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The impact on alcohol-related collisions of the partial decriminalization of impaired driving in British Columbia, Canada☆

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ABSTRACT

Introduction: The purpose of this paper is to assess the impact of administrative sanctions introduced as part of a new law for drinking drivers in British Columbia, Canada. The new law, known as immediate roadside prohibitions (IRP), aimed to increase the efficiency of police and courts for processing drinking drivers, thereby increasing the certainty of their being apprehended and punished. However, in order to maintain these efficiencies, sanctions under this new law largely replaced laws under the Criminal Code of Canada for Driving While Impaired (DWI) by alcohol, which had more severe penalties but lower certainty of punishment. We examined whether the intervention was related to abrupt significant declines in three types of alcohol-related collisions (i.e. fatalities, injuries or property damage only) compared to the same type of collisions without alcohol involvement.

Methods: An interrupted time series design, with a non-equivalent control was used, testing for an intervention effect. Monthly rates of the three types of collisions with and without alcohol involvement were calculated for the 15-year period before and the 1-year period after implementation of the new law. ARIMA time series analysis was conducted controlling for trend effects, seasonality, autocorrelation, and collisions without alcohol.

Results: Significant average declines ($p < 0.05$) in alcohol-related collisions were found as follows: 40.4% for fatal collisions, 23.4% for injury collisions and 19.5% for property damage only collisions. No significant effects were found for any of the three comparable non-alcohol-related types of collisions.

Conclusions: These results suggest that provincial law of administrative sanctions for drinking drivers and associated publicity was more effective for minimizing alcohol-related collisions than laws under the Canadian Criminal Code.

1. Introduction

Experimental research has confirmed the deleterious effects of alcohol on sensory, cognitive and motor functions needed for driving (Liu and Ho, 2010). Similarly, epidemiological studies clearly show that risk of a collision increases exponentially as Blood Alcohol Concentration (BAC) increases (Blomberg et al., 2009). In Canada, estimates from 2008 indicate that close to 600 fatally injured drivers had been drinking (Canadian Centre on Substance Abuse, 2011). Injuries and deaths associated with alcohol impaired driving have led many countries to adopt various penalties for driving with a BAC greater than a set per se level (Mann et al., 2001). These interventions are guided by the deterrence model, where perceived certainty, severity and swiftness of punishment for drinking and driving are thought to contribute to reductions in this behaviour (Mann et al., 2001; Vingilis et al., 1988). Several studies have found a decrease in alcohol-related collisions associated with lower per se limits (Wagenaar et al., 2007; Mann et al., 2001). Recent research found a significant intervention effect on total fatalities when 90 day administrative licence suspensions were implemented at the 80 mg/100 ml level in Ontario (Asbridge et al., 2009). Research suggests that increasing perceived certainty of being caught has a greater impact on changing behaviour than

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increasing the severity of the punishment. Little research has been conducted on the swiftness of punishment although it has been speculated to be important (Nagin and Pogarsky, 2001; Jiang, 1994). Additionally, publicity of the laws is a necessary condition for effectiveness (Vingilis et al., 1988).

Under the Criminal Code of Canada, it is a criminal offence to Drive While Impaired (DWI) by alcohol with a BAC >80 mg/100 ml, or to refuse a breath test. However, enforcement of these laws is time consuming and expensive for both the police and courts. Collecting evidence by police requires sophisticated non-portable evidential breath testing equipment in the police station and considerable paperwork. Research has showed that a single charge for impaired driving by alcohol under Criminal Code took police an average of 2 h 48 min to process and 4 h of police time in court, if the case goes to trial (Jonah et al., 1999). Although, the per se limit for the Canadian law is 80 mg/100 ml, research shows that driving at lower BAC's at 50 mg/100 ml is associated with increased collision risk (Blomberg et al., 2009). In response to this, nearly all Canadian provinces and territories have enacted administrative sanctions for drivers with BAC levels between 40 and 80 mg/100 ml (Chamberlain and Solomon, 2002).

British Columbia (BC) introduced new immediate roadside prohibition (IRP) sanctions for drinking drivers on September 20, 2010 in order to address some limitations of the Canadian law. The new sanctions were designed to maximize the deterrent effect by increasing the certainty, severity and swiftness of sanctions. Certainty of detection was increased by reducing the administrative time to charge offenders. Since less police and court resources for charging and convicting individuals were required under the new provincial law, police were able to spend a much greater proportion of their work directed towards drinking and driving detection and enforcement. The provincial legislation required much less paperwork and used evidence gathered at the roadside from a portable handheld breathalyzer device. Compared to the old provincial laws, the new BC legislation also increased the severity of punishment for drivers with BAC levels between 50 and 80 mg/100 mL, and emphasized swiftness of sanctions. For drivers with BAC levels between 50 and 80 mg/100 ml, the new penalties included an immediate 3 days driver's licence suspension (up from a 24 h suspension) and possible vehicle impoundment. For drivers with BACs over 80 mg/100 ml, the new penalties included an immediate 90 day license suspension (rather than a 21 day wait period) and a mandatory 30 day vehicle impoundment. A mandatory responsible driver programme and an ignition interlock device in their vehicle were required for those drivers who wished to re-instate their driver's licence (Ministry of Justice, 2012). Finally, the implementation of these sanctions was immediate, thus maximizing swiftness. However, in order to achieve these aforementioned efficiencies, drinking and driving offenders needed to be charged under provincial legislation rather than the Criminal Code of Canada. Thus, provincial offenders would not receive a criminal record that could have long-term negative consequences, such as travel restrictions outside the country or reduced educational and employment opportunities.

In order for a new intervention to be effective, citizens must be aware of it. Both public awareness campaigns and media attention helped to maximize awareness. Criticism that the new legislation was too strict and failed to allow those accused a fair appeal attracted considerable media attention. Potential unfairness was highlighted in media reports indicated that as many as 100 handheld breathalyzers were calibrated incorrectly and were unreliable at certain temperatures (Theodore, 2011). On November 30, 2011, the BC Supreme Court ruled that part of the IRP legislation infringed on the Federal Charter of Rights and Freedoms because those charged could not meaningfully challenge result for BACs above 80 mg/ml (i.e. 90 day fail). The new law that applied to those with BAC above 80 mg/ml were suspended until June 15th, 2012, when amended laws were introduced. The law for 50 mg/ml remained in effect throughout the entire post-intervention period. In addition to the media attention, the government initiated a number of public awareness activities and events reminding drivers of the new legislation and extra police enforcement.

The BC Government noted a 40% drop in alcohol-related road fatalities in the year following the new laws compared to the previous 5 year average (Ministry of Justice, 2011). In this study, we conducted a more sophisticated evaluation using 15 years of pre-intervention data with 2 years of post-intervention data, taking into account trends, seasonality, autocorrelation and moving average effects. We also controlled for trends in non-alcohol-related collisions in order to account for potential confounding effects of other factors that may affect all collisions, such as improved road conditions or other road safety initiatives. Finally, we conducted a newspaper media analysis to assess whether the issue of drinking and driving received increased coverage after the new legislation.

2. Hypotheses

The aim of this study is to examine the impact of the new laws on three types of alcohol-related collisions: fatal collisions, injury collisions, and property damage only collisions. Since the intervention was aimed specifically at alcohol-related collisions, we hypothesized that a successful intervention would be associated with a significant decline in alcohol-related collisions and no change in those without alcohol. Specific hypotheses were as follows: (1) significant declines in three types of alcohol-related collisions would be found in relation to the intervention, and (2) no significant declines would be found in relation to the interventions for three types of collisions without alcohol.

3. Methods

The study is an interrupted time series design with a non-equivalent control group. Data included monthly counts of police reported: (a) *fatal collisions*, (b) *injury collisions*, and (c) *property damage only collisions.* Collisions were deemed to be alcohol-related if police cited "alcohol involvement", "alcohol suspected", or "ability impaired by alcohol" as a contributory factor for any driver (including cyclists) or pedestrian involved in the crash. Fatalities were registered when a victim dies within 30 days of a collision. Injuries refer to collisions resulting in any level of injury but not death. Property damage only collisions are those where police were in attendance and completed a report of the incident. Police are legally obligated to attend all fatal collisions so the count of fatal collisions was comprehensive. The counts of injury and property damage only collisions were not comprehensive, as police were not required to attend all of these. In 2006, approximately 41% of injury collisions and 24% of property damage collisions, compared to insurance data, were reported by police and included in this data. By 2010, about 34% of injury collisions and 19% of property damage were included in the police database. Since our analytic approach was to assess a differential effect for alcohol and non-alcohol-related collisions, we do not see this lack of comprehensive data as a major limitation. Counts of each type of collision with and without alcohol were aggregated by month and divided by the number of monthly licensed drivers estimated using cubic spline interpolation (DeBoor, 1981; Mcneil et al., 1977) multiplied by 1,000,000 to produce rates. Monthly collision rates were adjusted to account for number of days in the month. Data were collected for 177 months before and 24 months after the intervention, ending September, 2012. The time period before the intervention was

decided a priori in order to exceed the recommended minimum number of observations (50 observations) required for an ARIMA model (Box and Jenkins, 1976). Ethics approval was obtained from the University of Victoria (#12-029).

Data were analyzed with ARIMA models that controlled for trends, seasonality, autocorrelation and/or moving average effect patterns (McDowall et al., 1976). Time series models for each type of alcohol-related collision were developed to examine effects of the intervention for the 2-year period after it was introduced. October 1, 2010 was treated as the intervention date as this was the first full month after the legislation was in effect. Some initial transformations were conducted in order to meet the assumptions of ARIMA. First the logarithm of collision rates was used to make variance stationary. Second, the difference of the collision series from one period to the next was calculated to remove the trend over time. Finally, a seasonal ARIMA model for the log-transformed rates was identified, with differencing required at lags 1 and 12 to eliminate the seasonal and trend effects (i.e. the current period-to-period collisions and the change 12 periods ago). Fatal, injury and property damage only collisions without alcohol involvement were used as control variables to account for other general conditions that could potentially confound the results. We then added the intervention indicator and transfer function to assess whether significant changes in alcohol-related collisions occurred 2 years after the intervention (Box and Jenkins, 1976; SAS Institute, 2011). The model was fitted by the conditional least squares method and the effect was tested as abrupt and permanent. We also conducted similar analyses to assess whether the intervention was associated with a significant change for the three types of non-alcohol-related collisions. A conservative two tailed test was used at the 5% level of significance.

In order to assess whether other interventions may have influenced alcohol-related collisions, we reviewed other traffic safety initiatives that were implemented during the 17-year period of the study. We also examined the intensity the BC government's advertising of the legislation. Additionally, to examine media attention of drinking and driving before and after the intervention a search was conducted on May 7th, 2013 of newspaper articles that included the search terms: "drinking and driving" or "drunk driver" or "drunk driving" or "alcohol-related crash" from the Canadian Newsstand Pacific data base, which includes major papers as well as smaller dailies and weeklies in the BC area. The search was restricted to September 21st–September 20th for the year periods prior to and the two years following the IRP law. Finally, the numbers of charges under the old laws, both provincial and Criminal Code, and under the new laws were documented for the same 1 year periods before and after the new law. Finally, we also documented changes in the number of various police charges related to drinking and driving for these periods.

4. Results

During the whole study period, there were 76,205 police reported alcohol-related collisions, accounting for approximately 10% of total police investigated collisions. These included 1636 alcohol-related fatal collisions (about 8 per month), 32,710 alcohol-related injury collisions (about 167 per month) and 41,859 alcohol-related property damage only collisions (about 212 per month). Figs. 1–3 illustrate monthly rates of alcohol-related fatal, injury and property damage only collisions per 1,000,000 licensed drivers. The seasonal pattern peaked in the summer months (July–September) and declined in the winter months (January–March). These seasonal patterns were observed for both alcohol and non-alcohol related collisions. Alcohol-related fatal collision rates and property damage only collision rates appear to have

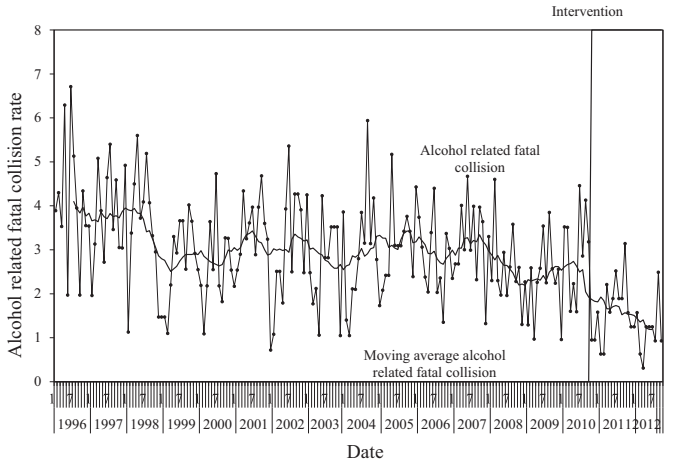

Fig. 1. Monthly alcohol-related fatal collision rate per 1,000,000 licensed drivers in BC, 1996–2012.

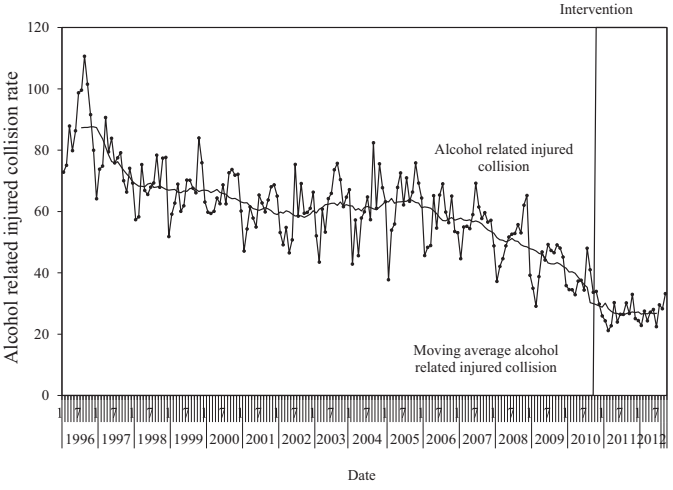

Fig. 2. Monthly alcohol-related injured collision rate per 1,000,000 licensed drivers in BC, 1996–2012.

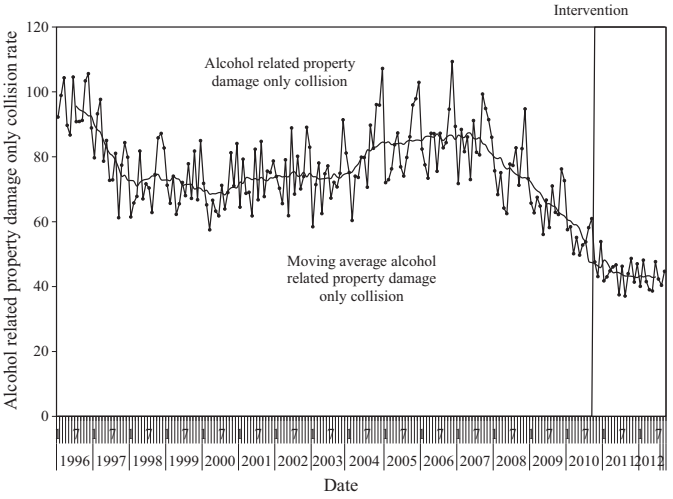

Fig. 3. Monthly alcohol-related property damage only collision rate per 1,000,000 licensed drivers in BC, 1996–2012.

Table 1
Intervention effects for alcohol-related fatal, injury and property damage only collisions controlling for comparable non-alcohol-related collisions, trend and seasonality (by differencing), moving average and autocorrelation (British Columbia, 1996–2012).

Parameter	Estimate	Standard error	Probability value
Model I: alcohol-related fatal collisions			
Moving average at lag 1	0.835	0.041	<0.0001
Autocorrelation at lag 8	−0.140	0.071	=0.0486
Autocorrelation at lag 12	−0.477	0.071	<0.0001
Intervention effect	−0.518	0.254	=0.0428
Non-alcohol-related fatal collision	−0.030	0.119	=0.8011
Effect size (R^2)	52.6%		
Model II: alcohol involved injury collisions			
Moving average at lag 1	0.810	0.046	<0.0001
Autocorrelation at lag 12	−0.439	0.070	<0.0001
Intervention effect	−0.267	0.069	=0.0001
Non-alcohol-related injury collision	0.249	0.113	<0.0293
Effect size (R^2)	50.7%		
Model III: alcohol-related property damage only collisions			
Moving average at lag 1	0.795	0.052	<0.0001
Autocorrelation at lag 1	−0.181	0.074	=0.0155
Autocorrelation at lag 12	−0.453	0.068	<0.0001
Intervention effect	−0.217	0.071	<0.0001
Non-alcohol-related property damage only collision	0.145	0.071	=0.0438
Effect size (R^2)	60.3%		

begun declining in 2007, while injured collision rates began moving downwards in 2005.

Based on the antilog of the parameters, the intervention was associated with a 40.4% (95% CI: 2.0–63.8%) mean reduction in alcohol-related fatal collisions, a 23.4% (95% CI: 12.4–33.1%) reduction in alcohol-related injury collisions and 19.5% (95% CI: 10.5–27.6%) reduction of alcohol-related property damage only collisions. These percentages translate into an annual reduction of approximately 44 (95% CI: 2–69) alcohol-related fatal collisions, 487 (95% CI: 257–687) alcohol-related injury collisions and 508 (95% CI: 274–718) alcohol-related property damage only collisions. In the foregoing analysis, non-alcohol-related collisions were treated as a covariate (see Table 1). Additional analyses were conducted to assess whether the intervention was related to changes in these three types of collisions without alcohol. In each analysis, the intervention effect was not significant (fatal, $p = 0.18$; injury, $p = 0.96$; property damage, $p = 0.20$) indicating the intervention effect was only specific to alcohol-related collisions.

In the 17 year study period, there were 22 legislative traffic safety initiatives enacted and eight could potentially have had some bearing on drinking drivers. However, all alcohol-related interventions were initiated before September, 2010 and therefore are not potential confounders requiring statistical control for an intervention effect. Some interventions before 2010 were aimed at reducing alcohol-related collisions. For example, in 2005 a remedial programme (i.e. educational course) and ignition interlock devices were implemented for drinking and driving offences. In 2006, forfeiture of vehicle became a possible consequence for convicted drunk drivers.

The intensity of provincial advertising of the new law and associated publicity was assessed. In addition, a number of public awareness activities, involving a number of road safety partners, occurred between July 2010 and December 2010 especially. The components included: a redeveloped website on impaired driving and the new laws; television and radio advertisements that encourage people to drink responsibly and to remind drivers of extra police enforcement; holiday-themed washroom ads, the use of posters and coasters with messages on them in bars and restaurants.

The introduction of the IRP programme was accompanied by a great deal of media attention which elevated the awareness of the new law. Newspaper reports on drinking and driving in BC increased from 978 in 2009–2010 to 1307 in 2010–2011, a 34% increase. In 2011–2012 the number of media reports decreased to 1053.

Table 2 shows the changes that occurred in charges and sanctions for the 1 year period before the new law and two 1 year periods afterwards. The number of Criminal Code charges in BC dropped substantially from 9079 in the year preceding the new laws to only 2890 in the following year, a 68.2% decline. Charges for administrative driving prohibitions under the old provincial law declined from 33,288 to 3719 for the year periods before and after the new law. As expected, immediate roadside prohibitions increased dramatically from 630 (all given out in the last days of September) in the year before to 22,725 charges after the new law. Interestingly, the total number of all drinking and driving charges decreased over the three time periods from 33,918 to 26,435, a 22.1% decline and a further decline to 21,571 charges in the second year after the IRP law.

5. Discussion

The decline in each type of alcohol-related collision is consistent with our hypothesis that a real change in drinking driver behaviour occurred. In this study, we used time-series analysis to assess whether significant changes in alcohol-related collisions occurred after the new legislation was implemented. We found significant reductions in all types of alcohol-related collisions, consistent with a positive effect of the intervention. In order to account for roads becoming safer with new traffic safety measures, we used non-alcohol-related collisions in each of three categories as control variables. We reasoned that a successful intervention should have a specific impact on alcohol-related collisions with little effect on collisions without alcohol. Since we include collisions without alcohol as a covariate to assess the intervention effect of the alcohol-related collisions and since separate analyses showed no intervention effect for non-alcohol collisions, we are confident that the reductions in alcohol-related collisions are due to the intervention (including publicity) and not some other phenomena. Using non-alcohol-related collisions as a control variable greatly reduces the likelihood that other generalized factors (i.e. traffic safety initiatives, economic conditions and vehicle safety) may have caused the reduction in alcohol-related collisions. We also controlled for autocorrelation effects, since rates in one month are more related to each other than those which are more distal. Finally we reviewed other safety initiatives that may have reduced only alcohol-related collision rates and none were found at the same time as the intervention.

Table 2
Number of charges and sanctions in the year prior and after the intervention.

Prohibitions	October 1, 2009–September 30, 2010	October 1, 2010–September 30, 2011	October 1, 2011–September 30, 2012
Alcohol criminal code driving charges in B.C. (Canada law)	**9079**	**2890**	**4215**[b]
Alcohol related driving prohibitions			
24 h alcohol (BC)	33,288[c]	3719[c]	8021[c]
Administrative driving prohibition "fail" (BC)	9903	1576	4115[b]
Administrative driving prohibition "refuse"	2021	437	812
Immediate roadside prohibitions (IRP)			
3, 7 or 30 day (BC)	262[a]	7699	6036
90 day "fail" (BC)	337[a]	13,561	6401[b]
90 day "refuse" (BC)	31[a]	1465	1113
Sub-total All Immediate roadside prohibitions (BC)	**630**	**22,725**	**13,550**
Grand total all drivers charged/prohibited	**33,918**	**26,444**	**21,571**

Data sources: CCC data obtained from the Criminal Justice Branch on April 8, 2013.
24 h prohibition data was provided by ICBC on March 31, 2013.
ADP and IRP data extracted from the ADP/VI database on April 16, 2013.

[a] Since the immediate roadside prohibitions law was enacted in September 20, 2010, all these prohibitions were issued between September 20th and September 30th, 2010.

[b] From November 30th 2011 to June 15th 2012, the 90 day "fail" IRPs were temporarily suspended from operation. Police reverted to issuing the previous sanctions and the Criminal Code process for drivers who provided a breath sample that contained a BAC of 0.08 and above.

[c] *Note:* All drivers with a criminal code charge or an administrative driving prohibition also received a 24 h suspension.

Convicting drivers of impaired driving under the Criminal Code of Canada is a difficult and lengthy process and many apprehended impaired drivers avoid Criminal Code sanctions altogether. In comparison, BC's new legislation is enforced immediately and with fewer avenues for appeal. Although the severity of punishment for drivers with BAC between 50 and 80 mg/100 ml increased from the old to new provincial law, overall severity likely did not increase for those with BAC >80 mg/100 ml who were not charged under the provisions of the Criminal Code of Canada, as they would not receive a criminal offence with potential long term consequences. However, 2890 drivers were charged under the Criminal Code after the new provincial legislation was implemented (down from 9079 in the year prior to the intervention), and these people will have experienced greater severity of sanctions. It is likely that the Criminal Code option was chosen by police in situations with greater harms of the offence, such as those with personal injury or with very high BACs or for repeat offenders. As well, police officers cannot issue an IRP for alcohol-related collisions they did not witness, and in these situations a Criminal Code charge is likely. This study suggests a beneficial reduction in alcohol-related collisions due to the new legislation but decisive conclusions regarding the relative importance of the three components of deterrence cannot be drawn, nor can we distinguish between the impact of the intervention itself and associated publicity.

The provincial legislation and its enactment raise some fundamental questions regarding the potentially conflicting roles of provincial and federal legislation to address drinking and driving. Laws within the Criminal Code of Canada apply to all Canadians and are designed to set limits of acceptable conduct in the interest of maintaining a safe and peaceful society. These laws are intended to achieve four multifaceted objectives: deterrence, rehabilitation, retribution and confinement (for individuals seen as a major threat to society). Enshrined within these laws are the rights of due process and the presumption of innocence unless proved guilty beyond a reasonable doubt. By contrast, provincial legislation such as traffic safety laws, applies only to people within each province or territory. Traffic safety laws are guided by the principles of deterrence towards maximizing public safety. Results of this study show that the goals of improved road safety by the provincial government were achieved. Furthermore, since Criminal Code convictions declined dramatically with the new sanctions, the study indicates that effective legislation for drinking and driving does not require all offenders to receive a Federal criminal offence. In effect, the 68.2% reduction in Criminal Code charges for drinking amounts to a partial "decriminalization" of impaired driving in BC. This decriminalization was associated with savings in police time and significant reductions in alcohol-related road deaths, collisions and nonfatal injuries.

Some limitations of the data should be noted. Our data only included collisions where a police officer was present and a substantial proportion of collisions, especially minor ones, are not reported to the police. It is reasonable to speculate that collisions involving alcohol may be less likely to be reported to police, especially for those that are less severe or involve a single vehicle, because inebriated drivers would be more likely to evade detection. Although there may be differential bias in the measures, such bias is likely consistent over the entire time period, and therefore likely did not meaningfully effect our conclusions. As well, this limitation would not apply to fatal collisions since police are mandated to investigate all fatal collisions. In addition, our counts of alcohol-related collisions included collisions where a pedal cyclist or pedestrian had been drinking. These cases are not likely to be impacted by the new IRPs and including them may have underestimated the effect of the new laws. A final limitation of this study is that we focused on the short-term changes (i.e. 2 years) in alcohol-related collisions related to the intervention. Some studies have suggested that these short-term changes may not be sustained in the longer run (Vingilis et al., 1988; Ross, 1973). Therefore, further research is required to assess longer-term effects.

References

Asbridge, M., Man, R.E., Smart, R.G., Stoduto, G., Beirness, D., Lamble, R., Vingilis, E., 2009. The effects of Ontario's administrative driver's licence suspension law on total driver fatalities: a multiple time series analysis. Drugs – Education Prevention and Policy 16 (2), 140–151.

Blomberg, R.D., Peck, R.C., Moskowitz, H., Burns, M., Fiorentino, D., 2009. The Long Beach/Fort Lauderdale relative risk study. Journal of Safety Research 40 (4), 285–292.

Box, G.E.P., Jenkins, G.M., 1976. Time Series Analysis: Forecasting and Control. Holden-Day, San Francisco.

Canadian Centre on Substance Abuse, 2011. Drug Use by Fatally Injured Drivers in Canada (2000–2008). Canadian Centre on Substance Abuse, Ottawa.

Chamberlain, E., Solomon, R., 2002. The case for a 0.05% criminal law blood alcohol concentration limit for driving. Injury Prevention 8, 1–17.

DeBoor, C., 1981. A Practical Guide to Splines. Springer-Verlag, New York.

Jiang, Y., 1994. Punishment celerity and severity: testing a specific deterrence model on drunk driving recidivism. Journal of Criminal Justice 22 (4), 11.

Jonah, B., Yuen, L., Au-Yeung, E., Paterson, D., Dawson, N., Thiessen, R., Arora, H., 1999. Front-line police officers' practices, perceptions and attitudes about the

enforcement of impaired driving laws in Canada. Accident Analysis and Prevention 31 (5), 421–443.
Liu, Y.C., Ho, C.H., 2010. Effects of different blood alcohol concentrations and post-alcohol impairment on driving behavior and task performance. Traffic Injury Prevention 11 (4), 334–341.
Mann, R.E., MacDonald, S., Stoduto, G., Bondy, B., Jonah, B., Shaikh, A., 2001. The effects of introducing or lowering legal per se blood alcohol limits for driving: an international review. Accident Analysis and Prevention 33 (5), 569–583.
McDowall, D., McCleary, R., Meidinger, E.E., Hay Jr., R.A., 1976. Interrupted Time Series Analysis. Sage Publications, Beverly Hills/London.
Mcneil, D.R., Trussell, T.J., Turner, J.C., 1977. Spline interpolation of demographic data. Demography 14 (2), 245–252.
Ministry of Justice, 2011. Alcohol-related motor vehicle fatalities. Ministry of Justice, Victoria, Available from http://www.pssg.gov.bc.ca/osmv/shareddocs/update-alcohol-related-fatalities-oct2010-apr2011.pdf (accessible 14.02.13).
Ministry of Justice, 2012. Driver Behaviour and Road Safety Information Sheet: Interim Approach to Impaired Driving in B.C. Ministry of Justice, Victoria, Available from http://www.pssg.gov.bc.ca/osmv/shareddocs/infosheet-interim-approach-impaired-driving.pdf (accessible 14.02.13).
Nagin, D.S., Pogarsky, G., 2001. Integrating celerity, impulsivity, and extra-legal sanction threats into a model of general deterrence: theory and evidence. Criminology 39 (4), 865–891.
Ross, H.L., 1973. Law, science, and accidents – British-Road-Safety-Act-of-1967. Journal of Legal Studies 2 (1), 1–78.
SAS Institute, 2011. SAS/STAT 9. 3 User's Guide. SAS Institute Inc., Cary, NC.
Theodore, T., 2011. Documents Cast on Accuracy of Breathalzer. The Canadian Press, December 26, 2011.
Vingilis, E., Blefgen, H., Lei, H., Sykora, K., Mann, R., 1988. An evaluation of the deterrent impact of Ontario 12-hour license suspension law. Accident Analysis and Prevention 20 (1), 9–17.
Wagenaar, A.C., Maldonado-Molina, M.M., Ma, L., Tobler, A.L., Komro, K.A., 2007. Effects of legal BAC limits on fatal crash involvement: analyses of 28 states from 1976 through 2002. Journal of Safety Research 38 (5), 493–499.