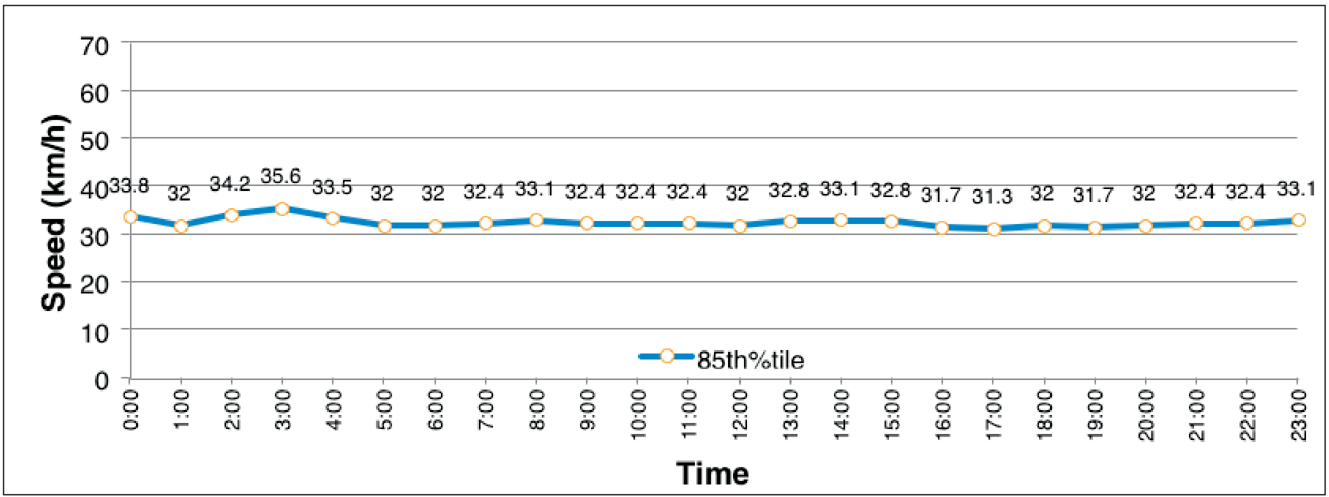


Figure A5. Between last crossing & gateway (aggregated 24-hour 2-way profile)

Canadian Legislation on excessive speeding: successful intervention through penalty increases

by Suliman A. Gargoum[a] and Karim El-Basyouny[1]*

[a] *Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AB, Canada T6G 1H9*

**Corresponding author. Tel.: +1 780-200-0161, Email: gargoum@ualberta.ca*

[1]*Tel: +1-780-492-9564, Email: basyouny@ualberta.ca*

Abstract

Excessive speeding is a global problem experienced on roads all around the world. The impacts of this behaviour on the safety of all road users have led many jurisdictions to adopt more significant sanctions when dealing with such offenders. This paper assesses the impacts of adopting more significant sanctions against excessive speeders in Canada while also considering issues which should be explored when adopting such a policy. The paper uses ARIMA intervention analysis to assess changes in fatal collision data since the adoption of stronger penalties. The changes were assessed for statistical significance, and the magnitude of the change was quantified. In general, the findings show that the legislative changes allowing for stronger penalties were associated with significant drops in province-wide fatal collisions. Reductions in the mean level of monthly collisions ranged from 5% to 22% at the three provinces. Moreover, the paper highlights four major areas, which must be considered for jurisdictions attempting the adoption of such a legislation.

Keywords

ARIMA, Intervention analysis, Time-Series, Severe sanctions, Canadian Legislation, Excessive speeding, Fatal collisions.

Introduction

Excessive speeding is an issue on roads all around the world, and many countermeasures have been considered in different provinces to overcome this challenge. Common reasons for exceeding speed limits by extremely high margins are illegal street racing and stunt driving, while speeding generally has multiple causes including simply being late (Prabhakar et al., 1996). However, street racing is not the only motive of excessive speeding.

There is no doubt that, regardless of the motives, excessive speeding puts the offenders at an extreme risk and could also affect the safety of other drivers and road users. Considering three years of data, Nerida L Leal and Watson (2011) found that drivers who were involved in street racing and stunt driving offences had a history of considerably more traffic infringements and crashes compared to non-offenders. Consequently, more attention and significant sanctions have been considered when dealing with such activities.

A form of stronger sanctioning which has often been introduced to supplement licence suspensions is vehicle-related punishment such as vehicle impoundment. Legislative changes enforcing stronger sanctions against excessive speeders have been adopted by many jurisdictions around the world including three provinces in Canada (British Columbia, Ontario and Quebec). Under the new laws, drivers who violate speed limits by margins deemed to be excessive are subject to a variety of sanctions including immediate licence suspension, higher fines and vehicle impoundment. The three provinces had different thresholds at which they defined excessive speeding and the fines a driver was subject to under the laws varied as well, details of this is provided in Table 1.

This paper aims to analyse the effects of the Excessive Speeding Legislation (ESL) on fatal collision counts at each of the three provinces. In order to account for exposure, collision counts per million litres of fuel sold were also analysed. A total number of six (i.e., 3 provinces, 2 levels - with or without a proxy for exposure) intervention models were developed, and the significance of the intervention was tested in each case. In addition to the statistical assessment, the paper also provides a discussion of the certain aspects of the policy which must be considered before adopting the legislation. This assessment provides other jurisdictions in Canada and around the world with valuable information which could help in decision making regarding adoption of the ESL.

Literature review

According to deterrence theory, compliance to laws and legislation is mainly due to the fear of being caught. This fear is known to deter (discourage) drivers from violating the law and is a function of three factors: (1) the apparent *severity* of the law, (2) the *certainty and the speed* in which an offender is penalised, and (3) the *administrative penalties* associated with the law (Watson, 2004). Moreover, deterrence is also a function of the amount of enforcement and publicity a law receives (WHO, 2015).

In the past, speeding offenders were mainly subject to monetary fines and demerit points, however, while these penalties have been effective in deterring some drivers, the laws have not been as effective when dealing with aggressive drivers such as excessive speeders. Castillo-Manzano and Castro-Nuño (2012) found that positive safety impacts of demerit points die out rapidly, with the study showing that effects vanish within 18 months of the introduction of the policy. Furthermore, in a study on factors influencing driver speed, Fleiter, Lennon, and Watson (2010) revealed that apart from financial stress, monetary fines did not seem to have any deterrence effects on excessive speeders.

In an attempt to achieve higher deterrence rates, stronger sanctions including licence suspensions and vehicle related sanctions have been used by legislators. Licence suspensions were first introduced as penalties against drivers who are convicted of DUI. This was found to have encouraging specific deterrence effects (Homel, 1989; Mann, Vingilis, Gavin, Adlaf, & Anglin, 1991), however, not many studies were able to find general deterrence effects for post-conviction licence suspension (Asbridge et al., 2009). As a result, administrative licence suspensions (ALS), where licence suspension occurs before conviction, were adopted. ALS was found to have a general deterrence effect in many studies ((Asbridge et al., 2009); Wagenaar and Maldonado-Molina (2007).

As a means of ensuring suspended drivers did not drive while suspended (DWS), ALS laws were combined with vehicle related sanctions. Voas and DeYoung (2002) provide a summary of most studies that worked on evaluating vehicle impoundment and forfeiture policies prior to their study.

Most studies that have evaluated this type of legislation conclude that vehicle impoundment has an effect on specific deterrence (i.e. drivers who were sanctioned under the law did stop DWS after being sanctioned), and hence, an alleged improvement in the safety of other road users see, for examples, DeYoung (1999) and Voas, Tippetts, and Taylor (1997). Unlike findings pointing to a specific deterrence effect, most studies could not find general deterrence effects of vehicle impoundment laws, see for example, DeYoung (2000) and (N. Leal, Watson, Armstrong, & King, 2009). It is worth noting however, that Beirness and Beasley (2014) was able to find a general deterrence effect for impoundments issued for DUI in British Columbia, Canada.

Meirambayeva, Vingilis, Zou, et al. (2014) studied the effects of the ESL on violation rates (i.e. the number of drivers caught driving at excessive speeds) in Ontario. The violations before and after the introduction of the law were compared, and it was found that the rates dropped for males since the introduction of the law (general deterrent effect); whereas, the rates were almost constant for females. This finding is reasonable considering that males are more likely than females to be involved in excessive speeding activities.

Table 1: ESL at the different provinces

		Sanctions	
Province	**Margin (kph)**	**1st Offence**	**2nd Offence**
BC	40	7day LC & VI, $368/483 fine, 3pts, $210 fee	30day VI, $700 fee
ON	50	7day LC & VI, [$2,000 to $10,000 fine, 6 pts, jail term, 2yr LC]*	10yr LC
QC	40/60 zone, 50/60-90zone, 60/100 zone	7day LC, Double fines and points	30day LC & VI, double fines.

LC: Licence Suspension, VI: Vehicle Impoundment.
*After Conviction

Table 2: Descriptive statistics for monthly fatal collisions at the three provinces

	Number of Observations			Monthly Collisions			
Province	**Total**	**Pre-Law**	**Post-Law**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
BC	97	57	40	11	46	25.57	7.124
ON	125	73	52	19	85	53.79	14.082
QC	122	52	70	18	80	42.03	13.266

Nerida Louise Leal (2010), who assessed the effects of anti-street racing/stunt driving laws on violations in Queensland, Australia, found that the vehicle impoundment policy did result in the reduction of street racing/stunt driving infringements in the offender sample (specific deterrence).

In one of the few papers which studied the road safety impacts of ESL, Meirambayeva, Vingilis, McLeod, et al. (2014) used time series analysis to assess the effects of the ESL on fatalities. The study found that the policy was effective in reducing speed-related casualties for the young male age group of 16-25 years in Ontario, with a statistically significant drop of 58 casualties per month observed. However, there was no effect for 'mature' males aged 26-65 years.

In general, previous studies show that there is some sort of deterrence effect associated with imposing strong sanctions for drivers who commit extreme offences with high crash risk to themselves and other road users. Nevertheless, policy makers are often reluctant to implement these laws due to a number of issues. Notable issues include the liability issues, legal issues and even funding burdens. (Peck & Voas, 2002; Voas and DeYoung (2002); Voas, Tippetts, & Taylor, 2000) provide a thorough discussion of those issues.

Dataset description

The data used in the analysis included fatal collisions recorded in the three provinces of interest. The collision data covered a period of time before implementing the law and after the law came into effect. The data was obtained from Ontario Road Safety Annual Reports (ORSAR) kept by Ontario's Ministry of Transport (MTO), Insurance Corporation of British Columbia (ICBC), and Société de l'assurance automobile du Québec (SAAQ).

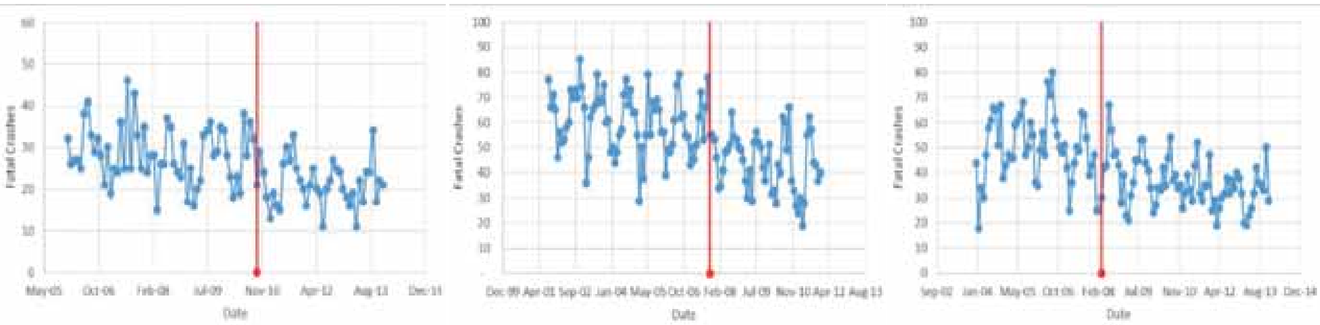
The overall time trends of the data are provided in Figure 1; the intervention date is also marked on each of the figures. Moreover, the descriptive statistics of the data are found in Table 2.

In order to avoid potential biases in the results, exposure measures had to be included in the analysis. Since vehicle miles travelled (VMT) per month were not available, a surrogate measure of exposure was collected. Motor vehicle fuel sales per month at each province, kept by Statistics Canada, were assembled for a similar period of time during which collision counts were available and were used in the analysis. Fuel sales have been used as a measure of traffic exposure in previous studies as well, see, for example, (Lasse Fridstrøm, 1999; L Fridstrøm, Ifver, Ingebrigtsen, Kulmala, & Thomsen, 1993). It is worth noting here that despite increases in fuel efficiency over time fuel consumption over the years follows a similar trend to VMT (Goodwin, Dargay, & Hanly, 2004). The reason here is twofold (i) fuel is an inelastic product and (ii) when fuel efficiency increases there is more tendency to travel.

In addition to collision counts and exposure measures, information regarding the implementation or withdrawal of traffic laws affecting collisions during the analysis period was essential. The policies, which took place during the analysis period at the provinces, can be found in Table 3. Since the analysis was conducted on a province-

Figure 1: Time plots for monthly collision data

Time Plots		
BC	**ON**	**QC**



level (aggregate level), it is fitting to assume that local (disaggregate) safety improvement such as changes in speed/enforcement improvements in a certain town or city did not affect the analysis.

Methodology

Autoregressive Integrated Moving Average (ARIMA) intervention analysis was used to model the data. The process involves using the Box-Jenkins methodology developed by Box and Jenkins (1976) to estimate an ARIMA model for the pre-intervention data and then performing an interrupted time series analysis to assess the magnitude and the significance of the effect of any intervention. While taking into account autocorrelations (correlation between observations from consecutive time periods), ARIMA intervention analysis also permits the addition of covariates to the model such as intervention terms; these terms can then be used in assessing the intervention effects.

In an ARIMA analysis the time series Y_t is assumed to follow an Autoregressive Integrated Moving Average model, which includes three terms (*p, d, q*):

ARIMA (p, d, q)(P, D, Q)s

Where, *p* represents the number of autoregressive (AR) terms; *d* represents the number of differences required in case of a non-stationary series; and *q* represents the number of moving average (MA) terms, *s* represents the number of periods per season and the uppercase terms represent the seasonal part of the model.

The notation of the ARIMA model proceeds as follows. Let Y_t represent the time series, where Y_t is the observation at time *t*, and let αt (error term) be a white noise process, $\alpha_t \sim N(0,\sigma^2)$. If *B* were to represent the backward shift operator of the seasonal period, defined such that $B^k Y_t = Y_{t-k}$, then the ARIMA equation can be written as follows:

$$(1-\varphi_1 B^1 - \ldots \varphi_p B^p)(1-\phi_1 B^{(s\times 1)} \ldots - \phi_P B^{Ps})(1-B)^d (1-B)^D Y_t = (1-\vartheta_1 B^1 - \ldots \vartheta_q B^q)(1-\theta_1 B^{(s\times 1)} \ldots \theta_Q B^{Qs})\alpha_t \quad [1]$$

Where, φ_1 *to* φ_p are the non-seasonal AR parameters; φ_1 *to* φ_p are the seasonal AR parameters; ϑ_1 *to* ϑ_q are the non-seasonal MA parameters; and θ_1 *to* θ_Q are the seasonal MA parameters.

The Box-Jenkins methodology is a four-step iterative procedure which involves tentative identification, model estimation, diagnostic checking and forecasting. These steps are applied to the pre-intervention data to develop an ARIMA model, which is then combined with a transfer function to perform the intervention analysis. Since the methodology works only for a stable dataset, the effects of

Table 3: All legislative changes during study period

Province	Major Legislation Within the Study Period			
	Type	**Implemented/Cancelled**	**Month**	**Year**
BC	Distracted Driving Law **(DDL)**	Implemented	Feb	2010
	Impaired Driving **(IDL)**	Implemented	Sept	2010
	Excessive Speeding Law (ESL)	**Implemented**	**Sept**	**2010**
	Impaired Driving Law	Cancelled	Nov	2011
ON	**Excessive Speeding Law (ESL)**	**Implemented**	**Oct**	**2007**
	Speed Limiter Legislation For Trucks **(Truck)**	Implemented	Jan	2009
	Impaired Driving Law: Drivers with BAC .05-.08 lose licence. **(IDL-BAC)**	Implemented	May	2009
	Distracted Driving	Implemented	Oct	2009
	Impaired Driving Law: Drivers under 21 subject to automatic suspension for alcohol in breath. **(IDL-u21)**	Implemented	Aug	2010
	Impaired Driving **(IDL)**	Implemented	Dec	2010
QC	Distracted Driving Law **(DDL)**	Implemented	Apr	2008
	Excessive Speeding Law (ESL)	**Implemented**	**Apr**	**2008**
	Impaired Driving **(IDL)**	Implemented	Dec	2008
	Truck	Implemented	Jan	2009

the seasonal variation within the data as well as long-term trends in the data must be removed before applying any of the steps.

As first demonstrated by Box and Tiao (1975), transfer functions can be used to model an intervention effect and determine whether there is evidence that a change in the series has actually occurred and, if so, its nature and magnitude.

Intervention analysis involves assessing the effects of an intervention by introducing an intervention term into the ARIMA model. The intervention term is represented through a transfer function, which models the behaviour of the change in the series. In intervention models, after suitable transformation, the general model for the ARIMA time series Y_t previously shown in equation 1 becomes:

$$(1-\phi_1 B^1 - \ldots.\phi_p B^p)(1-\varphi_1 B^{(s\times 1)} \ldots - \varphi_P B^{Ps})(1-B)^d (1-B)^D Y_t = (1-\vartheta_1 B^1 - \ldots \vartheta_q B^q)(1-\theta_1 B^{(s\times 1)} \ldots \theta_Q B^{Qs})\alpha_t + \omega I_t \quad [2]$$

Where, ω is the intervention parameter representing an unknown permanent change in the mean due to the intervention, and I_t is the function modelling the effect of the intervention on the mean level of the series. The combination of ωI_t is also known as the transfer function.

The effect of the intervention on the mean function was represented using a step function.

$$I_t = \begin{cases} 0 & if \quad t < T \\ 1 & if \quad T \geq t \end{cases} \quad [3]$$

where, T is the time (t) at which the intervention was implemented.

Modelling Procedure

As already mentioned, developing ARIMA models for time series data is an iterative process. The time trends of the pre-intervention data were first observed to ensure that the data was stationary and that no differencing or transformations were required. In addition to checking for non-stationarity by inspection, the Augmented Dicky Fuller (ADF) test was run for each of the datasets.

The test showed that only data from Quebec was non-stationary, however, differencing resolved the issue. The variance was also constant; therefore, the analysis was performed on the actual collision counts.

After testing for stationarity, correlation structures were explored. In each case, the plots of the ACF (autocorrelation) and the PACF (partial autocorrelation) functions were observed to help identify the order appropriate for a tentative ARIMA model. The parameters for this model were then estimated using the pre-intervention data only. Diagnosis of the tentative model was then performed by:

- Ensuring that the residuals represent white noise (i.e. the residuals are random with no patterns). This was done by checking the ACF plots of the residuals and by running the Box-Ljung test (a portmanteau test that tests the overall randomness of the series based on a number of lags). A large *p*-value (>0.1) indicates randomness, which was the case in all models.
- Checking the significance of the parameters in the selected model.
- Comparing the Akaike information criterion (AIC) of different models (a measure of relative statistical model quality). The model with the lowest AIC was selected.

If the model did not satisfy the requirements, a different model was estimated and assessed. After several iterations, the best fit ARIMA model was identified.

Intervention modelling

In the ARIMA intervention analysis process, the ARIMA model developed for the pre-intervention data is combined with a transfer function that best captures the hypothesised change due to the intervention. This combined model is known as the ARIMAX model.

Estimating the parameters of the ARIMAX model was done using the full dataset (pre- and post-intervention data). The same diagnostic checks of the Box-Jenkins procedure were applied to the ARIMAX model and adjustments were made to the model when required. Other policies, which took place during the study period, were also integrated into the ARIMAX model. After finalising the models, the significance of the model parameters including the intervention term was assessed.

All stages of analysis were carried out using statistical analysis software R v3.1.1. In order to account for exposure, the number of collisions per million litres of gasoline sold was computed. The gasoline sale estimates represented the sales of fuel used by road motor vehicles only.

The orders of the ARIMAX models selected, along with the AIC estimate, are presented in Table 4. Table 5 shows the parameter estimates for all the models, in addition to the standard error associated with each estimate. This also includes the estimates computed for the intervention terms in every model. Abbreviations are used to represent the policy names, and more information about these policies can be found in Table 3.

Table 4: ARIMAX models selected

Province	ARIMAX Model Order	AIC	Box-Ljung *p*-value
ON	$(0,0,0)(1,1,2)_6$	852	0.718
BC	$(0,0,2)(0,1,1)_{12}$	539	0.461
QC	$(1,1,1)(0,1,1)_{12}$	1420	0.246

For further verification of the model's fit, fitted figures for each of the estimated models were plotted. It was evident from the plots (not shown) that the models almost replicated the trends in the original data. The Box-Ljung test, which is a portmanteau test indicating randomness of the residuals if the test is insignificant (p-value>0.1), recorded in Table 4, also indicate that the residuals of each model are random and the model is a good fit of the data; this behaviour is also reflected in the ACF plot of the residuals (not shown in the paper).

The effects of the ESL on fatal collisions at the three provinces are summarised in Table 6, where a significance level of 5% is used. The next few paragraphs provide further discussion of the results. As evident in the table, the models show that the legislative changes related to excessive speeding were associated with a drop in average monthly fatal collisions at all three provinces, however, the drop was only statistically significant at two of those three. In Ontario, it was found that the legislative change related to excessive speeding was associated with a statistically significant drop in fatal collisions; the mean number of monthly fatal collisions for the post-intervention period decreased by 11 monthly fatal collisions (18.3%) when compared to the average in the pre-intervention time period. In British Columbia, the findings with respect to fatal collisions were similar to those observed in Ontario. The trend dropped by around six fatal collisions (22%) for the post-intervention period, a decrease that was deemed statistically significant.

Table 5: Parameter estimates for developed models

	Par[a]	Est[b]	S.E.[c]		Par[a]	Est[b]	S.E.[c]		Par[a]	Est[b]	S.E.[c]
	sar1	-0.9999	0.001		ma1	-0.0435	0.107		ar1	0.196	0.162
	sma1	0.1306	0.095		ma2	0.3036	0.139		ma1	-0.929	0.143
	sma2	-0.8375	0.090		sma1	-0.6945	0.159		sma1	-0.764	0.122
	ESL-	**-11.1188**	**2.239**		**ESL-**	**-6.2786**	**2.394**		**ESL-**	**-2.736**	**5.529**
ON	IDL-BAC-	-7.7041	4.846	**BC**	IDL-	2.5322	1.946	**QC**	IDL-	-14.079	7.950
	DDL-	2.1747	3.871		DDL-	-1.9927	2.220		Truck	11.370	7.779
	IDL-u21-	2.5638	4.239								
	IDL-Test-	-7.7211	4.075								
	Truck	0.4953	4.010								

[a]Par: Model Parameter, [b]Est: Parameter Estimate, [c]S.E.: Standard Error.
Modelling Results

Table 6: Intervention parameter estimates and significance

	Effect	%Change in Monthly Fatal Crashes	*p*-value
Ontario			
	-11.12	-18.3%	*<0.01*
British Columbia			
	-6.28	-22%	*<0.01*
Quebec			
	-2.736	-5%	0.621

**p*-value<0.05 indicates significant effect

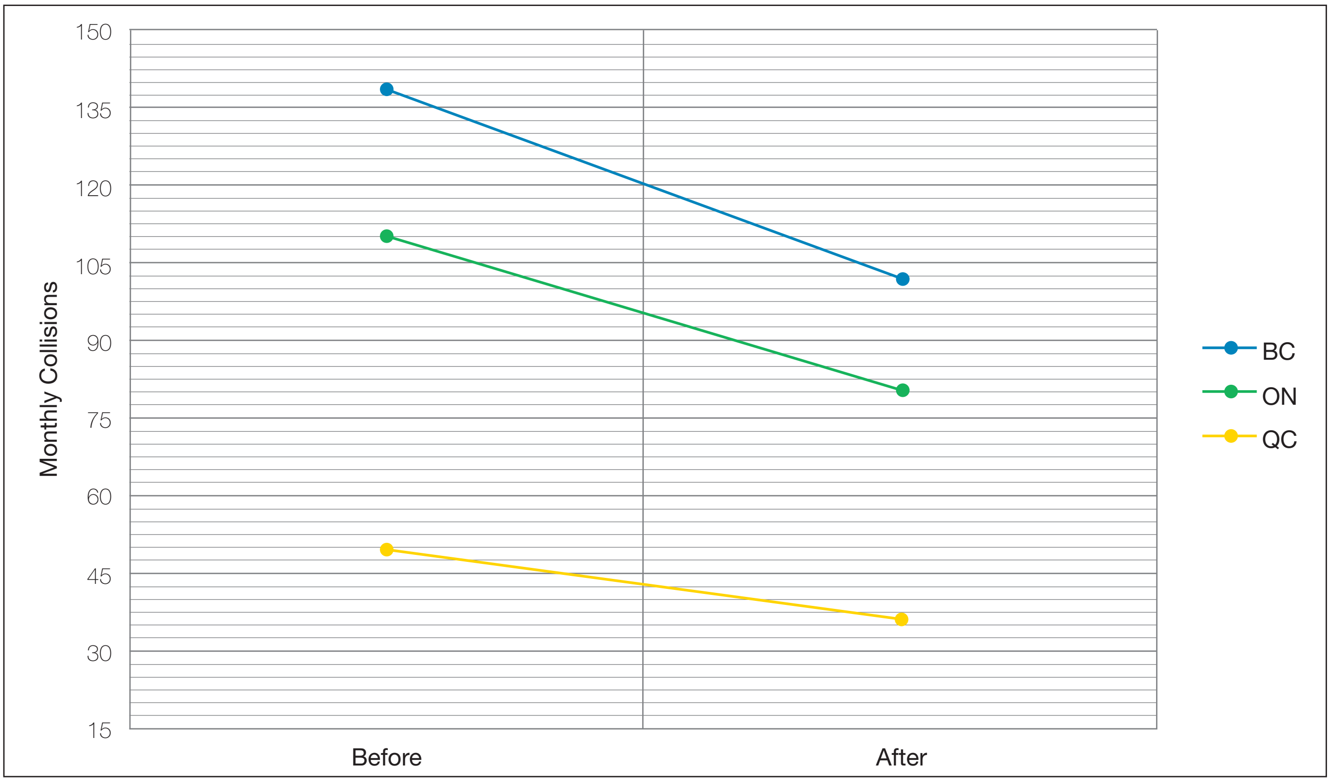


Figure 2: Change in the mean level of monthly fatal collisions

Modelling fatal collision data for Quebec showed that the post-intervention data had a slightly lower mean number of fatal crashes when compared to pre-intervention. The drop was quantified to be almost three collisions (5%); however, unlike Ontario and BC, the change was not statistically significant. It is worth noting here that the observations at each of the three provinces did not change when the exposure-based analysis was conducted.

The fact that the change was not statistically significant in Quebec could be down to the difference in the sanctioning strategy between QC and the other two provinces (this is discussed further in the next section). Another important point to note is that the effects of the policy might not be immediate. Depending on the publicity and enforcement rates, it could take some time for the law to have significant effects. Finally, it is worth noting that a DDL was implemented at the same date as the ESL in QC. This makes it statistically impossible to separate the impacts of the two laws given the current dataset since, unlike the case of BC where the IDL was discontinued, in QC both laws (ESL and DDL) were in place throughout the whole study period.

In general, the results show that the initial hypothesis that the legislative changes related to excessive speeding were effective in reducing fatal collisions are valid. The introduction of the policy changes was associated with a statistically significant drop in the mean number of fatal crashes at two provinces, which points towards the presence of some general deterrence effect. In other words, the introduction of the law possibly influenced speeders in general to reduce their speeds, hence, a reduction in fatal crashes.

The results are also consistent with other work assessing the impacts of ESL. Brubacher et al. (2014) observed a 21% reduction in fatalities since the inception of the policy in BC. Similarly, Meirambayeva, Vingilis, McLeod, et al. (2014), found that Ontario's policy was effective in reducing speed-related casualties for males in the young male age group of 16-25 years. In fact, this study extends on the findings observed in previous work through the analysis of fatal collisions of different causes. The analysis shows that the impacts of the policy extend to include all fatal collisions. This is reasonable when considering that, while speed might not be the main factor in all severe collisions, it is still one of the contributing factors in those type of collisions.

Policy discussion

Given the positive effects of the ESL at the provinces analysed in this study, other jurisdictions in Canada and around the world might be interested in adopting the policy. Nevertheless, as with any legislative change, adopting the policy requires considering a number of factors. In this paper, four important factors are identified and discussed.

One factor which must be taken into account before adopting the policy is the definition of excessive speeding. As already noted, the literature lacks a specific definition of excessive speeding, in other words, the threshold over the speed limit above which vehicles are considered excessively speeding is defined locally by each jurisdiction. In Ontario, for instance, a 50kph threshold was used. BC, on the other hand, defined excessive speeding as driving at 40kph over the speed limit. In Quebec, a different approach was used by which the threshold differed based on the speed limit of the road.

Some jurisdictions might be interested in making the laws as stringent as possible by using the 40kph or 30kph threshold. Other locations might use a more scientific approach by considering percentile speeds of vehicles on local highways and defining the threshold based on that data. Regardless of the approach, it is important that highway agencies take this into consideration when adopting the policy.

Another factor which must be considered before implementing the law is the structure of the sanctioning system. This is also something which was different among the three provinces analysed in this paper. In Quebec, only second time offenders were subject to vehicle impoundment. This was not the case in BC and Ontario where a violator's vehicle was impounded even if it was their first offence. The impoundment and licence suspension period are also things which must be clearly specified in the law. In Canadian provinces, typical practice included a seven-day impoundment/suspension for the first offence and 30 days for the second offence. In fact, dealing with repeat offenders is also an important aspect of the law since it has significant impacts on specific deterrence effects of the policy.

The structure of the sanctioning system must also be made clear to the public as legislators could run into disputes with offenders if the law is not properly publicised. Publicity of the law and the means by which this is achieved are extremely important matters particularly during the first few months of the legislation. Not only does this limit the amount of disputes for offenders caught under the legislation, but it also increases the general deterrence effects of the policy.

Another important factor which increases the general deterrence effects is the amount of enforcement the law receives and the timings and means by which it is conducted. Typically, enforcement practice can be automated, manned, covert or overt etc. Unfortunately, when dealing with excessive speeding offences there are some limitations on the types of enforcement that could be used. Since the laws typically involve administrative licence suspensions and vehicle impoundments, the presence of an officer at the site is essential for this to take place and hence automated enforcement is not practical for immediate action although rapid follow-up of offenders is an option following automated detection. On-site officers involve a considerable amount of resources to be deployed at enforcement locations depending on the enforcement schedule defined. Towing and storage of impounded vehicles are also matters worth considering by enforcement officials before implementing the policy. However, alterative options for disabling vehicle access such as registration plate confiscation and wheel locks may reduce costs, or costs may be charged to offenders.

Conclusions and recommendations

Overall, the findings of this study represents valuable information for jurisdictions considering adopting the Excessive Speeding Legislation. In addition to highlighting the positive safety impacts of the legislation, this paper discusses the importance of considering several aspects including appropriately defining the thresholds at which a driver is considered excessively speeding; carefully defining the structure of the sanctioning system; understanding and managing the enforcement resources required for implementing the policy; and finally, the importance of running an effective publicity campaign informing the public of the legislative changes.

Although the paper does provide some important insight into the safety effects and challenges associated with adopting the ESL, there are opportunities for future research to build on this study. One way to build on this study is to assess the effects of publicity and enforcement rates within the analysed provinces. Analysing those aspects of the law and comparing them among the different provinces could provide answers to the enforcement and publicity challenges highlighted in the policy discussion section of this paper. Future work might also consider analysing the specific deterrent effect of the legislative changes (i.e. understanding how the policy affects those caught under the new legislation) if data on individual records becomes available.

Acknowledgements

This study was sponsored jointly by NSERC Discovery Grant, the City of Edmonton's Office of Traffic Safety (OTS) and Edmonton's Police Service (EPS).

References

Asbridge, M., Mann, 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.

Beirness, D. J., & Beasley, E. E. (2014). An evaluation of immediate roadside prohibitions for drinking drivers in British Columbia: findings from roadside surveys. Traffic injury prevention, 15(3), 228-233.

Box, G. E., & Jenkins, G. M. (1976). Time series analysis: forecasting and control, revised ed: Holden-Day.

Box, G. E., & Tiao, G. C. (1975). Intervention analysis with applications to economic and environmental problems. Journal of the American Statistical Association, 70(349), 70-79.

Brubacher, J. R., Chan, H., Brasher, P., Erdelyi, S., Desapriya, E., Asbridge, M., . . . Pike, I. (2014). Reduction in fatalities, ambulance calls, and hospital admissions for road trauma after implementation of new traffic laws. American journal of public health, 104(10), e89-e97.

Castillo-Manzano, J. I., & Castro-Nuño, M. (2012). Driving licenses based on points systems: Efficient road safety strategy or latest fashion in global transport policy? A worldwide meta-analysis. Transport Policy, 21, 191-201.

DeYoung, D. J. (1999). An evaluation of the specific deterrent effects of vehicle impoundment on suspended, revoked, and unlicensed drivers in California. Accident Analysis & Prevention, 31(1), 45-53.

DeYoung, D. J. (2000). An evaluation of the general deterrent effect of vehicle impoundment on suspended and revoked drivers in California. Journal of Safety Research, 31(2), 51-59.

Fleiter, J. J., Lennon, A., & Watson, B. (2010). How do other people influence your driving speed? Exploring the 'who'and the 'how'of social influences on speeding from a qualitative perspective. Transportation Research Part F: Traffic Psychology and Behaviour, 13(1), 49-62.

Fridstrøm, L. (1999). Econometric models of road use, accidents, and road investment decisions. Volume II.

Fridstrøm, L., Ifver, J., Ingebrigtsen, S., Kulmala, R., & Thomsen, L. (1993). Explaining the variation in road accident counts. A four-country, generalized Poisson regression analysis. Report Nord, 35.

Goodwin, P., Dargay, J., & Hanly, M. (2004). Elasticities of road traffic and fuel consumption with respect to price and income: a review. Transport reviews, 24(3), 275-292.

Homel, R. (1989). Policing and Punishing the Drinking Driver: A Study of General and Specific Deterrence: Wiley Online Library.

Leal, N., Watson, B., Armstrong, K., & King, M. (2009). " There's no way in hell I would pull up": Deterrent and other effects of vehicle impoundment laws for hooning. Paper presented at the Proceedings of the 2009 Australasian Road Safety Research, Policing and Education Conference and the 2009 Intelligence Speed Adaptation (ISA) Conference.

Leal, N. L. (2010). Illegal street racing and associated (hooning) behaviours. (PhD), Ph.D. Thesis. Centre for Accident Research & Road Safety, Queensland University of Technology, Queensland University of Technology, Queensland, Australia., Queensland, Australia.

Leal, N. L., & Watson, B. C. (2011). The road safety implications of illegal street racing and associated risky driving behaviours: An analysis of offences and offenders. Accident Analysis & Prevention, 43(4), 1547-1554.

Mann, R. E., Vingilis, E. R., Gavin, D., Adlaf, E., & Anglin, L. (1991). Sentence severity and the drinking driver: Relationships with traffic safety outcome. Accident Analysis & Prevention, 23(6), 483-491.

Meirambayeva, A., Vingilis, E., McLeod, A. I., Elzohairy, Y., Xiao, J., Zou, G., & Lai, Y. (2014). Road safety impact of Ontario street racing and stunt driving law. Accident Analysis & Prevention, 71, 72-81.

Meirambayeva, A., Vingilis, E., Zou, G., Elzohairy, Y., McLeod, A. I., & Xiao, J. (2014). Evaluation of deterrent impact of Ontario's street racing and stunt driving law on extreme speeding convictions. Traffic injury prevention, 15(8), 786-793.

Peck, R., & Voas, R. B. (2002). Forfeiture programs in California: Why so few? Journal of Safety Research, 33(2), 245-258.

Voas, R. B., & DeYoung, D. J. (2002). Vehicle action: effective policy for controlling drunk and other high-risk drivers? Accident Analysis & Prevention, 34(3), 263-270.

Voas, R. B., Tippetts, A. S., & Taylor, E. (1997). Temporary vehicle immobilization: Evaluation of a program in Ohio. Accident Analysis & Prevention, 29(5), 635-642.

Voas, R. B., Tippetts, A. S., & Taylor, E. (2000). Effectiveness of the Ohio vehicle action and administrative license suspension laws.

Wagenaar, A. C., & Maldonado□Molina, M. M. (2007). Effects of Drivers' License Suspension Policies on Alcohol□Related Crash Involvement: Long□Term Follow□Up in Forty□Six States. Alcoholism: Clinical and Experimental Research, 31(8), 1399-1406.

Watson, B. C. (2004). How effective is deterrence theory in explaining driver behaviour: A case study of unlicensed driving. WHO. (2015). Global status report on road safety. (1475-5785). World Health Organisation.