b) Densities of privately owned and operated outlets that sell alcohol should be positively associated with rates of alcohol-involved traffic violations and crimes against persons.

On September 20, 2010, BC introduced new impaired-driving legislation that simplified enforcement processes and enabled civil penalties to be imposed immediately on offenders. The introduction of this legislation was preceded by much public debate in the media. An evaluation of these new laws found them to be effective in reducing alcohol-related traffic violations (Macdonald et al., 2013). As a consequence, although it only directly affected the last 3 months of the period used in the present study, it was decided to adjust for the possible effects of this new policy in the foregoing analyses.

Method

Study design

A cross-sectional versus time-series design (Beck, 2001; Kervin, 1992) was used to investigate associations of alcohol outlet densities and periodic increases to minimum prices of different beverages with rates of alcohol-related crimes and violations while adjusting for confounding effects of trend, local socioeconomic and demographic characteristics (age and sex, family income, percentage of aboriginal population, and population density), regional differences, and temporal autocorrelation. Yearly data were collated from 89 geographic regions defining local health areas (LHAs) nested within 16 health service delivery areas (HSDAs) for 9 calendar years from January 1, 2002, until December 31, 2010. These are administrative areas defined by the BC Ministry of Health for the delivery of local and regional health services.

Data sources

Crime incidents. Annual counts of crime incidents (charges or arrests) by LHAs were received from BC Stats. The data were aggregated into alcohol-involved traffic violations, non–alcohol-involved traffic violations, and crimes against persons for the years 2002–2010 as outlined in Table 1. Annual crime rates per 100,000 persons age 15 years and older for each LHA were calculated and modeled.

Minimum alcohol prices. Rates of minimum prices for specific beverage types and dates when they were changed were obtained from the BC Liquor Distribution Branch (LDB) (Stockwell et al., 2012). Minimum prices increased from $25.91 to $27.00 per liter of distilled spirits in August 2004, to $28.33 in September 2006, to $29.33 in January 2008, and to $30.66 in April 2009. (All prices are in Canadian dollars. At press time, CAD $1.00 = USD $0.79.) Minimum prices for packaged and draft beers increased from $3.00 and $2.05 per liter, respectively, to $3.47 and $2.18 in May 2006, next rising to $3.54 and $2.22 in January 2008. Minimum prices for liqueurs, coolers, and wines remained unchanged. Annual consumer price index (CPI)–adjusted average minimum prices per standard drink were computed for each of these beverage types based on the proportion of each year that a minimum price level was in effect. These beverage-specific series were then averaged into a single minimum price series across beverage types weighted by overall proportion of sales over the complete study period. The relationship between the rates of crimes and mean minimum alcohol price for all beverages was investigated.

Table 1. Categories of alcohol-attributable crimes or violations in British Columbia, 2002–2010

Alcohol-involved traffic violations	Impaired operations (alcohol) causing death, impaired operation (alcohol) causing bodily harm, impaired operation (alcohol) of motor vehicle, vessel or aircraft, impaired operation, failure to provide breath sample, impaired operation, failure to provide blood sample of alcohol
Non–alcohol-involved traffic violations	Impaired operation (drugs) causing death, impaired operation (drugs) causing bodily harm, impaired operation (drugs) vehicle, vessel, aircraft, impaired operation, failure to provide breath sample of drugs, failure to comply or refusal (drugs), and failure to provide blood sample (drugs), total other Criminal Code traffic violations such dangerous operations causing death and bodily harm, dangerous operation of motor vehicle, vessel or aircraft, dangerous operation evading police causing death and bodily harm, dangerous operation of motor vehicle evading police, failure to stop or remain, driving while prohibited, other Criminal Code traffic violations, causing bodily harm by criminal negligence while street racing, dangerous operation causing bodily harm while street racing, dangerous operation of motor vehicle while street racing
Crimes against persons	Homicide, total other violations causing death, attempted murder, sexual assaults (Level 1–3), weapon or bodily harm, sexual violations against children, sexual interference, invitation to sexual touching, sexual exploitation, luring a child via a computer, assaults (Level 1–3), total other assaults, total firearms (use of, discharge, pointing), total robbery, total forcible confinement or kidnapping, total abduction, extortion, criminal harassment, uttering threats, threatening or harassing phone calls, total other violent violations

Alcohol outlet data. Alcohol outlet data were also obtained from the LDB for restaurants, bars, government liquor stores, and private liquor stores. Grocery stores were not permitted to sell alcohol during this period. Annual population rates (stores/100,000 population age ≥15 years) were calculated for each LHA, and the associations of these rates with crime rates were examined.

Population data. Provincial population data, classified into 89 LHAs, were obtained from BC Stats (2012) to calculate crime rates and alcohol outlet densities per 100,000 adults age 15 years or older per LHA for each year. The percentages of the population age 20–29 years old and males in the population in each LHA per year were also computed based on the estimated population obtained from BC Stats (2012) and were included as covariates in the analyses.

Socioeconomic and demographic data. Several socioeconomic and demographic variables were included in the analyses, being selected for their potential to confound the main relationships of interest (Gruenewald & Ponicki, 1995; Gruenewald et al., 1995; Holder & Parker, 1992; Sloan et al., 1994; Stockwell et al., 2011). Time-invariant census variables available from the 2006 census for each LHA (Statistics Canada, 2006) included percentages of aboriginal people and mean family income. The annual population density was calculated as estimated total population in each LHA for each year divided by land area (km^2). These three covariates were included in the analyses.

Statistical analyses

Annual rates of crime incidents were analyzed to examine trend changes using bivariate regression (Cody & Smith, 1991). Mixed models were used to investigate the association of minimum alcohol prices and densities of four types of alcohol outlets (private liquor stores, government liquor stores, restaurants, and bars) with three types of crime outcomes (alcohol-involved traffic violation, non–alcohol-involved traffic violation, crimes against persons, and total counts of three types of crime) after controlling for potential confounders. Potential sociodemographic and economic confounding characteristics at the LHA level included population density, average household income, and the proportions of the population that were (respectively) ages 20–29 years and male. The models also included controls for temporal autocorrelation and heteroskedasticity. We examined the interaction effects of minimum prices and outlet densities but did not find any significant interaction terms in the models.

Mixed models were used (Laird & Ware, 1982), which provide straightforward but flexible methods for assessing regional and temporal dynamics of longitudinal panels of data. More orthodox autoregressive integrated moving average (ARIMA) models were not appropriate for these data because of (a) the need to adjust for variation in outlet density and other covariates across 89 geographic areas and (b) the availability of only nine time periods. Mixed models permit tests of fixed effects through either maximum likelihood or restricted maximum likelihood estimation. These methods are superior to traditional repeated-measures analysis of variance because they (a) allow simultaneous inference about regional and temporal factors through the use of fixed and random effects and (b) apply to a wide variety of covariance (correlation) structures. This means that more appropriate covariance data structures can be analyzed. Regional as well as temporal autocorrelation effects were included in all models. Log transformations were applied where necessary to correct for significantly skewed distributions and make the variance stationary for dependent variables. The rates of the crimes, minimum alcohol price, and rates of outlet densities were log-transformed. As a result, the coefficients can be interpreted as the percentage change in the rates of crimes resulting from a 1% increase in minimum prices and outlet densities (Chaloupka et al., 2002). The equation for the mixed models was as follows:

$$Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it} + \beta_5 X_{5it} + \beta_6 X_{6it} + \beta_7 X_{7it} + \beta_8 X_{8it} + \beta_9 X_{9it} + \beta_{10} X_{10t} + \beta_{11} X_{11t} + u_i + \tau_t + \varepsilon_{it},$$

where i = 1–89 for each LHA, t = 1–9 for each time period, and k = 1–16 index values for each HSDA; Y_{itk} is the natural log-transformed rate of alcohol-involved traffic violation, for example, at the i^{th} LHA and k^{th} HSDA at the t^{th} year; β_0 is the intercept; β_1 is the percent change in the rate of violations due to a 1% increase in minimum price; X_{1itk} is the log-transformed CPI-adjusted minimum price (Canadian dollars) per standard drink; and coefficients β_2 to β_9 represent the percent change in the rate of alcohol violations resulting from 1% increases in outlet variables (i.e., the density of restaurants, government stores, private stores, and bars) and all other independent variables (percentage of males in the population, percentage of the population that is ages 20–29 years, mean household income, and population density), the values for which are all represented by X_{2itk} to X_{9itk} (all log-transformed measures). In addition, β_{10} is the estimated effect of the 2010 impaired driving law reforms X_{10t} (after vs. before), β_{11} is the estimated effect for the trend X_{11t} (i.e., year), ν_k is the variance component for HSDA, u_i is the variance component for LHA, τ_{it} is the temporal autocorrelation effect, and ε_{itk} is the error term.

All statistical analyses were conducted using SAS 9.3 (SAS Institute; Cary, NC, 2011). All significance tests assumed two-tailed p values or 95% confidence intervals (CIs).

Results

Table 2 presents estimates of associations between the mean minimum price across all beverages, outlet densities, rates of the three types of crime events, and the overall rate of all three crime types combined after adjustment for demographic and economic variables. A 10% increase in average minimum price (dollars per standard drink) for all the beverages was estimated to be significantly associated with a 9.39% reduction (95% CI ±3.80%, $p < .001$) in the rate of all three crime types, an 18.81% reduction (95% CI ±17.99%, $p < .05$) in alcohol-involved traffic violations, and 9.17% reduction (95% CI ±5.95%, $p < .01$) in crimes against persons. Figures 1 and 2 present trends in the rates of mean annual alcohol-involved traffic violations and crimes against persons for all 89 LHAs compared with trends in the mean CPI-adjusted value of minimum alcohol prices over time, indicating mostly decreasing trends in both crime outcomes as average minimum prices increased. A 10% increase in private liquor store density was associated with a 1.91% (95% CI ±1.74%, $p < .05$) increase in non–alcohol-involved traffic violations. When terms were introduced into these models for interactions between the effects of minimum pricing and outlet density, these were not significant and so are not reported here.

The models also confirmed significant associations with some sociodemographic variables and some crime outcomes, as well as the presence of regional effects in both the small (LHA) and larger (HSDA) areas. For example, average fam-

Table 2. Associations of alcohol outlet density and average minimum price for all beverages with the rates of crime in British Columbia, 2002–2010

	Total traffic violations & crimes against the person[a]			Alcohol-involved traffic violation[a]			Non–alcohol-involved traffic violation[a]			Crimes against the person[a]		
Variables	Est.	95% CI	Pr > |t|	Est.	95% CI	Pr > |t|	Est.	95% CI	Pr > |t|	Est.	95% CI	Pr > |t|
Minimum prices	**-0.939**	**±0.380**	**.0001**	**-1.881**	**±1.799**	**.0405**	2.811	±4.296	.1994	**-0.917**	**±0.595**	**.0026**
Restaurants	-0.042	±0.103	.4259	-0.043	±0.058	.1447	-0.016	±0.026	.2405	-0.036	±0.106	.5068
Government liquor stores	-0.014	±0.078	.7157	0.024	±0.091	.6092	0.032	±0.105	.5458	-0.027	±0.074	.4742
Bars	-0.083’	±0.099	.1015	0.001	±0.167	.9944	-0.168	±0.173	.0574	-0.075	±0.096	.1225
Private liquor stores	0.104	±0.125	.1028	0.022	±0.222	.8435	**0.191**	**±0.174**	**.0316**	0.105	±0.127	.1070
Year	**-0.016**	**±0.010**	**.0013**	**0.041**	**±0.025**	**.0018**	-0.007	±0.033	.6899	**-0.026**	**±0.010**	**.0001**
% of 20–29 population	**0.512**	**±0.233**	**.0001**	**0.502**	**±0.244**	**.0001**	**0.561**	**±0.543**	**.0429**	**0.518**	**±0.258**	**.0001**
% of males in the population	0.678	±1.341	.3213	0.418	±1.715	.6323	0.129	±2.991	.9326	0.099	±1.265	.8776
Population density	**-0.096**	**±0.016**	**.0001**	**-0.140**	**±0.023**	**.0001**	-0.044	±0.045	.0602	**-0.093**	**±0.022**	**.0001**
Average family income	-0.353	±0.367	.0592	0.227	±0.467	.3410	-0.089	±0.419	.6763	**-0.580**	**±0.446**	**.0109**
2010 Impaired driving law	**-0.075**	**±0.050**	**.0032**	**-0.118**	**±0.099**	**.0196**	-0.131	±0.145	.0766	**-0.063**	**±0.053**	**.0196**
	Covariance parameter estimates											
Random effect variables	Est.	*SE*	Pr > Z	Est.	*SE*	Pr > Z	Est.	*SE*	Pr > Z	Est.	*SE*	Pr > Z
HSDAs (Level 2)	0.018	0.011	.0521	0.003	0.008	.3479	0.067	0.034	.0277	0.034	0.018	.0295
LHAs (Level 1)	0.039	0.012	.0004	0.061	0.020	.0013	0.055	0.020	.0037	0.052	0.013	.0004
Autoregressive effect at level	0.705	0.054	.0001	0.563	0.045	.0001	0.406	0.044	.0001	0.624	0.057	.0001
Residual	0.046	0.008	.0001	0.156	0.016	.0001	0.229	0.017	.0001	0.044	0.006	.0001

Notes: Est. = estimate; HSDAs = health service delivery areas; LHAs = local health areas. **Bold** indicates estimates significant at $p < .05$ level. [a]Estimates are interpreted as percent changes in annual crime or violation rates as minimum alcohol prices and each of the other covariates increase by 1%. All the estimates in mixed models (alcohol-involved traffic violation, non–alcohol-involved traffic violation, and crimes against the person) were adjusted for variation between HSDAs and LHAs and time series autoregressive effects. Pr > |t| = p value of t test; Pr > Z = p value of F test.

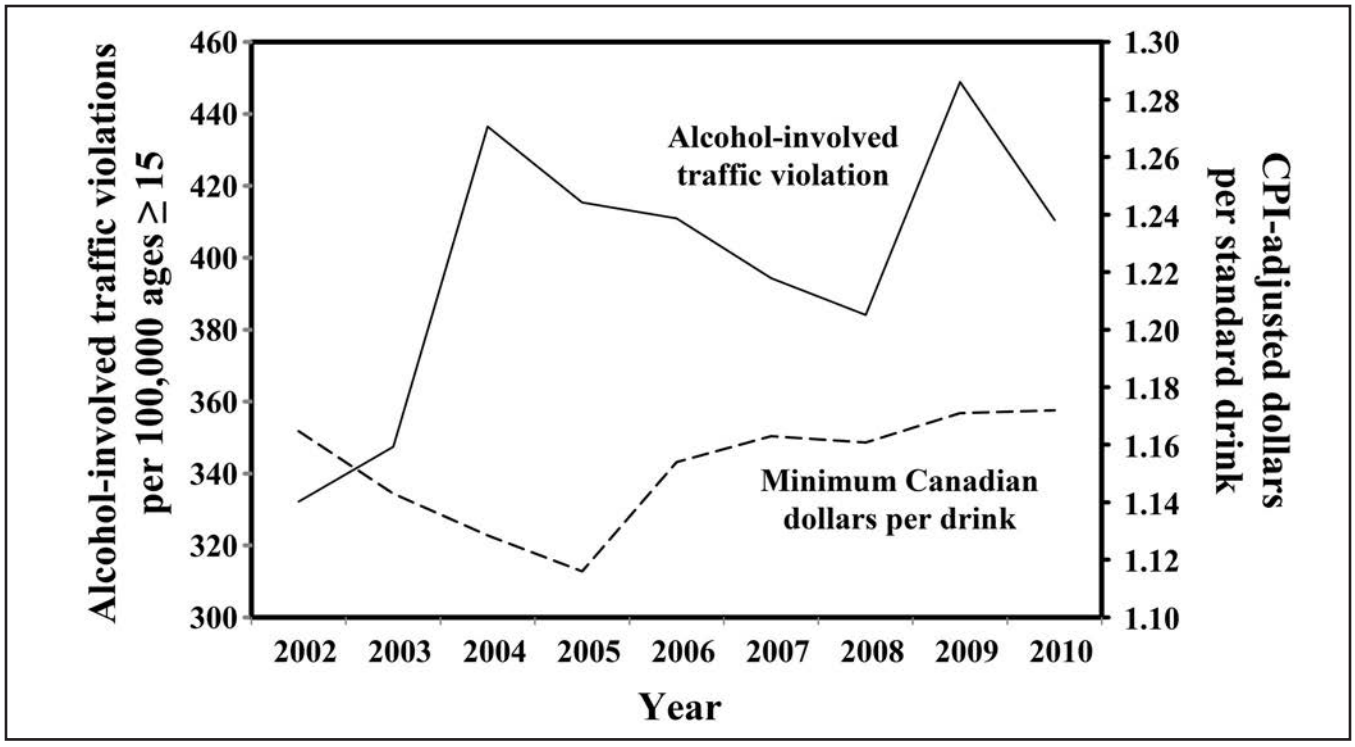

FIGURE 1. Annual alcohol-involved traffic violation rate per 100,000 population ages ≥ 15 and minimum alcohol price (consumer price index–adjusted Canadian dollars per drink) in British Columbia in 2002–2010

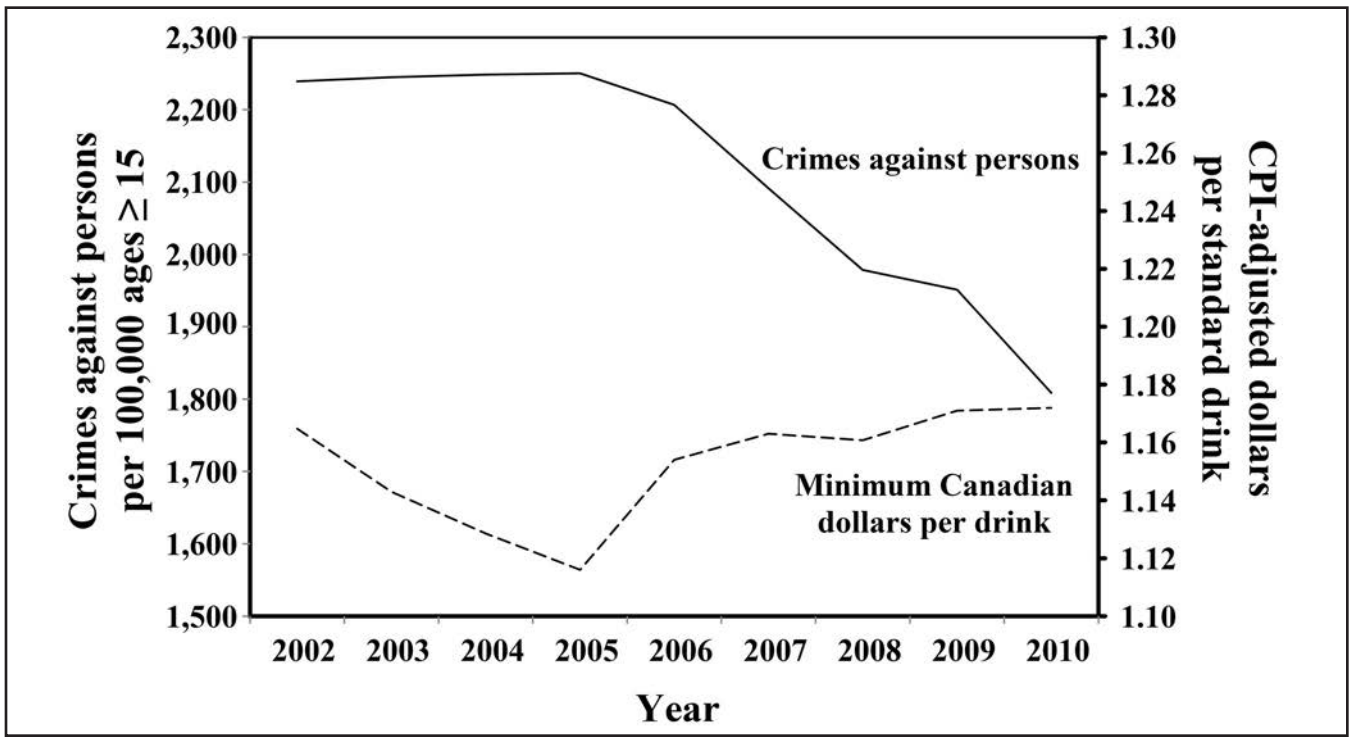

FIGURE 2. Annual rate of crimes against person per 100,000 population ages ≥ 15 and consumer price index–adjusted minimum alcohol price (Canadian dollars per drink) in British Columbia in 2002–2010

ily income was negatively associated with crimes against persons. The percentages of the population ages 20–29 years were positively associated with both rates of traffic violations and crimes against persons. In addition, the models confirmed a significant reduction in alcohol-related traffic violations but not non–alcohol-related traffic violations associated with the introduction of new impaired driving laws in BC at the end of 2010 as reported in more detailed analyses of longer time series (Macdonald et al., 2013).

Discussion

The recent history of alcohol control policies in the United States and Canada has been typified by the dismantling of governmental monopolization and increased privatization. In this study of one Canadian province, no association was observed between increased densities of private liquor outlets (brought about by privatization) and rates of alcohol-related crime events. However, strong associations were observed between the values of minimum alcohol prices and both alcohol-related traffic violations and crimes against persons. This is consistent with earlier findings concerning associations between minimum alcohol prices in BC and rates of acute alcohol-related hospital admission and death (Stockwell et al., 2013; Zhao et al., 2013).

These two policy measures were implemented simultaneously but perhaps with different degrees of impact on health and safety: restrictions on outlet density were being loosened while minimum prices were being periodically increased. The analyses indicated that the impacts of minimum pricing were substantial and significant, whereas the effects of increasing the density of liquor outlets were relatively weak. Although private liquor store density was positively associated with each category of crime examined, this relationship was only statistically significant for non–alcohol-involved traffic violations. We note that in other more powerful analyses with more time periods available, significant positive relationships were observed between the density of private liquor stores and both morbidity and mortality outcomes (Stockwell et al., 2011, 2013; Zhao et al., 2013). The significant effect of minimum price on alcohol-related traffic violations but not on non–alcohol-related citations, along with the larger literature on alcohol pricing, consumption, and harm (Wagenaar et al., 2009a, 2010), is consistent with the interpretation that increases in minimum alcohol prices can cause reductions in alcohol-related traffic violations. The earlier findings that increased minimum prices significantly and immediately reduce acute (injuries and poisonings) but not chronic (dependence and diseases) alcohol-related hospital admissions in the short term is also consistent with this pattern of results (Stockwell et al., 2009).

The economic processes underlying the effects of minimum prices on rates of alcohol-related harm are relatively well understood (Gruenewald et al., 2006; Meier et al., 2010). There is ample evidence that alcohol in general behaves like other commercially available products in the sense that consumption is sensitive to price. For example, meta-analyses indicate that a 10% increase in the average price of alcohol is associated with a significant 4%–5% decrease in consumption (Gallet, 2007; Wagenaar et al., 2009a). Gruenewald et al. (2006) analyzed the Swedish alcohol-monopoly sales data and reported that, in general, the cheapest products were the most price sensitive (i.e., consumption decreased the most for a given increase in price). Adding to this, studies in the United Kingdom (Holmes et al., 2014) and the United States (Kerr & Greenfield, 2007) find that the heaviest consumers tend to select the cheapest alcohol and therefore are likely to be most affected by increases in minimum alcohol prices.

There are a number of possible mechanisms by which an increase in the density of liquor stores may create some adverse consequences for public health and safety (e.g., longer operating hours, changes in days of sales, lax enforcement of laws against selling to minors and intoxicated customers, increased physical availability, discounting resulting from price competition, and stocking of beverages associated with risky use). It is possible that efficiently structured distribution systems may lead to increased external costs to both individuals (including nondrinkers) in particular and the broader society in general.

We note several limitations with this study. The units of analysis varied greatly in geographic size and population, raising questions about the comparability of population distributions. We had a limited number of periods across which to observe relationships (nine), albeit examined across 89 separate local areas in our models, and there were wide 95% CIs around our estimates of effect sizes. Further, we report only associations between variables—not evidence of causation—and other simultaneous events not included in this study may better explain the relationships found. Our measures of crime rates also captured a diverse range of charges and arrests grouped into two broad categories: traffic violations and violent incidents. It is possible that these reflect changes in levels and priorities in police enforcement practices in addition to changes in underlying crime rates. The use of non–alcohol-related traffic violations, however, does provide a degree of control for this possibility.

In conclusion, the present findings add to the growing literature indicating that public health and safety benefits can flow from policies that seek to limit cheap alcohol by setting minimum prices. In earlier research (Stockwell et al., 2013; Zhao et al., 2013), we reported substantially greater public health and safety impacts of minimum alcohol pricing than of changes to liquor outlet density caused by privatization. Because government-controlled alcohol distribution systems provide a means of regulating both alcohol prices and the density of liquor outlets, these findings still support the idea that government alcohol monopolies can have beneficial im-

pacts on public health and safety if they apply such policies effectively. As a final note, the BC government announced a series of radical reforms in 2014 to permit the sale and consumption of alcohol at more times and places along with restrictions on liquor store density (no new stores within 1 km of an existing store) and a new set of minimum alcohol prices for liquor stores and bars (BC Ministry of Justice, 2014). Future studies will be required to confirm predicted public health and safety benefits from these measures.

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