Motor vehicle crashes (MVCs) are a major public health problem that disproportionately affects youths and young adults. Worldwide, more than 3300 people per day are killed in road trauma, and many more are disabled. Crashes are caused by numerous factors, including faulty vehicles and poor road design, but the majority are attributed to driver-related factors, especially alcohol-impaired driving, speeding, and driver distraction. In Canada, driving with a blood alcohol concentration (BAC) of 0.08% or more is a federal criminal offense. Most provinces have regulations that allow for administrative sanctions (fines or license suspension) for drivers with a BAC of 0.05% or more. Speed limits are set by the provinces and enforced through administrative sanctions.

Before September 2010, drunk drivers in British Columbia were subject to fines and administrative driving prohibitions of 24 hours for a BAC of 0.05% or more and of 90 days for a BAC of 0.08% or more or failure to provide a breath sample. The 90-day driving ban came into effect after a 21-day period that allowed the driver to find alternative means of transportation or to appeal the decision. There were no vehicle impoundments for drunk drivers. In addition to administrative penalties, drivers with a BAC of 0.08% or more and those who refused to provide a breath sample were subject to possible penalties under the Criminal Code of Canada. Before September 2010, the penalty for street racing was vehicle impoundment for 2 days for a 1st offense and for 30 days for 2nd and subsequent offenses in addition to fines and possible criminal code charges.

In September 2010, British Columbia introduced harsher penalties for drunk drivers and for excessive speeding (>40 km/h over the speed limit) as well as for drivers caught street racing or stunt driving. Under these laws, which add to but do not replace the older laws, drivers with a BAC of 0.05% or more may be subject to license suspension of 3, 7, or 30 days; vehicle impoundment of 3, 7, or 30 days (discretionary with 3- or 7-day license suspensions, mandatory for 30-day license suspensions); and possible referral to remedial programs (including ignition interlock) for third-time offenders. Drivers with a BAC of 0.08% or more are subject to 30-day vehicle impoundment, 90-day license suspension, and possible referral to remedial programs (including ignition interlock). In addition, drunk drivers are subject to fees that include towing costs, vehicle storage costs, and a processing fee to have their license reinstated. License prohibitions and vehicle impoundments are issued immediately at the roadside on the basis of results of a handheld breathalyzer. The penalties for excessive speeding, street racing, and stunt driving include fees and mandatory vehicle impoundment of 7 to 60 days.

Table 1 summarizes penalties for drinking and driving and for speeding and related offenses under the old versus new traffic laws.

British Columbia’s laws were designed to deter drinking and driving by increasing the severity, certainty, and speed of punishment for drunk drivers with a BAC of 0.05% or more. Deterrence is effective in laws against traffic violations, but increased likelihood of punishment acts as a greater deterrent than increased severity. The speed with which a punishment is applied is an additional deterrent. For drivers with a BAC of 0.08% or more, the administrative sanctions under the new laws are actually less severe than those associated with a criminal code conviction for drunk driving. However, the new sanctions are applied immediately at roadside and are less subject to legal challenge, making punishment more swift and certain. Not all drunk drivers are deterred by threat of punishment, but through vehicle impoundment and license suspension, British Columbia’s new laws remove more dangerous drivers from the roads.
quicker. High-risk drunk drivers can also be mandated to undergo therapy, install an alcohol interlock device on their vehicle, or both. These laws were promoted through public awareness and educational campaigns and received considerable media coverage. Opinion and roadside surveys in 2012 found that majority of drivers were aware of the new measures and that public perception of police commitment to traffic enforcement had increased. During the first 12 months, British Columbia police used the new laws to issue 22,734 roadside license prohibitions for drinking and driving. At the same time, the number of criminal code convictions for impaired driving fell from 8,221 per year in the 5 years preceding the new laws to 1853 in the subsequent 12 months (Figure 1). The new laws were associated with change in driver behavior. In the 2012 British Columbia roadside surveys, 6.5% of evening and nighttime drivers tested positive for BAC compared with 9.9% in 2010 before the new laws were introduced.

### TABLE 1—Comparison of British Columbia’s Old and New Speeding and Street Racing Laws

<table>
<thead>
<tr>
<th>Driving Offense</th>
<th>Before September 2010</th>
<th>After September 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BAC level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.0-0.049</td>
<td>12-h driving prohibition for drivers with restricted license</td>
<td>3-d driving prohibition</td>
</tr>
<tr>
<td>0.05-0.079 (1st offense)</td>
<td>24-h driving prohibition</td>
<td>Possible 3-d vehicle impoundment</td>
</tr>
<tr>
<td>0.05-0.079 (2nd offense within 5 y)</td>
<td>24-h driving prohibition</td>
<td>7-d driving prohibition</td>
</tr>
<tr>
<td>0.05-0.079 (3rd offense within 5 y)</td>
<td>24-h driving prohibition</td>
<td>Possible 7-d vehicle impoundment</td>
</tr>
<tr>
<td>≥ 0.08 or refuses breath test</td>
<td>90-d driving prohibition beginning 21 d after the offense</td>
<td>90-d driving prohibition (immediate)</td>
</tr>
<tr>
<td><strong>Speeding and stunt driving</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speeding ≤ 40 km over limit</td>
<td>Fines and demerit points</td>
<td>No change</td>
</tr>
<tr>
<td>Speeding &gt; 40 km per hour or stunt driving</td>
<td>Fines and demerit points</td>
<td>7-d vehicle impoundment</td>
</tr>
<tr>
<td>(first offense)</td>
<td></td>
<td>Fees ≤ $210</td>
</tr>
<tr>
<td>Speeding &gt; 40 km per hour or stunt driving</td>
<td>Fines and demerit points</td>
<td>30-d vehicle impoundment</td>
</tr>
<tr>
<td>(second offense within 2 y)</td>
<td></td>
<td>Fees ≤ $700</td>
</tr>
<tr>
<td>Speeding &gt; 40 km per hour or stunt driving</td>
<td>Fines and demerit points</td>
<td>60-d vehicle impoundment</td>
</tr>
<tr>
<td>(third offense within 2 y)</td>
<td></td>
<td>Fees ≤ $1200</td>
</tr>
<tr>
<td><strong>Street racing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st offense</td>
<td>48-h vehicle impoundment</td>
<td>7-d vehicle impoundment</td>
</tr>
<tr>
<td>2nd offense within 2 y</td>
<td>Fines and demerit points (street racing only)</td>
<td>Fees ≤ $210</td>
</tr>
<tr>
<td>3rd and subsequent offense within 2 y</td>
<td>Fines and demerit points (street racing only)</td>
<td>30-d vehicle impoundment</td>
</tr>
</tbody>
</table>

Note. BAC = blood alcohol concentration; IRP = immediate roadside prohibitions.  
*All penalties that existed before September 2010 remain in effect. Starting September 2010, IRPs provided an additional tool for police to use at their discretion.*  
*Since September 2010, police usually apply immediate penalties under the new laws. However, they still have the option of using the preexisting laws instead. Therefore, the 3 typical outcomes for drivers with BAC ≥ 0.05% or who refuse a breath test are as follows: (1) most get an IRP, (2) some get a 24-h (or 12-h) driving prohibition, and (3) some get a 90-d driving prohibition plus criminal code charges.*  
*Note that the penalties for excessive speeding (> 40 km over limit), street racing, and stunt driving are identical under the new laws.*  
*Drivers with 3 offenses for BAC = 0.05%-0.079% or 1 offense for BAC > 0.08% may be referred to the responsible driver program, the ignition interlock program, or both.*  
*The new laws expanded the vehicle impound program to introduce and define “stunt driving,” something that was not specifically covered under the old laws.*
of British Columbia drivers reporting driving while over the legal limit was above the national average in 2009 and 2010 but fell below the national average in 2011 and 2012. The new laws included harsher penalties for excessive speeding but, unlike the case with drinking and driving, the number of sanctions for speeding or for excessive speeding did not increase (Figure 1).

We previously reported a reduction in alcohol-related fatal crashes in the 2 years after introduction of British Columbia’s new laws. We investigated the effects of the new laws on total fatal crashes, hospital admissions, and ambulance calls. We drew on police, ambulance, and hospital data from British Columbia and on police data from adjacent jurisdictions in which similar legislative changes were not implemented.

METHODS

We used deidentified administrative data and obtained approval from our institutional research ethics board. Briefly, we used an interrupted time-series approach to model the impact of the new laws on crashes and medical events. We assessed the intervention effects using a linear regression model with an autoregressive integrated moving average (ARIMA) error term.

Data Sources

We analyzed British Columbia data from MVC fatalities from police reports (2000–2012), hospital admissions (2005–2011), and ambulance calls (2004–2012). We obtained MVC fatality data from Alberta, Saskatchewan, and Washington State police reports (2000–2012). We did not have access to hospitalization or ambulance data from any jurisdiction other than British Columbia.

Road fatality. The British Columbia traffic accident system contains details of all police-reported crashes in British Columbia, including factors that police believe contributed to the crash (e.g., speeding, impaired driving). The traffic accident system is reconciled with coroners’ data to ensure that it captures all fatal crashes (i.e., those who died on a public road and within 30 days of the crash). Nonfatal crashes may not be captured because police attendance at nonfatal crashes is discretionary. For this reason, we studied only fatal crashes. Fatal crashes related to alcohol or speeding were our outcome of interest, and fatal crashes unrelated to alcohol or speeding served as an internal control.

Similarly, we obtained monthly counts of total fatal crashes and of fatal crashes involving alcohol or speeding from police reports of neighboring jurisdictions (Alberta, Saskatchewan, and Washington State). We used the analyses of these data as an external comparison to account for regional trends and conditions that might explain the observed effects of the new laws in British Columbia.

Hospital admissions and ambulance dispatches. All hospital admissions in Canada are recorded in the Discharge Abstract Database, which includes mechanism of injury but has no information on factors that caused the crash. In this study, we used admissions for road trauma as a measure of hospital utilization by road injury victims in British Columbia. We defined “road trauma admissions” as those with International Classification of Diseases, 10th Revision (ICD-10),

FIGURE 1—Monthly charges for (a) impaired driving, (b) speeding, and (c) excessive speeding: British Columbia, September 2007–September 2011.
external cause of injury codes ranging from V02.1 (pedestrian injured in collision with 2- or 3-wheeled motor vehicle, traffic accident) through V89.9 (person injured in unspecified vehicle accident). We also included sequelae of transport accidents (Y85, Y850, Y959).

We excluded non–traffic accident events such as boarding or alighting from a vehicle, events that occurred on industrial premises, events that did not involve a motorized vehicle, and events in which the only vehicle involved was a streetcar, railway vehicle, specialized agricultural vehicle, airplane, or watercraft. We included traffic injury involving snowmobiles and all-terrain vehicles because these vehicles are subject to traffic laws when driven on a public road. We used hospital admissions for non-MVC trauma (i.e., all other injury codes) as controls.

The British Columbia Ambulance Service provides emergency medical service for the entire province. Each call for emergency medical assistance is assigned 1 of 32 Advanced Medical Priority Dispatch System numbers using standardized questions. Multiple calls for the same event are combined into a single dispatch record. We used ambulance dispatches for traffic and transportation incidents (code 29) as a measure of ambulance service use by road injury victims. We used ambulance calls for non-MVC trauma as controls.

Analysis

For each outcome, we aggregated counts by month and converted them to rates. For crashes, rates were per 1 000 000 licensed drivers. Hospital admissions and ambulance calls included victims of all ages and were converted to rates per 1 000 000 British Columbia residents. We adjusted rates to account for the number of days in each month. We chose the time before intervention a priori to count for the number of days in each month.

For the purpose of this study, we considered fatal crashes to be alcohol related if police cited alcohol involvement, alcohol suspected, or ability impaired by alcohol as a contributory factor for any driver involved in the crash. Crashes with multiple contributory factors were included in all relevant analyses. We conducted subgroup analyses that excluded crashes involving both alcohol and speeding. We excluded cases in which relevant contributory factors were cited only for pedestrians or pedal cyclists.

We analyzed event rates using an interrupted time-series approach. We fitted a multivariate linear regression model that included an indicator variable for the intervention (new law) effect, an internal control variable, and a seasonal ARIMA error term to control for seasonality, autocorrelation, and data instability. Internal controls served as a surrogate for unmeasured confounders and trends unrelated to the intervention. Controls were scaled and centered for model convergence. We originally included the effects of other events, such as a court challenge and temporary suspension of the new laws (November 2011).22 in the regression model. However, these events did not have a statistically significant effect on crash rates, and we omitted them from the final model.

To complement ARIMA analyses, which estimate permanent changes in mean crash rate, we performed supplementary analyses to identify breakpoints (significant changes in the slope of the crash rate trendline) and to estimate the year in which any detected breakpoint occurred. To do this, we fitted regression models to annual crash rates with a segmented relationship for the yearly trend. The number of breakpoints was automatically selected but constrained to be less than 3.23,24

Data transformations were made to meet the assumptions of the model. First, we took the logarithm of crash rates to stabilize the variance when necessary. Second, we used differencing to achieve a stationary time series. If necessary, we calculated the difference from one period to the next to remove trends over time. We also used seasonal differencing to eliminate any strong seasonal patterns.

An iterative procedure was used to identify the order of the ARIMA error model. We selected the initial model using a stepwise algorithm to minimize the corrected Akaike information criterion. We explored correlation structures via plots of the autocorrelation and partial autocorrelation functions. If the model fit was deemed inadequate, we used residual diagnostics to identify improved error structures. We selected the model with the lowest Akaike information criterion that also satisfied residual assumptions. The error model was not constrained to be the same across jurisdictions or outcomes.

We fitted all models using conditional-sum-of-squares to find starting values. Final estimates were obtained by maximum likelihood. We performed all regression analyses with R version 3.0.1 (R Foundation for Statistical Computing, Vienna, Austria). The intervention effect was treated as abrupt and permanent. We considered P<.05 to be statistically significant; all tests were 2-sided.

RESULTS

Between January 2000 and December 2012, 4507 fatal crashes occurred in British Columbia, including 1121 related to alcohol and 1600 related to speeding (163 to excessive speed). In 589 fatal crashes, both alcohol and speeding were involved. We found overall downward trends and seasonal patterns with peaks during summer months for both alcohol- and speeding-related fatal crashes. Figure 2 shows monthly rates of fatal alcohol-related crashes over the study period.

Table 2 summarizes the changes in occurrence rates for each outcome after the new laws went into effect. In the 24 months after British Columbia’s new laws were implemented, statistically significant reductions occurred in total fatal crashes and in fatal crashes related to alcohol and to speeding. Segmented regression analyses detected 1 breakpoint in the annual trend for alcohol-related fatal crash rates in 2010 (95% confidence interval [CI] = 2009, 2011). Breakpoints for speeding-related and all-cause fatal crash rates occurred in 2005, before the new laws.

In subgroup analyses that excluded crashes involving both alcohol and speeding, we found a 46.5% reduction (95% CI = 23.1, 70.0) in alcohol-related crashes and a non-statistically significant reduction of 21.1% (95% CI = –4.4, 46.7) in speeding-related crashes. During the same period, we observed a smaller reduction in alcohol-related fatal crashes in Alberta (32.7%) and much smaller reductions in Saskatchewan and
Washington State (1.2% and 9.8%, respectively); the latter 2 were not statistically significant. Similarly, fatal crashes related to speeding decreased by 30.6% (95% CI = 17.0, 41.9) in Washington State. We found a smaller, nonsignificant decrease in fatal speeding crashes in Alberta (14.4%) and a trivial, non-statistically significant increase in Saskatchewan (2.5%).

During the study period, British Columbia had 3553 hospital admissions and 32225 ambulance calls for road trauma per year. Monthly rates of road trauma-related hospital admissions and ambulance calls are illustrated in Figures 3 and 4. We found an 8.0% (95% CI = 0.6, 14.9) reduction in hospital admissions and a 7.2% (95% CI = 1.1, 13.0) reduction in ambulance calls attributable to road trauma.

DISCUSSION

British Columbia’s new traffic laws were associated with decreases in fatal crashes (21.0%) and in hospital admissions (8.0%) and ambulance calls (7.2%) for road trauma, corresponding to monthly decreases of 2.21 fatal crashes per 1,000,000 drivers and 5.71 hospital admissions and 47.29 ambulance dispatches per 1,000,000 residents. Our findings of reductions not only in fatal crashes but also in ambulance calls and hospital admissions for road trauma strengthen the conclusion that British Columbia’s laws were effective in reducing road trauma. An alternate explanation is that these benefits are attributable to factors other than the new laws. We feel that this is unlikely for several reasons. First, we used internal controls to account for trends in need for trauma care or the number of fatal crashes. Second, with the exception of fines for drivers using cell phones (February 2010), British Columbia did not introduce any other significant traffic laws or policy changes in 2010 or 2011. The cell phone laws are likely primarily the result of prevention of crashes caused by drinking and driving.
Consistent with this premise, we found a marked reduction (52.0%) in fatal alcohol-related crashes. The segmented regression analysis finding that alcohol-related fatal crashes began to decline more rapidly in 2010 strengthens the evidence linking the new law to a reduction in alcohol-related MVC fatalities. Neither Saskatchewan nor Washington had declines in fatal alcohol-related crashes. Alberta, however, had a 32.7% reduction in fatal alcohol-related crashes that we attribute to a spillover effect from the changes in British Columbia. Spillover effects are common in studies of law and public policy and are closely related to the degree of population mobility between jurisdictions. At the time British Columbia’s new laws were put into effect, Alberta politicians were debating similar laws. In December 2011, in an example of policy diffusion, Alberta passed laws with immediate roadside penalties for drunk drivers. Alberta’s new laws were put into effect incrementally between July and September 2012. It is not surprising that British Columbia’s laws received considerable media coverage in Alberta, with headings such as “Alta. May Stiffen Drinking and Driving Laws” and “B.C. Drunk Driving Law Sobers Alberta.”

Many Albertans likely changed their drinking and driving behavior as a result of press coverage. In addition, several municipalities in Alberta have programs that encourage citizens to report impaired drivers. Increased news coverage of drinking and driving may have encouraged greater participation in those programs. Furthermore, the adjacent nature of the 2 provinces, and easy migration of workers between British Columbia and Alberta, suggests that many drivers might have carried their knowledge of British Columbia laws into Alberta either from habit or from not knowing the policy differences between the 2 provinces. Finally, it is possible that Alberta police informally increased their own enforcement efforts in response to reports from British Columbia.

British Columbia’s new laws also targeted speeding, with harsher penalties for excessive speeding, street racing, and stunt driving. We
found a 33.3% reduction in fatal speeding crashes in British Columbia. In a subgroup analysis that excluded crashes related to both alcohol and speeding, the reduction in fatal speeding-related crashes was smaller (21%) and was not statistically significant at the nominal level. However, this analysis was based on half as many events, resulting in an imprecise estimate of the effect (i.e., wide confidence intervals), and important reductions in this subgroup cannot be ruled out. Other researchers found that both higher fines and visible enforcement reduce the incidence of speeding but that increased enforcement is more effective. British Columbia’s new laws did not include increased speed enforcement and did not increase sanctions for the majority of speeding drivers. This limited scope may explain why British Columbia’s laws had a smaller effect on speeding fatalities. Neither Alberta nor Saskatchewan had reductions in speeding-related fatal crashes. It is interesting to note that Washington State had a statistically significant reduction in speeding-related fatal crashes. Beginning in July 2010, Washington began to roll out “target zero teams.” These teams use a systems approach including education and increased enforcement to target speeding, impaired driving, and failure to use seatbelts. The reduction in speeding-related crashes seen in Washington may be related to this approach.

**Strengths and Limitations**

We used multiple data sources to examine the effects of British Columbia’s new laws on health outcomes and on fatal crashes. Most evaluations of traffic laws rely exclusively on police data, which often have limited information on injury severity and may not capture all injury crashes. To account for trends and unmeasured confounders, we used ARIMA models and internal controls. We also compared British Columbia traffic fatalities with those in adjacent jurisdictions. Because medical data do not include factors that caused the crash, we cannot confirm that the observed reduction in ambulance calls and hospital admissions for road trauma was attributable to fewer crashes caused by the targeted risk factors (alcohol, speeding). Finally, deterrence-based laws often have reduced effectiveness over time. Longer follow-up will be required to determine whether the beneficial effects of British Columbia’s new laws are long lasting.
Conclusions

Traffic laws that introduced immediate license suspension and vehicle impoundment for drunk drivers and vehicle impoundment for excessive speeding, stunt driving, or street racing were associated with significant reductions in fatal crashes and in hospital admissions and ambulance dispatches for road trauma. These findings suggest that laws calling for immediate sanctions for dangerous drivers can reduce road trauma and should be supported.

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Contributors

J R Brubacher oversaw the project as a whole and was primary author of the article. H. Chan coordinated data access and assisted with methodology. P. Brasher oversaw statistical analysis and helped with interpretation of results. S. Erdelyi performed statistical analysis under supervision of P. Brasher and prepared figures and tables. E. Desapriya contributed relevant background information on the importance of media awareness campaigns and on driver surveys showing that drivers are aware of the new laws. M. Asbridge contributed to the section on policy diffusion and helped with interpretation of results. R. Purssell provided background information on details of British Columbia’s new laws. S. Macdonald provided background information on deterrence theory and its application to traffic laws. N. Schuurman assisted with data access and mapping. I. Pike assisted with access to hospital admission data and with interpretation of hospital admission data. All authors reviewed and contributed to the final article.

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Human Participant Participation

This study was approved by the University of British Columbia Clinical Research Ethics Board.

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