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Journal of Interpersonal Violence
27(12) 2303–2321

DOI: 10.1177/0886260511433515
http://jiv.sagepub.com
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Canadian Firearms Legislation and Effects on Homicide 1974 to 2008

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Abstract

Canada has implemented legislation covering all firearms since 1977 and presents a model to examine incremental firearms control. The effect of legislation on homicide by firearm and the subcategory, spousal homicide, is controversial and has not been well studied to date. Legislative effects on homicide and spousal homicide were analyzed using data obtained from Statistics Canada from 1974 to 2008. Three statistical methods were applied to search for any associated effects of firearms legislation. Interrupted time series regression, ARIMA, and Joinpoint analysis were performed. Neither were any significant beneficial associations between firearms legislation and homicide or spousal homicide rates found after the passage of three Acts by the Canadian Parliament—Bill C-51 (1977), C-17 (1991), and C-68 (1995)—nor were effects found after the implementation of licensing in 2001 and the registration of rifles and shotguns in 2003. After the passage of C-68, a decrease in the rate of the decline of homicide by firearm was found by interrupted regression. Joinpoint analysis also found an increasing trend in homicide by firearm rate post the enactment of the licensing portion of C-68. Other factors found to be associated with homicide rates were median age, unemployment, immigration rates, percentage of population in low-income bracket, Gini index of income equality, population per police officer, and incarceration rate. This study failed to demonstrate a beneficial association between legislation and firearm homicide rates between 1974 and 2008.

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Keywords

community violence, criminology, domestic violence, homicide, legal intervention

Introduction

As in many first world and emerging nations, homicide and spousal homicide by firearm is an important and controversial public health issue in Canada. The Canadian homicide rate by firearms is approximately 0.6 per 100,000, representing roughly 200 deaths a year. It is the means of death in more than 30% of all homicides (Statistics Canada). Firearms account for only 0.05% of the 1.2 million presentations to Emergency Departments in Canada's most populous province, Ontario; however, they usually result in hospitalization (Macpherson & Schull, 2007). Homicide by firearm peaked dramatically in 1974 and has been gradually declining prior to the implementation of legislation (Mauser & Holmes, 1992).

Spousal violence in Canada rarely involves firearms, in the range of 0.2%; however, when homicides occur, 30% involve a firearm, specifically a rifle or shotgun (Ogrodnik, 2008). Spousal homicide by firearm has declined in Canada since 1974, from 3.2 to 0.6 per million.

With the recent close defeat of Bill C-391, a bill to abolish the long-gun registry, firearms legislation is once again a contentious issue in Canada (Hoeppner, 2010). There currently exists a range of studies regarding firearms legislation as a public health issue. Some studies suggest that the control of availability of firearms has a preventative or opportunistic effect on homicide (Bridges, 2004; Bridges & Kunselman, 2004; Cook, 1983). Others demonstrate that the control of firearms has no significant effect (Kleck, 1993; Maki & Mauser, 2003; Mauser & Holmes, 1992). Some research even reveals that legislation may increase violent crime rates possibly by limiting a resource for defense or deterrence (Kleck & McElrath, 1991; Lott & Whitley, 2001). Recently, the National Academies of Science published an extensive review of existing firearms studies, but the results were equivocal and suggestive that more research in this area was needed (Wellford, Pepper, & Petrie, 2004).

Canada has adopted an incremental series of three firearms laws over the past 40 years providing a model to study the effects of each particular legal intervention on homicide rates (Royal Canadian Mounted Police, 2009). Previous studies of Canadian firearms legislation have been contradictory, have not included current data, and have not examined all legislations

(Bridges, 2004; Leenars & Lester, 1994; Mauser & Holmes, 1992; Sproule & Kennett, 1988). Moreover, a report for the Department of Justice of Canada has called for evaluation of the Canadian legislation on homicide and spousal homicide, in particular legislations enacted in 1991 and 1995 (Dandurand, 1998).

Bill C-51, passed by Canada's House of Commons in 1977, required all firearms purchasers to undergo a criminal record check and obtain a firearms acquisition certificate (FAC). Mandatory minimum sentences and increased penalties were enacted, search and seizure powers granted, new definitions for prohibited and restricted firearms were given, and individuals were no longer allowed to register handguns at commercial addresses. C-17, passed in 1991, added two reference checks as well as spousal endorsement, photo identification, safety training involving written and practical testing, and a mandatory waiting period prior to obtaining an FAC. Safe storage laws, transportation laws, magazine capacity restrictions, prohibition of fully automatic firearms, restrictions on military-appearing firearms, and new criminal code offences and minimum sentences were also added. Finally in 1995, Bill C-68 introduced two types of licenses in place of the FAC, possession only (POL) and possession and acquisition (PAL), and added further screening of licensees, made license mandatory to purchase ammunition, dealt with the requirements of authorization to transport restricted firearms, and enacted harsher sentences for serious crimes involving firearms.

It should be noted that portions of Canadian legislation are implemented over subsequent years after their passage; for example, the FAC came into effect in 1979 and the PAL/POL in 2001. As part of C-68, the registration of all rifles and shotguns was mandatory by 2003, known as the "long-gun registry," whereas handguns have been registered since 1934 (Royal Canadian Mounted Police, 2009).

Method

Data Sources

Data from 1974 to 2008, including population, crime rates, economic information, numbers of police, and homicide, were obtained from Statistics Canada Juristat Database 85-002-XIE, and CANSIM 051-0001, 051-0011, 251-0001, 253-0002, 253-0003, 254-0001, 254-0002, 202-0708, 202-0709 (accessed March 2011). Spousal homicide rates for same-sex couples were not obtainable.

Statistical Analysis

To test for factors effecting homicide rates, regression analysis was performed on the time frame 1974-2008, using variables suggested in the literature to be associated with criminality that could be obtained from available data: the median age of population, population attributed to immigration, population per police officers, the rate of prison incarceration, the rate of unemployment, the percentage of 15-to-24-year-old population in the low-income bracket, percentage of the total population in the low-income bracket (defined as spending 63% of after tax income on food, shelter, and clothing), and the Gini index of equality (Lee & Slack, 2008; Marvell & Moody, 1996; Mauser & Holmes, 1992; Nadanovsky & Cunha-Cruz, 2009; Ouimet, 1999).

Three methods of statistical analysis to search for legislative effects were performed on the data. Method A used an interrupted time series Poisson regression analysis on a selected point pre- and postfirearms legislation to search for immediate impacts (defined as a "step" change) or changes in the trend of homicide rates due to legislation effects. Negative binomial regression was chosen over Poisson regression when the data contained evidence of overdispersion (Klieve, Barnes, & De Leo, 2009). The following mathematical model was designed:

$$\text{Log (homicide/population)} = \alpha + \beta_1 T + \beta_2 L + \beta_3 T \times L$$

where T represents time, L is a dummy variable coded 0 for prelegislation and 1 for postlegislation and $T \times L$ represents the interaction. A change in the rate of homicide is determined by the postlegislation slope, β_3, while an immediate change, defined as a step change, in the homicide rate is indicated by β_2 (Supplementary Figure A).

Regression was performed using GENLIN in SPSS version 19 with the log of the Canadian population used as the offset.

Analysis was performed on pre-post firearms legislation at points prior to each of the following years, 1978, 1992, 1996, and 2002 or with all years in a combined model. Total homicide due to firearms, long guns, and handguns were tested to examine for any specific effect of firearms legislation. The model was also tested against nonfirearms homicide as a test of internal validity to check for potential external factors effecting homicide rates at pre-post time points confounding the results. To search for delayed effects due to the duration involved in the application of legislation and the fact that provisions of the firearms legislation are implemented in subsequent years, pre-post points were advanced up to 4 years after passage of C-51 and C-17 and up to 8 years after passage of C-68 with a focus on the dates of enactment of portions of legislation. C-17 (1991) introduced and C-68 (1995) added additional background and spousal reference checks, and therefore spousal homicide by firearm type was also examined as above.

Method B used autoregressive integrated moving average (ARIMA) analysis in SPSS 19 (SPSS Inc., 1999) and ARIMA procedure using SAS 9.1.3 software (SAS Institute Inc., 1998). Parsimony was adhered to using the Schwarz's Bayesian Criteria for selection of p, d, and q values, and a stationary process was obtained prior to choosing best p and q terms using an Augmented Dickey-Fuller test (McCleary & Hay, 1980).

Method C was carried out with Joinpoint regression software version 3.4.3 (http://srab.cancer.gov/joinpoint/) to search for changes caused by implementation of firearms legislation. Joinpoint is a statistical tool designed to locate a point or "joinpoint" in a time series where a change in magnitude and direction of a linear trend occurs. Although primarily developed to study cancer data, it has also been used to detect changes in suicide rates (Gagne, Robitaille, Hamel, & St. Laurent, 2010). Joinpoint regression involves permutation tests on a Monte Carlo data set to select a final model that includes a Bonferroni adjustment to control for error probability arising from multiple tests (Kim, Fay, Feuer, & Midthune, 2000). An analysis begins with no joinpoints and then tests whether an addition of a joinpoint provides a statistically significant improvement on the model. The benefit of the Joinpoint analysis is that it can detect a specific time where a change occurs that the prior methods may miss.

Joinpoint analysis was performed with the following parameters: a maximum of 4 joinpoints and a minimum of 4 years between joinpoint. Random errors were assumed to be heteroscedastic between rate variances.

Results

Regression analysis was performed on the variables described above and significant results are reported in Table 1. The median age of the population was associated with homicide rates in all categories other than homicides from both handgun and nonfirearm causes. However, an alternative model for nonfirearm homicide can be constructed using median age ($B = -0.03$, $p < .001$) and unemployment rate ($B = 0.22$, $p = .003$) with slightly less goodness of fit (Bayesian Information Criterion = 360.80 vs. 342.22). When homicide data were adjusted for the effects of median population age, a more stable rate over time of homicide can be appreciated graphically (Figure 1).

Table 1. Results of Multivariate Regression Analysis

Homicide Type	*B*	χ^2	*p* (Significance)
All homicide			
Median age	−0.019	12.035	.001*
Population per police	−0.003	18.926	<.001*
Unemployment rate	0.017	8.033	.005*
Nonfirearm homicide			
Median age	−0.010	2.981	.084
Population per police	−0.004	109.237	<.001*
Unemployment rate	0.030	21.688	<.001*
Firearm homicide			
Median age	−0.091	27.571	<.001*
Percent population immigrants	0.771	10.924	.001*
Population per police	−0.004	13.956	<.001*
Incarceration rate	0.012	9.572	.002*
GINI Index	10.132	11.309	.001*
Long gun homicide			
Median age	−0.148	346.429	<.001*
Incarceration rate	0.007	4.725	.030*
Handgun homicide			
Median age	0.034	1.983	.159
Percent population immigrants	1.783	37.796	<.001*
Population per police	−0.008	37.763	<.001*
Unemployment rate	0.082	22.388	<.001*
Percent low-income population	0.046	5.268	.022*
GINI Index	20.161	58.311	<.001*
Spousal homicide by firearm			
Median age	−0.135	347.849	<.001*
Percent population immigrants	0.906	8.669	.003*
Unemployment rate	0.035	5.873	.015*
Spousal homicide by long gun			
Median age	−0.134	270.793	<.001*

*Represents results considered to be significant, having a statistical p value less than 0.05.

Interrupted time-series regression analysis produced no statistically significant associations in terms of reduced immediate impact or long-term trend in the overall firearm homicide rate, long-gun, and handgun homicide rate immediately and within 4 years after the passage of C-51 and C-17 (Table 2).

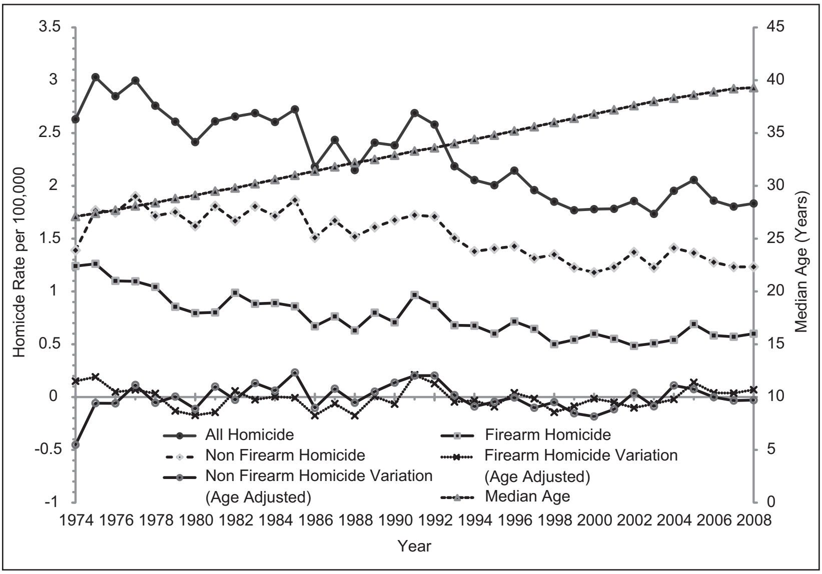

Figure 1. Homicide rates in Canada 1974 to 2008

Note: All homicide rates are decreasing over time following a dramatic peak in 1974. The median age of the Canadian population is also increasing over time. When the effect of median age is removed, the rate of nonfirearm- and firearm-related homicide appears to follow a steady state.

Statistically significant effects were not immediately appreciated after the introduction of C-68 in 1996. However, when pre-post points are advanced to 1998, a statistically significant step effect, or reduction, in overall firearm and subcategory long-gun homicides was found (Table 2). During this time frame and prior to C-68, a statistically significant step effect for nonfirearms homicides was also occurring each year. This suggests an external factor contributing to the reduction of all homicides during those years. There was also an increasing trend in firearms homicides as well as long-gun homicides post C-68 suggesting the step effect may be due to the presence of a confounding variable.

To control for associated factors, median age was applied to the regression model. There was no longer a significant step effect in 1998 for homicide by firearm (year 1998: $B_{step} = -0.19$, $p = .06$; $B_{trend} = 0.04$, $p = .005$); however, the trend of increasing homicide by firearm compared with prelegislation was maintained. When all significant variables were included in the regression, no significant effects were found (Table 2).

Table 2. Selected Results of Interrupted Time Series Regression

Homicide	Constant	Intervention		Multivariate		Factor Components Multivariate[a]	
		B	*p*	*B*	*p*	*B*	*p*
Nonfirearm 1978	β_2 (immediate)	−0.050	.450	−0.061	.275		
	β_3 (slope)	−0.105	.001[a]	−0.068	.019[a]		
Firearm 1978	β_2 (immediate)	−0.138	.243	−0.054	.595	−0.1195	.3504
	β_3 (slope)	0.032	.579	0.017	.779	0.0503	.4574
Long gun 1978	β_2 (immediate)	0.019	.886	−0.047	.611	−0.0476	.6862
	β_3 (slope)	0.001	.982	0.052	.245	0.0478	.4340
Handgun 1978	β_2 (immediate)	−0.103	.622	0.052	.741	−0.1547	.4765[e]
	β_3 (slope)	0.121	.240	−0.007	.932	0.1823	.0962
Nonfirearm 1979	β_2 (immediate)	−0.013	.841	−0.016	.763		
	β_3 (slope)	0.059	.015[a]	−0.032	.137		
Firearm 1979	β_2 (immediate)	−0.128	.194	−0.144	.111	−0.1454	.2489
	β_3 (slope)	0.031	.375	0.001	.985	0.0320	.5319
Long gun 1979	β_2 (immediate)	−0.061	.510	−0.130	.123	−0.1482	.2329
	β_3 (slope)	−0.013	.676	0.025	.423	0.0158	.7289
Handgun 1979	β_2 (immediate)	−0.047	.827	−0.069	.634	−0.1978	.3466[e]
	β_3 (slope)	0.102	.179	−0.031	.626	0.1380	.0937
Nonfirearm 1992	β_2 (immediate)	−0.107	.035[a]	−0.057	.217		
	β_3 (slope)	−0.010	.045[a]	−0.010	.146		
Firearm 1992	β_2 (immediate)	−0.021	.814	−0.100	.275	−0.0983	.4462
	β_3 (slope)	0.012	.194	0.016	.435	0.0182	.1722
Long gun 1992	β_2 (immediate)	−0.075	.422	−0.096	.348	−0.1117	.2910
	β_3 (slope)	−0.012	.192	0.010	.524	0.0131	.3999
Handgun 1992	β_2 (immediate)	0.265	.095	−0.129	.317	0.1397	.4934

(continued)

Table 2. *(continued)*

Homicide	Constant	Intervention B	Intervention p	Multivariate B	Multivariate p	Factor Components Multivariate[a] B	Factor Components Multivariate[a] p
	β_3 (slope)	0.011	.467	0.041	.208	0.0491	.1255
Nonfirearm 1996	β_2 (immediate)	−0.149	.007[a]	0.070	.322		
	β_3 (slope)	0.002	.720	−0.022	.067		
Firearm 1996	β_2 (immediate)	−0.099	.285	0.123	.347	−0.1845	.0923
	β_3 (slope)	0.021	.040[a]	0.025	.347	0.0398	.0073[a,b,d]
Long gun 1996	β_2 (immediate)	−0.101	.314	0.006	.961	0.0722	.5547
	β_3 (slope)	−0.004	.712	0.014	.456	0.0181	.2627
Handgun 1996	β_2 (immediate)	−0.001	.995	0.244	.142	−0.1815	.3811
	β_3 (slope)	0.011	.569	0.000	.998	0.0856	.0136[a]
Nonfirearm 1998	β_2 (immediate)	−0.145	.017[a]	0.018	.759		
	β_3 (slope)	0.009	.274	−0.021	.110		
Firearm 1998	β_2 (immediate)	−0.218	.017[a]	−0.242	.081	−0.1502	.0956
	β_3 (slope)	0.039	.001[a]	0.021	.394	0.0686	.0002[a,b,c,d]
Long gun 1998	β_2 (immediate)	−0.302	.007[a]	−0246	.079	−0.2077	.1104
	β_3 (slope)	0.018	.263	0.035	.093	0.0227	.0944
Handgun 1998	β_2 (immediate)	−0.131	.467	−0.136	.454	−0.1062	.6580[e]
	β_3 (slope)	0.024	.316	−0.011	.774	0.0605	.1420[e]
Firearm 2001	β_2 (immediate)	−0.117	.322	−0.111	.429	−0.0987	.3179
	β_3 (slope)	0.050	.016[a]	0.046	.132	0.0732	.0007[a,d]
Long gun 2003	β_2 (immediate)	−0.170	.342	−0.068	.710	0.0379	.7865
	β_3 (slope)	0.047	.279	0.090	.091	0.0332	.2876
C-17 spousal	β_2 (immediate)	−0.025	.820	−0.194	.093	−0.0533	.6292
homicide by firearm	β_3 (slope)	−0.016	.151	0.023	.174	−0.0167	.1521

(continued)

Table 2. *(continued)*

Homicide	Constant	Intervention		Multivariate		Factor Components Multivariate[a]	
		B	*p*	*B*	*p*	*B*	*p*
C-68 spousal homicide by firearm	β_2 (immediate)	−0.172	.171	0.028	.828]	−0.1885	.1075
	β_3 (slope)	0.001	.924	0.015	.376	−0.0023	.8627
C-68 spousal homicide by long gun	β_2 (immediate)	−0.162	.286	−0.035	.773	0.0389	.8034
	β_3 (slope)	0.015	.409	0.005	.689	0.0005	.9772
C-68 spousal homicide by firearm post-PAL/POL	β_2 (immediate)	−0.253	.145	−0.169	.416	−0.2248	.1391
	β_3 (slope)	0.035	.279	0.062	.171	0.0442	.1601
C-68 spousal homicide by long gun post–long gun registry	β_2 (immediate)	−0.288	.213	−0.197	.456	−0.1008	.6411
	β_3 (slope)	0.115	.034[a]	0.086	.200	0.0527	.3969

Note: Regression results under Intervention include only the legislation within the model, while Multivariate reports results for the effects of legislation with the inclusion of variables found to be significant in Table 1. Procedure for multivariate regression: Subtractive regression for all other variables as per Table 1 followed by additive and subtractive regression with those other variables to the time model to control for multivariates contribution.

[a]Principal components analysis was performed using procedure FACTOR in SAS software to reduce the number of independent variables to control for multicollinearity. As well regression of correlated variables were regressed and residuals used in multivariate analysis as an alternative method to principal components analysis.

[b]Statistically insignificant with Median Age as multivariate.

[c]Removal of GINI from primary components analysis produces statistically significant variable factor.

[d]Statistically insignificant with all variable residuals, orthogonalized by year. Produces acceptable VIF of <10.

[e]Statistically insignificant factor 1 removed.

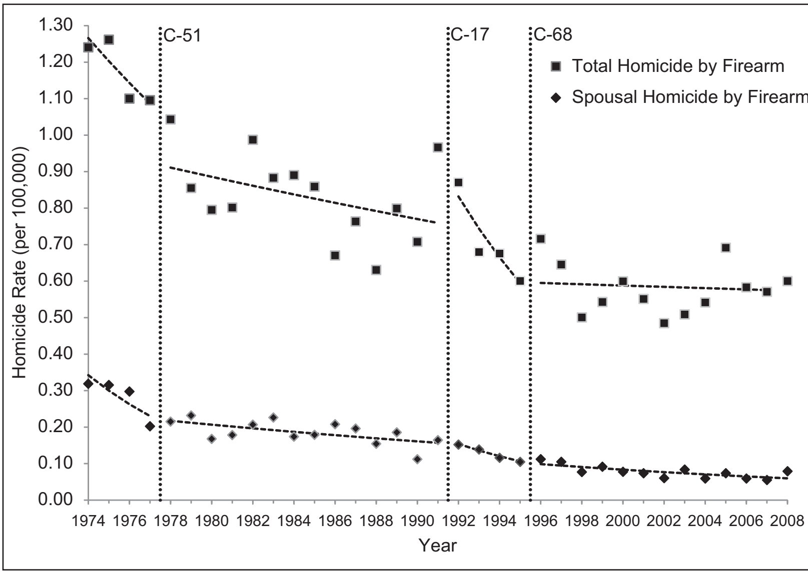

Figure 2. Interrupted regression analysis, all legislation included
Note: Breakpoints in trend lines indicate years pre- and postlegislation. The decrease in the declining trend of all firearms homicide following C-68 is the only significant change.

ARIMA was performed as a separate method to verify the regression model. No statistically significant associations with C-68 was found in 1998 (firearm homicide: ARIMA[1,1,0] 29.21% reduction, $B = -0.15$, $p = .15$; long gun: ARIMA[1,1,0] 18.72% reduction, $B = -0.09$, $p = .18$). ARIMA analysis also did not demonstrate a beneficial associative effect with the other legislations in all homicide categories over all years of interest with and without median age and other significant variables. ARIMA analysis also failed to find gradual permanent effects that might have occurred after 1998 with the replacement of the FAC by the PAL/POL and the implementation of the long-gun registry (firearm homicide: ARIMA[1,1,0] 86.21% increase, $B = 0.27$, $p = .94$; long gun: ARIMA[1,1,0] 77.61% reduction, $B = -0.65$, $p = .60$).

To adjust for the effects of previous legislation on subsequent legislation, a model combining all legislation was produced (Figure 2, Supplementary Figures B and C). A trend of increasing firearms homicide was noted post C-68 (year 1998: $B_{trend} = +0.06$, $p = .05$, % change = +14.8%) but no significant step effects were discovered suggesting the step noted in 1998 is not significant. Late effects of C-68 coming into effect in 2001, such as the PAL/POL, was also tested with this model, and no statistically significant effects of the legislation were noted (year 2001: B_{step} = –0.06, *p* = .70, B_{trend} = 0.079, *p* = .07).

Spousal homicide by firearm was also examined using interrupted regression and ARIMA. No associations were found after C-17 was passed and up to 4 years afterward (Figure 2; Table 2; Spousal Firearm Homicide: ARIMA[0,1,1] 2.1% reduction, *B* = –.009, *p* = .75). C-68 also produced no association either immediately after passage or after the implementation of the PAL/POL (2001) or long-gun registry (2003; Figure 2; Table 2; Spousal Firearm Homicide: ARIMA[0,1,1], 1996, 0.9% reduction, *B* = –0.004, *p* = .89; 2001, 2.5% reduction, *B* = –0.01, *p* = .72; 2003, 2.8% increase, *B* = 0.01, *p* = .69; spousal long-gun homicide, ARIMA[2,1,0], 1996, 1.1% reduction, *B* = –0.005, *p* = .82; 2003, 1.9% increase, *B* = 0.01, *p* = .74).

Joinpoint analysis was performed on homicide due to firearms, long guns, and handguns as well as spousal homicide by firearms and long guns. Joinpoint failed to detect any point in time where a change in trend occurred that would support legislation causing a decrease in the rate of any type of homicide. A joinpoint was generated at 2002 (C-68), where an increase in the baseline rate of firearm homicide occurred from an annual percentage change (APC) of –2.7% (95% CI [–3.2, –2.1]) to an increased APC of 2.3% (95% CI [–4.2, 9.2]; Figure 3). Interestingly, in 1991 (C-17), the rate of handgun homicide increased from an APC of –3.6% (95% CI [–6.0, –1.1]) to an APC of –0.3% (95% CI [–1.7, –1.2]). All joinpoint changes in trend are statistically significant (*p* = .01).

Discussion

This study demonstrated an association between increasing median age of the population and a decline in both homicide and firearms homicide, in agreement with previous work over an earlier timeframe (Table 1; Mauser & Holmes, 1992). Research in other countries have also associated decreased criminality with an older population (Gartner & Parker, 1990; McCall, Parker, & MacDonald, 2007). It is interesting that once the effects of median age are taken into account, the trend of homicide and homicide by firearm remains at a relatively steady rate suggesting the gradual decline in homicide is in part due to the increasing median age of the population over the time frame studied (Figure 1).

Socioeconomic factors found to have a correlation with homicide rates were the percentage of population attributed to immigrants, the unemployment rate, the percentage of population in low-income bracket, and the Gini index of income equality (Table 1). Immigration and unemployment were

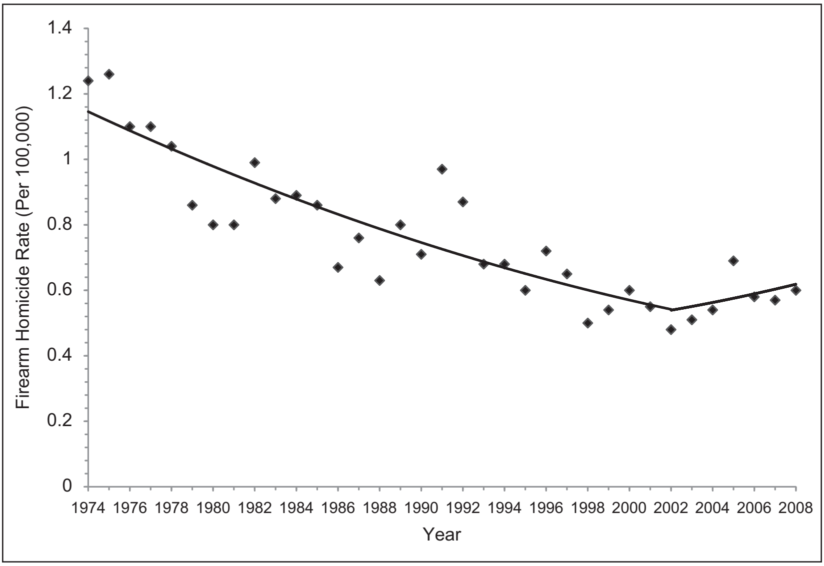

Figure 3. Joinpoint graphical depiction of firearm homicide
A point of inflection in 2002 is noted. Just at that time the final portion of C-68, the long-gun registry, came into effect.

previously found by Mauser and Holmes (1992) to be related to homicide by firearm, and economic factors have also been shown to be associated with criminality, so this is not unexpected (Lee & Slack, 2008; Mauser & Holmes, 1992; Nadanovsky & Cunha-Cruz, 2009). What is interesting to note is that the subcategory of firearm homicide by handgun is associated with most of these variables, suggesting an area of further study for risk reduction.

An increase in the number of police officers per population and incarceration rate was found to have an associated increase in homicide rates, possibly reflecting a response to increased crime rates (Table 1). However, the potential for error exists with the use of proxy variables. For example, an increase in the number of police could be tempered by concurrent decreases in efficiency and effective use of manpower unaccounted for in analysis.

No statistically significant step effects or increasing decline of firearms homicide was associated with C-51. This is in agreement with previous research which used different methodology and examined the data for 1968 to 1991 (Mauser & Holmes, 1992). Neither were any significant effects shown due to C-17, which contradicts the conclusions of Bridges who used a

7-year duration pre-post legislation sample and a simple linear regression model (Bridges, 2004). This study differs in that a longer duration was used to control for error and random short trends. In addition, contributing factors such as median age were included in the model, overdispersion and autocorrelation were taken into account, and potential effects of prior legislation, C-51, were studied.

Regarding C-68, a beneficial effect on homicide by firearm was only found in one year, 1998. This effect is unlikely to be explained by legislation as the effects were lost when median age was accounted for. In addition, ARIMA and joinpoint analysis failed to indicate an association. During the same time frame, step effects were found with nonfirearm homicide, possibly suggesting the occurrence of an unknown factor. Moreover, a trend toward an increase in the rate of firearms homicide occurred in the years following 1998 negating a step drop. Further lending credence to this is that the implementation of portions of C-68 only came into effect in 1999 with little occurring in 1997 and 1998 (Royal Canadian Mounted Police, 2009). Finally, the rate of criminal conviction for "discharging a firearm with intent" (R.S., 1985, c. C-46, s. 244) was analyzed and C-68 was found to have had no association.

No beneficial immediate reduction was seen on homicide by firearm in 2001 after full implementation of the PAL/POL licensing system or on homicide by long gun in 2003 after the long-gun registry became mandatory in both interrupted regression and ARIMA analysis. It is possible that an immediate effects model would miss a significant effect due to the gradual phasing in of these interventions starting late 1998. However, as reported by Canada's Auditor General, most firearms owners waited until the deadline to comply (Office of the Auditor General of Canada, 2002). Still ARIMA analysis of gradual permanent effects was conducted and failed to demonstrate a benefit supporting the prior models.

Both C-51 and C-17 had nonsignificant effects on the long-term trend of the overall firearm homicide rate. However, after the implementation of C-68, there was a statistically significant increase in the firearm homicide rate over time in both interrupted time series and Joinpoint analysis (Figures 2 and 3). Interestingly, the joinpoint occurred right after the implementation of the POL/PAL. What this represents is unclear. The addition of median age to the model alone does not account for the increase, though adding further variables does suggesting rather an effect due to contributing factors. Or this could simply be a return to the mean. Further research is required to determine whether this increase is related to the deterrent effect of firearms, as some authors have suggested (Kleck, 1993; Lott & Whitley, 2001).

The inability to find a consistent association between legislation and homicide by firearms in this study is not entirely unusual. A Canadian study by Mauser and Holmes (1992) failed to find a significant effect of C-51 on homicide, and a second study by Maki and Mauser (2003) found no beneficial effect of C-51 on robbery involving the use of firearms and may have even contributed to an increase in rate of armed robbery (Maki & Mauser, 2003; Mauser & Holmes, 1992). Australia instituted strict legislation in 1996, and a number of conflicting studies have been published since (Baker & McPhedran, 2007; Neill & Leigh, 2007). Recently, a rigorous study using ARIMA analysis demonstrated no measureable effect on homicide (Lee & Suardi, 2008). Finally two systematic reviews in the United States concluded that there was insufficient evidence supporting firearms legislation (Hahn et al., 2003; Wellford et al., 2004).

The author has no definitive explanation as to why legislation was not found to have a measureable effect in this study. Some researchers have maintained that a number of regulations target legal firearms owners, a group of people who were already low-risk individuals and were unlikely to contribute to criminality (Mauser, 2001). Others state that in regard to the criminal use of firearms, studies of minimum sentencing, a part of the Canadian legislation, have suggested it has not had the positive intended effect (Tonry, 2009). Other work has revealed that criminals tend to purchase, and often lend firearms, between intimate contacts and prefer not to purchase through legitimate sources; nor are firearms particularly difficult for them to obtain (Morselli, 2002; Wellford et al., 2004).

Limitations

This quasi-experimental study is limited by potential internal validity errors and lacks a control group. For example, some confounding force not included in the study may have occurred at the time point of legislation causing an effect error. An attempt has been made to control for population, social, criminal, and economic factors related to criminal rates and homicide in this study, but as Canadian firearms laws are applied at the federal level, geographical controls and cross-sectional studies were not possible. Pure time series, as opposed to panel data, usually make it difficult to disentangle various factors that might change crime rates. One advantage of the time-series data used in this article is that the new statistical techniques provided here better make use of the multiple changes in Canadian gun-control laws. In some cases, pure time-series data are the only data that are available and that the approach used here can hopefully be generalized to other issues.

Recently in 2008, Quebec enacted provincial legislation pertaining to firearms creating a future opportunity for these types of studies (Quebec, 2007).

Statistics Canada official sources were used, but all data are susceptible to input error and validity. Finally though the suggested minimum of 25 data points for ARIMA analysis have been exceeded, the time since legislation is still relatively recent, and longer term trends may develop (McCleary & Hay, 1980). Hence, a continued examination of the longer term effects of firearms legislation in Canada is encouraged.

Conclusions

Three different methods of analysis failed to definitively demonstrate an association between firearms legislation and homicide between 1974 and 2008 in Canada. Although further study using future data may clarify the issue, this analysis adds important information in an area where there exists a paucity of studies.

Acknowledgements

The author appreciates the contributions of J. Sherbino MD, MEd, FRCP; M. Welsford MD, ABEM, FACEP, FRCPC; R.H. Hemmingson BA, BEd, JD (dist); and O.C. Ramirez BSc, MD, CCFP.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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