FORM 80A - Rule 80

AFFIDAVIT

Court File No. T-577-20

FEDERAL COURT

BETWEEN:

CANADIAN COALITION FOR FIREARM RIGHTS, RODNEY GILTACA, LAURENCE KNOWLES, RYAN STEACY, MACCABEE DEFENSE INC., WOLVERINE SUPPLIES LTD., AND MAGNUM MACHINE LTD.

Applicants

and

ATTORNEY GENERAL OF CANADA and CANADA (ROYAL CANADIAN MOUNTED POLICE)

Respondents

APPLICATION UNDER sections 18 and 18.1 of the *Federal Courts Act*, RSC 1985, c F-7.

AFFIDAVIT

I, Caillin Langmann, Doctor, of the City of Hamilton, in the Province of Ontario, SWEAR or AFFIRM THAT:

1. I am a medical doctor with an appointment as an Assistant Clinical Professor of Medicine in the Department of Medicine, Division of Emergency Medicine at McMaster University. I am also an Emergency Physician at St Joseph's Hospital and Hamilton Health Science, both in Hamilton, Ontario.

2. I am aware of the Application filed in Court File No. T-577-20 ("**Application**") regarding the May 1, 2020 Order in Council SOR/2020-96 (the "**Order in Council**") which made the *Regulations Amending the Regulations Prescribing Certain Firearms and Other Weapons, Components and Parts of Weapons, Accessories, Cartridge Magazines, Ammunition and Projectiles as Prohibited, Restricted or Non-Restricted*, SOR/2020-96 (the "**Regulation**"), and regarding certain things done by the Royal Canadian Mounted

Police ("**RCMP**"), including through the Specialized Firearms Supports Services Unit ("**RCMP SFSS**"), in relation to the Firearms Reference Table ("**FRT**") as described in the Application. I am also aware of the *Order Declaring an Amnesty Period (2020)*, SOR/2020-97 (the "**Amnesty Order**") with respect to the Regulation.

3. I understand that my duty is to assist the Court, and I am not an advocate for any particular party. My opinion is independent and unbiased. It is based upon my own observations and expertise.

Education and Experience

4. From 1992 to 1999 I attended undergraduate studies at Simon Fraser University in Burnaby, British Columbia ("**SFU**"). In 1999, I graduated with a Bachelor of Science with a double major in Biochemistry and Molecular Biology and Economics. That same year I commenced my post-graduate studies at SFU. I received my Ph.D. in Biochemistry and Molecular Biology from SFU in 2004.

5. Following my matriculation from SFU, I attended Queen's University School of Medicine in Kingston, Ontario, where I obtained my Medical Doctorate degree with honours in 2008.

6. After graduating from medical school, I pursued my residency in emergency medicine and furthered my studies in the speciality of emergency medicine at McMaster University from 2008 to 2013 as a Fellow Royal College of Physicians Canada, Specialist in Emergency Medicine. During this time, I was the Chief Trauma Fellow in 2011 and received the Original Research Award in Emergency Medicine in 2013 for research on Canadian firearms legislation and homicide.

7. In 2011, I started working as a Critical Care Clinical Assistant with Hamilton Health Science. I held this position until 2013.

8. I was certified as a Diplomate American Board of Emergency Medicine in October 2014.

9. Since completing my studies in 2013, I have been working as an Emergency Physician at St. Joseph's Hospital and Hamilton Health Science, as well as an Assistant Clinical Professor of Medicine at McMaster University and the Director of the Clinical Teaching

Unit at St. Joseph's Hospital. My *curriculum vitae* is attached as **Exhibit "A"** to this my Affidavit, which lists my credentials, employment history, memberships and certificates, publications and abstracts, presentations, and scholarships.

Publications on Firearm Violence and Legislation

10. While doing my residency in emergency medicine, I became interested in firearm legislation and the pursuit of reduced harm by firearms. As an emergency physician, I am called upon to medically respond to the effects of firearms violence, including injuries and death caused by firearm. As a result of my education and practice, I have had the opportunity to study the causes of firearms violence and possible ways to mitigate and reduce firearms violence in Canada and elsewhere.

11. In 2011, I published a research paper entitled "Canadian Firearms Legislation and Effects on Homicide 1974 to 2008". This research paper is attached as **Exhibit "B"** to this my Affidavit. This paper was a statistical study on the rates of homicide (and, as a subcategory, spousal homicide) in response to legislative changes enacted by Bill C-51 (1977), C-17 (1991) and C-68 (1995).

12. I recently published a sequent research paper entitled "Effect of firearms legislation on suicide and homicide in Canada from 1981 to 2016". I have attached this research paper as **Exhibit "C"** to this my Affidavit.

13. Both of the foregoing research papers conclude that Canadian legislation to regulate and control firearm possession and acquisition does not have a corresponding effect on homicide and suicide rates. What appears to occur is that either there is a substitution effect (i.e., the homicide or suicide is carried out in a different method), or the firearms were obtained illegally and hence unaffected by the legislation.

14. In 2013, I published an article entitled the "Criticism of Firearms Legislation and Firearms-Related Fatalities in the United States". I have attached this article as **Exhibit "D"** to this my Affidavit. This article is a criticism of the paper "Firearms Legislation and Firearms-Related Fatalities in the United States" which had concluded a higher number of firearm laws were associated to a lower rate of firearm fatalities. The authors self-report being

unable to define the nature of this association. As stated in my criticism of the paper, the paper does not show causation between the existence of laws and reduced rates of firearm fatalities. It does demonstrate that so-called assault weapon bans have no associated reduction in homicide rates.

15. As described in my *curriculum vitae* I have also published many other research papers.

Past Testimony

16. I testified to the House of Commons Committee hearing in respect to proposed changes to firearms legislation on November 24, 2011. Attached as **Exhibit "E"** to this my Affidavit is my brief from that testimony.

17. I also testified to the Standing Committee on Public Safety and National Security in respect to Bill C-71, An Act to amend certain Acts and Regulations in relation to firearms. My brief was submitted in April 2018, and I testified to this Committee on February 25, 2019. Attached as **Exhibit "F"** to this my Affidavit is my brief. Attached as **Exhibit "G"** to this my Affidavit are my presentation materials from my testimony.

The Regulation

18. It is my understanding from the Regulatory Impact Analysis Statement contained in the Order in Council, that the Regulation's purpose and intent is to reduce incidents of gun violence and mass shootings in Canada. Generally, the Regulation hopes to improve public safety by prohibiting firearms that were, previous to May 1, 2020, legal to possess and acquire in Canada.

19. My research papers on this topic show that previous legislative changes which prohibit the possession and acquisition of certain firearms have made no discernable impact on the rates of homicide or suicide in Canada or elsewhere. Increased legislation has had no demonstrable beneficial effect on homicide or suicide rates in Canada.

20. For example, the following findings have been made in the academic literature on the subject of firearm legislation and firearm violence:

(a) There was no demonstrable, beneficial association between firearms legislation and firearm homicide rates between 1974 and 2008 in Canada. The introduction of the Canadian firearms legislation of 1977 did not have a significant associated effect on homicide rates. The rates of homicides carried out with legal registered firearms (firearms associated to restricted or prohibited authorizations under the *Firearms Act*, SC 1995, c 39) have not responded to the introduction of firearm laws in Canada. There is little evidence to suggest that increased firearms legislation in Canada has a significant impact on pre-existing trends in lethal firearm violence against women. The results do not support the view that increasing firearms legislation is associated with a reduced incidence of firearm-related domestic homicide victimization.[1]

(b) The buyback of firearms from legal owners implemented by governments in connection with legislation prohibiting the ownership, and use of certain firearms, including semi-automatic firearms, had no statistically observable impact on suicide or assault mortality attributed to firearms in Australia. The buyback program in that case did not have any large effects on reducing firearm homicide or suicide rates in Australia.[2]

(c) It was also found that the so-called assault weapon ban of 1994 did not significantly affect murder rates at the state level in the United States. No evidence was found to show reductions in multiple-victim gun homicides or multiple gunshot wound

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[1] Langmann C. Effect of firearms legislation on suicide and homicide in Canada from 1981 to 2016. PLoS One. 2020;15(6):e0234457.
Langmann C. Canadian firearms legislation and effects on homicide 1974 to 2008. J Interpers Violence. 2012;27(12):2303-2321.
Leenaars A, Lester D. The impact of gun control. Journal of Criminal Justice. 2001;29(4): 287–294.

[2] Gilmour S, Wattanakamolkul K, Sugai M. The Effect of the Australian National Firearms. American Journal of Public Health. 2018;108(11):1511-1516.
Chapman S, Alpers P, Jones M. Association Between Gun Law Reforms and Intentional Firearm Deaths in Australia, 1979-2013. Journal of the American Medical Association. 2016;316(3):291-299.
Lee WS, Suardi S. The Australian Firearms Buyback and its Effect on Gun Deaths. Contemporary Economic Policy. 2008;28(1):65-79.

victimizations in the United States following the so-called Federal assault weapons ban in that country.[3]

21. What has been shown is that legal firearms owners in Canada are less likely to engage in firearms violence than average citizens.[4] There is no evidence to suggest that targeting this group in legislating the acquisition and possession of firearms will result in reduction of firearms violence, homicide or suicide.

22. According to my research and analysis, there are a number of factors that may be associated to homicide and suicide rates. None of these factors are related to whether a particular firearm was legally accessible.

23. There are a number of alternative actions that a government may take that have shown promising results in reducing the rates of homicide and suicide.[5] For example, by targeting offenders through gang deterrence, intervention, and collaboration, there is a reduction in gang violence and activity. Social programs which reduce poverty, income inequality and unemployment rates and provide a focus on education have also been shown to reduce firearms violence.

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[3] Guis M. An examination of the effects of concealed weapons laws and assault weapons bans on state-level murder rates. Applied Economics Letters. 2014;21(4):265-267.
Koper C, Roth J. The Impact of the 1994 Federal Assault Weapon Ban on Gun Violence Outcomes: An Assessment of Multiple Outcome Measures and Some Lessons for Policy Evaluation. Journal of Quantitative Criminology. 2001;17(1):33-74.
Fleegler E, Lee L, Monuteaux M, Hemenway D, Mannix R. Firearm Legislation and Firearm-Related Fatalities in the United States. Journal of American Medical Association Internal Medicine. 2013;173(9):732-740.
Santaella-Tenorio J, Cerda M, Villaveces A, Galea S. What Do We Know About the Association Between Firearm Legislation and Epidemiologic Reviews. 2016;38:140-157.
[4] Langmann C. Effect of firearms legislation on suicide and homicide in Canada from 1981 to 2016. PLoS One. 2020;15(6):e0234457.
Langmann C. Canadian firearms legislation and effects on homicide 1974 to 2008. J Interpers Violence. 2012;27(12):2303-2321.
Kleck G. Measures of Gun Ownership Levels for Macro-Level Crime and Violence Research. Journal of Research in Crime and Delinquency. 2004; 41(1): p. 3–36.
Kleck G. The Impact of Gun Ownership Rates on Crime Rates: A Methodological Review of the Evidence. Journal of Criminal Justice. 2015; 43(1): p. 40–48.
[5] Langmann C. Effect of firearms legislation on suicide and homicide in Canada from 1981 to 2016. PLoS One. 2020;15(6):e0234457. Published 2020 Jun 18.
Smith-Moncrieffe D. Youth Gang Prevention. National Crime Prevention Centre, Ottawa. 2013.

SWORN BEFORE ME at the City of Hamilton, in the Province of Ontario, this 25 day of August, 2020.

A Notary Public or Commissioner for Oaths in and for the Province of Ontario

Dr. Caillin Langmann

This is **Exhibit "A"** referred to in the Affidavit of Dr. Caillin Langmann, sworn before me this 25 day of August, 2020.

A Notary Public or a Commissioner of Oaths
in and for the Province of Ontario

Caillin Langmann MD PhD ABEM FRCPC

Education

Diplomate American Board of Emergency Medicine
Certified October 2014 #51230

Fellow Royal College of Physicians Canada
Specialist Emergency Medicine
2008 – 2013 McMaster University Hamilton, ON CANADA
- Completed rotations in ER, Critical Care, Pediatric Critical Care, Trauma, Cardiac Critical Care, Internal Medicine, General Surgery
- Chief Trauma Fellow 2011
- Original Research Award 2013

M.D. Queen's University School of Medicine
2004 – 2008 Queen's University Kingston, ON CANADA
- Maintained Honors average.

Ph.D. Biochemistry and Molecular Biology
1999 – 2004 Simon Fraser University Burnaby, BC CANADA
- Demonstrated new roles for intracellular proteins involved in Jun receptor kinase signaling pathways using animal models.
- The gene Plenty of SH3 (POSH) was shown to encode a protein involved in activation and termination of Imd-mediated immunity.
- Specific Rac associated protein 1, Sra-1, was shown to be important in neuron path-finding during development.
- Funded by National Sciences and Engineering Research Council Canada (NSERC) Post Graduate Scholarship.

BSc. Biochemistry and Molecular Biology, Economics
1992 – 1999 Simon Fraser University Burnaby, BC CANADA

Work experience

Assistant Clinical Professor of Medicine McMaster University
2013 – Present Department of Medicine McMaster University, ON CANADA
- Member Hamilton Integrated Ethics Review Board
- Director Clinical Teaching Unit St. Joseph Hospital

Emergency Physician
2013 - Present St Joseph Hospital Hamilton, ON CANADA
- Staff Emergency Physician

Emergency Physician
2013 - Present Hamilton Health Science Hamilton, ON CANADA
- Staff Emergency Physician

Emergency Physician Emergency Physician
2013 - 2017 William Osler Brampton, ON CANADA
- Staff Emergency Physician

Critical Care Clinical Assistant
2011 - 2013 Hamilton Health Science Hamilton, ON CANADA
- Physician providing critical care medicine for multi-bed intensive care facility
- Contact: Joanne Hordienko 905 521-2100 X44697 hordienk@HHSC.CA

Advanced Trauma and Life Support Instructor
2010 Hamilton Health Science Hamilton, ON CANADA
- Instruction and certification of physicians in Advanced Trauma and Life Support

Residency Emergency Medicine
2008 – 2013 McMaster University Hamilton, ON CANADA
- As described above under FRCP Program
- Contact: Teresa Vallera 905 521-2100 X76207 vallera@mcmaster.ca

Research Semester
Summer 2005, 2006 Queens University Kingston, ON CANADA
- Conducted research on Acetaminophen toxicity.
- Constructed computerized and statistical algorithms to analyze a subset of 3500 patients from the Canadian Acetaminophen Overdose Study database.
- Characterized time-course of biochemical markers.
  Constructed clinical prognostic tool for predicting survival or death in acute and chronic overdose

Sessional Instructor
Sept. 2002 Simon Fraser University Burnaby, BC CANADA
- Instructed classroom lectures of upper division course in Biochemistry and Molecular Biology, Intermediary Metabolism MBB 321.
- Supervised teaching assistants.
- Designed and directed the application of educational material.

Teaching Assistant
Jan. 2000 – May 2002 Simon Fraser University Burnaby, BC CANADA
- Instructed upper division classes in Biochemistry and Molecular Biology.
- Assisted in the evaluation of students, graded exams, and other course work.
- Provided one on one supplementary teaching for students requiring additional instruction.
- Mentored undergraduate students .
- Received excellent student and instructor evaluations

Memberships and Certificates

Fellow Royal College of Physicians and Surgeons Canada
Diplomate American Board of Emergency Medicine
Licentiate Medical Council of Canada
College of Physicians and Surgeons Ontario
Canadian Medical Protective Association
Canadian Medical Association
Advanced Trauma and Life Support
Advanced Cardiac Life Support
Neonatal Resuscitation Program

Publications and Abstracts

Publications:

1. Langmann C. (2020) Effect of firearms legislation on suicide and homicide in Canada from 1981 to 2016. PLoS ONE 15(6): e0234457. https://doi.org/10.1371/journal.pone.0234457
2. Langmann C. Canadian firearms legislation and effects on homicide 1974 to 2008. J Interpers Violence. 2012;27(12):2303-2321.
3. Sivilotti ML, Green TJ, Langmann C, Yarema M, Juurlink D, Johnson D. Multiplying the serum aminotransferase by the acetaminophen concentration to predict toxicity following overdose. Clin Toxicol (Phila). 2010 Oct;48(8):793-9.
4. Green TJ, Sivilotti ML, Langmann C, Yarema M, Juurlink D, Burns MJ, Johnson DW. When do the aminotransferases rise

after acute acetaminophen overdose? Clin Toxicol (Phila). 2010 Oct;48(8):787-92.

5. Sanny J., Chui V., Langmann C., Pereira C., Zahedi B., Harden N. "Drosophila RhoGAP68F is a putative GTPase activating protein for RhoA participating in gastrulation." Dev Genes Evol. 2006 Sep;216(9):543-50.
6. Tsuda, M., Langmann, C., Harden, N., Aigaki, T. "The RING-finger scaffold protein Plenty of SH3s targets TAK1 to control immunity signalling in Drosophila." Embo. Rep. 2005 Nov;6(11):1082-7.
7. Schenck, A., Bardoni, B., Langmann, C., Harden, N., Mandel, J.L., Giangrande, A. "CYFIP/Sra-1 controls neuronal connectivity in *Drosophila* and links the Rac1 GTPase pathway to the fragile X protein." Neuron 2003 Jun 19;38(6):887-98.
8. Harden, N., Ricos, M., Yee, K., Sanny, J., Langmann, C., Hong, Y., Chia, W., and Louis, L. "Drac1 and Crumbs participate in amnioserosa morphology during dorsal closure in *Drosophila*." J Cell Sci 2002 May;115(10):2119-29.
9. Verheyen, E.M., Mirkovic, I. I., MacLean, S.J., Langmann, C., Andrews, B.C., and MacKinnon, C. "The tissue polarity gene nemo carries out multiple roles in patterning during *Drosophila* development." Mech Dev 2001 Mar;101(1-2):119-132.

Presentations:

1. Trotter B, Chan TM, Langmann C, Sennik S, Worster A, Welsford M. Communication in the Emergency Department between Physicians and Paramedics: A pilot quantitative study to determine Emergency Physician's accuracy, awareness and satisfaction with Paramedic handover. Submitted for consideration as abstract at Canadian Association of Emergency Physicians Conference 2012.
2. Langmann C. Witness to House of Commons of Canada: Committee of Public Safety for the Bill C-391 An Act to Amend the Long Gun Registry. 2011.
3. Adams CL, Langmann C, Welsford, M (2011) Prehospital induction of therapeutic hypothermia: A meta-analysis. Prehosp Emerg Care. 15(1):121; (poster presentation, PEC 2011)
4. Sivilotti MLA, Langmann C, Yarema MC, Juurlink DN, Johnson DW, Spyker DA, Thompson M, Green TJ, Dart RC, Rumack BH: Which *N*-acetylcysteine protocol is associated with better outcomes? Clin Toxicol 2010; (oral platform NACCT 2010).
5. Langmann C, Sivilotti M.L.A., Green, T.J., Yarema, M.C., Johnson, D.W. for CAOS Study Group. "The Serum Acetaminophen Multiplied by the Aminotransferase is an Early Predictor of Mortality Following Acetaminophen Overdose."; 45(5) (poster presentation, North American Congress of Clinical Toxicology, New Orleans 2007)
6. Langmann, C., Sivilotti, M.L.A., Green, T.J., Yarema, M.C., Johnson, D.W. for CAOS Study Group. "Multiplying the Serum Acetaminophen by the Aminotransferase to Risk-stratify Patients Following Acetaminophen Overdose."; Can J Emerg Med 2007; 9(3): 193 (oral presentation, Canadian Association of Emergency Physicians Annual Scientific Assembly, Victoria BC, June 2007).
7. Langmann, C., Sivilotti, M.L.A., Green, T.J., Yarema, M.C., Johnson, D.W. for CAOS Study Group. "Multiplying the Serum Acetaminophen by the Aminotransferase to Risk-stratify Patients Following Acetaminophen Overdose." Acad Emerg Med 2007;

14(5 supp 1):S197 (poster presentation, Society for Academic Emergency Medicine Annual Meeting, Chicago IL, May 2007).

8. Langmann, C., Sivilotti, M.L.A., Green, T.J., Yarema, M.C., Johnson, D.W. for CAOS Study Group. "Using Serum Acetaminophen and Aminotransferase Concentrations to Predict Death Following Acetaminophen Overdose." KGH Residents Research Day 2006. Recipient Best Medical Student Presentation.
9. Langmann, C., McKenzie, J., Ryz, K., Arsenijevic, A., and Harden, N. "Characterization of *Drosophila* Specific Rac1-associated (DSra-1) protein function during development." 43rd Annual Drosophila Research Conference, April, 2002.
10. Langmann, C., and Harden, N. "Characterization of *Drosophila* Specific Rac-associated (DSra-1) protein function during dorsal closure." 6th Canadian *Drosophila* Research Conference, May 2001.
11. Langmann, C., and Harden, N. "Characterization of specific Rac associated protein (Sra-1) function during dorsal closure in *Drosophila* melanogaster." Northwest Regional Developmental Biology Conference, March 2001.
12. Maroofi, A., Langmann, C., and Harden, N. "Characterization of Putative Rac-specific Effector Proteins in *Drosophila*." Genes and Development 10th Annual CSBMCB/CBBMC Winternational Symposium, March 2000.

Scholarships

Name of Award	Value	Type	Location of Tenure	Period Held
Emergency Physician Mentorship Award	-	Institutional	McMaster University	2018
Original Research Award Emergency Medicine 2013	$500	Institutional	McMaster University	2013
Quality Assurance Award Hamilton Health Sciences 2012	$250	Institutional	McMaster University	2012
St. Joseph Hospital Resident Appreciation Award	$500	Institutional	McMaster University	2010
PMAC Summer Research Program	$4,252	National	Queens University	2006
J.F. Sparks Scholarship	$1,748	Institutional	Queens University	2006
McLaughlin Medical Education	$6,000	Institutional	Queens University	2005
2002 National Sciences and Engineering Research Council Canada (NSERC) PGSB	$19,100 /yr duration : 2 years	National	Simon Fraser University	May 2002 – May 2004
2001 MacMillan-Bloedel Graduate Scholarship	$5,000	Institutional	Simon Fraser University	Jan. 1 2002 – April 30 2002

President's Entrance Scholarship	$10,000	Institutional	Simon Fraser University	Sep. 1 1992 – Sep.1 1993
BC Provincial Government Scholarship	$800	Provincial	Simon Fraser University	Sep. 1 1992

This is **Exhibit "B"** referred to in the Affidavit of Dr. Caillin Langmann, sworn before me this 25 day of August, 2020.

A Notary Public or a Commissioner of Oaths
in and for the Province of Ontario

Canadian Firearms Legislation and Effects on Homicide 1974 to 2008

Caillin Langmann

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Canadian Firearms Legislation and Effects on Homicide 1974 to 2008

Caillin Langmann, MD, PhD[1]

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.

[1]McMaster University, Hamilton, Ontario, Canada

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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).

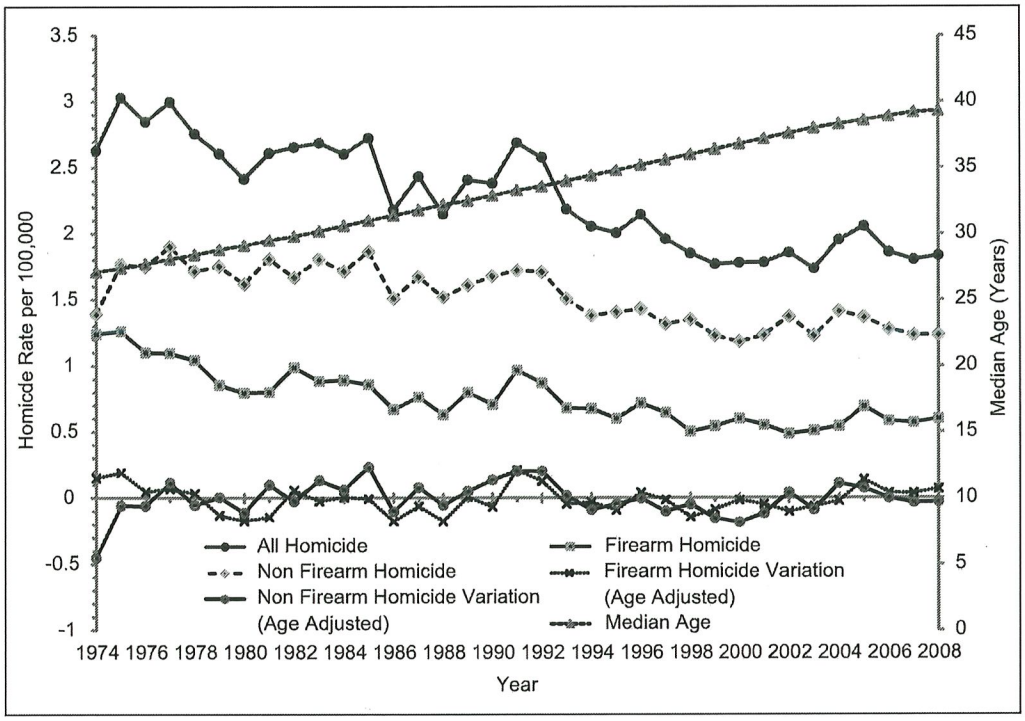

Figure 1. Homicide rates in Canada 1974 to 2008
Note: All homicide rates are decreasing over time following a dramatic peak in 1974. The median age of the Canadian population is also increasing over time. When the effect of median age is removed, the rate of nonfirearm- and firearm-related homicide appears 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		Multivariate		Factor Components Multivariate[a]	
		B	*p*	*B*	*p*	*B*	*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.

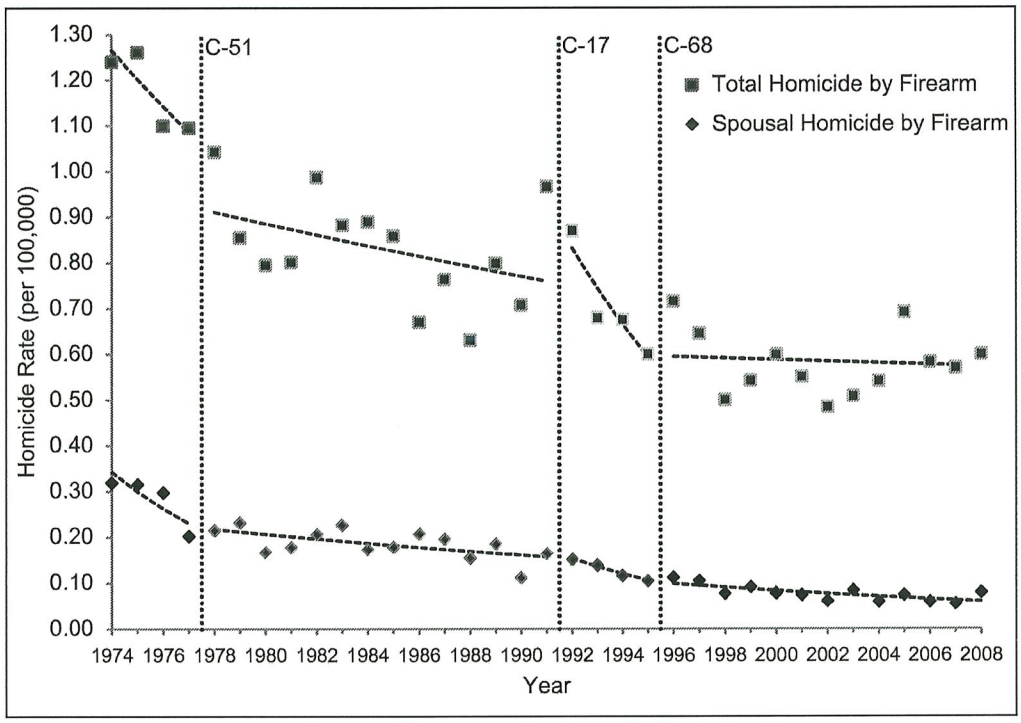

Figure 2. Interrupted regression analysis, all legislation included
Note: Breakpoints in trend lines indicate years pre- and postlegislation. The decrease in the declining trend of all firearms homicide following C-68 is the only significant change.

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

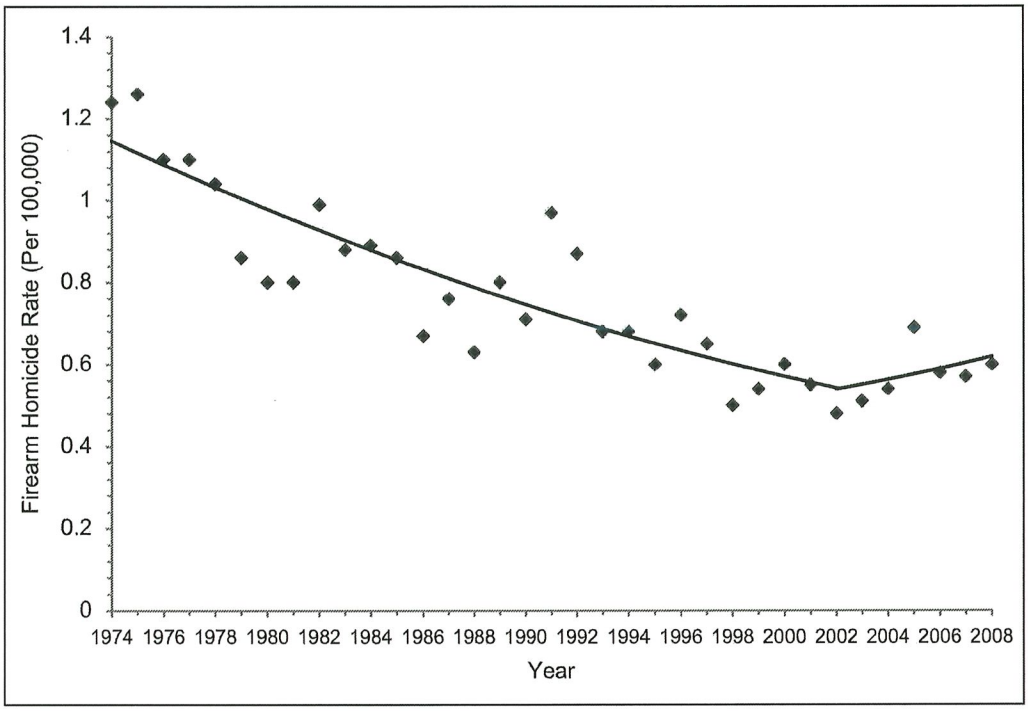

Figure 3. Joinpoint graphical depiction of firearm homicide
A point of inflection in 2002 is noted. Just at that time the final portion of C-68, the long-gun registry, came into effect.

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.

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Bio

Caillin Langmann holds a PhD in Molecular Biology and Biochemistry, and an MD. He has published in the areas of molecular genetics, toxicology and has an interest in violence reduction and public policy issues.

This is **Exhibit "C"** referred to in the Affidavit of Dr. Caillin Langmann, sworn before me this 25 day of August, 2020.

A Notary Public or a Commissioner of Oaths
in and for the Province of Ontario

PLOS ONE

RESEARCH ARTICLE

Effect of firearms legislation on suicide and homicide in Canada from 1981 to 2016

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Abstract

Canada implemented a series of laws regulating firearms including background and psychological screening, licensing, and training in the years 1991, 1994, and 2001. The effects of this legislation on suicide and homicide rates were examined over the years 1981 to 2016. Models were constructed using difference-in-difference analysis of firearms and non firearms death rates from 1981 to 2016. In addition, negative binomial regression was used to test for an association between rates of suicide by Canadian Province and firearms prevalence, using licensing rates as a proxy for prevalence. No associated benefit from firearms legislation on aggregate rates of male suicide was found. In men aged 45 to 59 an associated shift from firearms suicide after 1991 and 1994 to an increase in hanging resulted in overall rate ratios of 0.994 (95%CI, 0.978,1.010) and 0.993 (95%CI, 0.980,1.005) respectively. In men 60 and older a similar effect was seen after 1991, 1994, and 2001, that resulted in rate ratios of 0.989 (95%CI, 0.971,1.008), 0.994 (95%CI, 0.979,1.010), and 1.010 (95%CI, 0.998,1.022) respectively. In females a similar effect was only seen after 1991, rate ratio 0.983 (95%CI, 0.956,1.010). No beneficial association was found between legislation and female or male homicide rates. There was no association found with firearm prevalence rates per province and provincial suicide rates, but an increased association with suicide rates was found with rates of low income, increased unemployment, and the percentage of aboriginals in the population. In conclusion, firearms legislation had no associated beneficial effect on overall suicide and homicide rates. Prevalence of firearms ownership was not associated with suicide rates. Multifaceted strategies to reduce mortality associated with firearms may be required such as steps to reduce youth gang membership and violence, community-based suicide prevention programs, and outreach to groups for which access to care may be a particular issue, such as Aboriginals.

Introduction

Civilian firearms ownership is relatively common in Canada at an estimated rate of 34.7 firearms per 100 people placing it at seventh highest in the list of 230 countries surveyed in the Small Arms Survey 2017, and death caused by the use of firearms is an important and controversial public health issue [1]. Suicide and homicide predominantly account for the causes of

text=11-10-0018-01 Aboriginal population 2011, 2016: https://www12.statcan.gc.ca/nhs-enm/2011/dp-pd/prof/details/download-telecharger/comprehensive/comp-ivt-xml-nhs-enm.cfm?Lang=E https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/download-telecharger/comp/page_dl-tc.cfm?Lang=E Canadian Firearms Program Annual Reports: https://www.rcmp-grc.gc.ca/en/firearms/firearms-reports.

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death associated with firearms in Canada [2]. In 2017 there were 266 firearm related homicides in Canada with 52% of firearms homicides related to gang activity and this percentage is gradually increasing [3]. Additionally, the majority of homicide victims (74% or 485 victims) and those accused (87% or 459 accused) were male.

Suicide accounts for approximately 4,000 deaths a year in Canada, a rate of 11 to 12 deaths per 100,000 [4]. Hanging is the most common method of death by suicide accounting for 44% of deaths, whereas 16% of suicides are the result of the use of firearms. Males are much more likely to use firearms in 20% of suicides while females only use firearms in 3%.

The regulation and control of firearms in Canada is primarily the responsibility of the Federal government and as such represents an interesting model to study the effects of gun control legislation as the regulations are applied homogenously across the country. Some exceptions to federal control do exist, however, such as the Province of Quebec, having implemented long gun registration in 2019 [5]. Bill C-51, passed by Canada's House of Commons in 1977, for the purpose of reducing homicide associated with violent crime, required all firearms purchasers to undergo a criminal record check and obtain a Firearms Acquisition Certificate (FAC) prior to purchasing a firearm. Mandatory minimum sentences and increased penalties were enacted, search and seizure powers granted, new definitions for prohibited and restricted firearms, and individuals were no longer allowed to register handguns at commercial addresses.

The controls enacted under Bill C-51 remained in place for a decade until mounting pressure after a mass homicide at the Polytechnique Institute in Quebec caused Parliament to completely redesign Canadian gun control. In the attempt to reduce all deaths associated with firearms, Canada enacted significant legislation in 1991 (C-17) and 1995 (C-68). C-17, passed in 1991 added two personal reference checks from people familiar with the applicant as well as required spousal endorsement, photo identification, safety training involving written and practical testing, psychological questionnaires, and a mandatory waiting period prior to obtaining a FAC. The psychological questionnaire was designed to screen applicants for a past history of mental health diagnosis associated with an increase risk of suicide or violence. 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. Furthermore in 1995, Bill C-68 introduced two types of licenses to replace the FAC, Possession-Only (POL) and Possession and Acquisition (PAL) and added further screening of licensees, a license needed to purchase ammunition, regulated the requirements of authorization to transport restricted firearms such as handguns, and enacted harsher sentences for serious crimes involving firearms. The difference between the previous FAC vs. the PAL/POL is important to note. The FAC was only required at initial time of purchase of a firearm, whereas after the PAL/POL was implemented, possession of a firearm required a valid license, licenses required renewal every 5 years, and holders of PAL/POLs are checked daily to ensure that the holder is not subject to court orders prohibiting the possession of weapons as well as any new criminal charge(s). In this way licenses can be revoked, and firearms confiscated should such issues occur.

It should be noted that portions of Canadian legislation are implemented years after their passage, for example the FAC came into effect in 1979 and the PAL/POL in 2001. The psychological questionnaire was first implemented in 1994. As part of C-68, the registration of all rifles and shotguns was mandatory by 2003, known as the "long gun registry", while handguns have been registered since 1934. However, in 2012 the Government of Canada repealed the registration of long guns. See S1 Table for a comprehensive list of legislation.

Previous studies have looked at the effects of legislation in Canada and its effects on suicide using 1991 as the point of intervention. Caron examined suicide rates on a native reservation in northern Quebec, Canada, between 1986 to 1996 and found that while legislation enacted in

1991 was associated with a reduction suicide by firearm, hanging and suffocation appeared to replace it as a method, and overall suicide rates increased [6]. Specifically, the rate of suicide by firearm decreased from an average rate of 12.7/100,000 between 1986 to 1991, to a rate of 10.0/100,000 between 1992 to 1996 while the rate by other methods increased from 11.8/100,000 to 16.8/100,000 between the same time periods. Amongst men there was a 31% decrease in suicide by firearm while hanging increased by 53.3%. For women, suicide by firearm dropped by 64% while suicide by hanging increased by 26.9% and suicide by poisoning doubled, from 17.9% to 35.5%.

Another study examined suicide rates in youth between ages 15–19 over the years 1979 to 1999 and found, associated with legislation enacted in 1991, a reduction from 60% to 22% in the percentage of death by suicide by firearm with a compensatory increase in the percentage of suicide by hanging from 20% to 60% [7]. This result suggested a substitution effect had occurred, where suicide by firearm was replaced by suicide by hanging. Additionally, a study on males in Quebec from the years 1981 to 2006 using Joinpoint analysis found that there was a decrease in suicide by firearm that occurred at the same time as firearms legislation was enacted in 1991 [8].

These studies may be subject to error as they examined post legislation trends over only a 5 and 8 year time span or did not control for any potential confounding variables that have shown to be associated with suicide in previous studies, such as poverty rates, percentage of Native American population, unemployment rates, and alcohol use [9,10]. In addition, no previous studies have examined the implementation of psychological screening that was introduced in 1994, and firearms licensing implemented in 2001 in Canada.

The association between firearm legislation and homicide by firearms in Canada has also been examined. The most recent study on overall homicide examined the years 1974 to 2008 and found no associated relationship between homicide rates and firearms legislation enacted in 1977, 1991, and 1995 [11]. Another study looked specifically at homicide of female spouses by firearms and also found no associated benefit with the 1995 legislation, however it did not include any potential explanatory variables such as poverty and unemployment rates [11,12]. A third study examined the legislation enacted in 1991 and found some associated reduction in firearms homicide but this study only examined 7 years pre and post legislation and did not include potential confounders [13].

In this study, trends and levels of firearms homicide and suicide were examined in Canada over the years 1981 to 2016. Since many studies of legislative intervention potentially suffer from errors due to confounding variables, the impact of Canadian legislation was assessed using a difference-in-difference (DiD) approach, a method that can mitigate the potential effects of confounders. This is the first study to look at specific points of firearms legislation implemented after 1991 and the effects on suicide by firearm in Canada as well as the first study to examine homicide in Canada by firearm using a DiD approach.

Since all firearms owners in Canada have been required to hold a license since 2001, it is possible to use that data as a proxy for the availability of firearms per person. It has been hypothesized that increased availability of firearms increases the rate of firearms suicide and therefore overall suicide due to the high lethality of that method [14]. This is the first study to examine the prevalence of firearms and suicide in Canada using licensing as a proxy for availability. A regression model was created to test that relationship.

Materials and methods

Mortality data was obtained from Statistics Canada [15]. Homicide statistics from the years 1981 to 2016 were obtained from the Canadian Socio-Economic Information Management

System (CANSIM) table 35-10-0072-01, 102–0551, 13-10-0156-01, and table 35-10-0069-01. Homicide was defined based on International Classification of Diseases (ICD) codes appropriate to the era (ICD-9 1981–1999: All Assault Homicide E960-E969, Firearms E965; ICD-10 2000–2016: Assault X85-Y09, Y87.1, Firearms X93-X95). Due to confidentiality reasons and internal regulations at Statistics Canada, gender breakdown of homicide data was not obtainable per Province.

Suicide was defined based on International Classification of Diseases codes appropriate to the era (ICD-9 1981–1999: Suicide and Self Inflicted Injury E950-E959, Suicide and Self Inflicted Injury by Hanging, Strangulation and Suffocation E953, Suicide and Self Inflicted Injury by Jumping from a High Place E957, Suicide and Self Inflicted Injury by Firearms E955.0-E955.4; ICD-10 2000–2016: Intentional Self Harm X60-X84, Intentional Self-Harm by Hanging, Strangulation, and Suffocation X70, Intentional Self-Harm by Jumping From a High Place X80, Intentional Self-Harm by Handgun Discharge, Rifle, Shotgun, and Larger Firearm Discharge, and Other and Unspecified Firearm Discharge X72-X74). Population data from the years 1981 to 2016 were obtained from Statistics Canada CANSIM table 051–0001.

Unemployment data was obtained from Statistics Canada table 14-10-0090-01. -Alcohol-volume-purchased-per-capita obtained from Statistics Canada table 10-10-0010-01. Aboriginal population obtained from the Canadian Census 2011 and 2016. Low-income-persons-per-province were obtained from Statistics Canada table 11-10-0018-01. Data for the number of firearms licenses in Canada by region was obtained from the Canadian Firearms Program annual reports [16].

Statistical analysis

The study was constructed with the null hypothesis that firearms regulations implemented in 1991, 1994, and 2001 were not associated with reductions in the rate of suicide and homicide by firearms. A Difference in differences (DiD) technique was used to construct a quasi experimental time series analysis to compare a control group to a treatment group exposed to the effects of firearms legislation. The benefits of using this model is that it mitigates the effects of external confounders and potential selection bias involved in choosing independent variables to include in regression. Two dependent variables were investigated, suicide and homicide. In the study of suicide, suicide by hanging was used as the control group as it was not expected to be directly affected by firearms legislation, while the treatment group consisted of suicide by firearm. Suicide by hanging was also chosen as the control group, as it is reported to be almost as likely to result in death as suicide by gunshot, and is the most frequent method used by males [14]. Sensitivity tests were performed using all non-firearm and firearm suicide data in the model in order to ensure that a switch from methods other than hanging into hanging, e.g.: a switch from use of poisoning to hanging, was not responsible for any substitution effects. Sensitivity tests were also performed using non-firearm-non-hanging suicide data for men, and suicide by jumping from a high place for women, to test whether any changes in suicide by firearm were independent of changes in hanging. In the study of homicide, the control group consisted of non firearms homicide while the treatment group consisted of homicide by firearms. (Non firearm homicide was calculated as per the ICD era as follows: ICD-9 1981–1999: All Assault Homicide E960-E969 minus Firearms E965; ICD-10 2000–2016: Assault X85-Y09, Y87.1 minus Firearms X93-X95).

A Generalized DiD models was constructed to allow for the relaxation of the parallel trends assumption, in this study a model was constructed including terms to account for differing trends prior to legislation in the control and treatment group as well as changes in trends after legislation in each group [17,18]. Observational quasi experimental designs are also unable to

control for crossover from one group to another, in this case while it was expected that firearms legislation would not directly have an effect on suicide by hanging or non firearm homicide, it would potentially be the case that people who were unable to use firearms for suicide or homicide would be forced to choose another method and thus "crossover" into the respective non firearms groups. Constructing a model that includes all pre and post trends can allow for an accounting of the crossover.

The Generalized DiD model was constructed with variables for year (x_{i1}), cause of death: firearms or hanging for the analysis of suicide or firearm and non firearm for the analysis of homicide (x_{i2}), and a variable to account for whether legislation was in effect (x_{i3}). The model utilized the variable "year (x_{i1})" as a term to construct a linear time trend, with interaction terms to allow for different time trends by the cause of death. To account for whether there is a variation in changes in each suicide or homicide category, an interaction between the step term, legislation in effect, and cause of death was included. To allow for a common effect on the trend, an interaction between year and the step term was included. Finally, a 3-way interaction between year, cause of death, and legislation was included and is the difference in difference term that represented the additional effect of legislation. The population of each cohort at that year, n_i, was used in the model as an offset to ensure changes in population were accounted for. The equation is written as follows:

$$\ln(\text{Death rate}) = \alpha + \ln(n_i) + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + \beta_4 x_{i1} x_{i2} + \beta_5 x_{i2} x_{i3} + \beta_6 x_{i1} x_{i3} + \beta_7 x_{i1} x_{i2} x_{i3}$$

The intercept term is indicated by α. The coefficient β_1 measures the time trend in non firearm mortality before the implementation of legislation, β_2 measures the rate ratio of mortali in firearm vs. non firearm mortality at the starting year (1981), β_3 measures the level change in non firearm mortality after the implementation of legislation, β_4 measures the difference in trend for firearms relative to non firearms before the implementation of legislation, and β_5 measures the level change in firearm mortality after the implementation of legislation relative to non firearm mortality. The coefficient, β_6, measures the change in trend in non firearm mortality after the implementation of legislation. Finally, the 3-way interaction coefficient, β_7, measures the additional change in trend in firearm mortality relative to non firearm mortality after legislation, is known as the difference in difference coefficient, and if significant it indicates that the effect of legislation on time trends differed between the non firearm and firearm categories. This 3-way term, β_7, is the specific measure of the impact of the intervention.

The results were then interpreted as follows, if β_7 was significant and less than 0 then the firearm mortality trend decreased after the implementation of legislation, while conversely if it is greater than 0 it increased after legislation. If β_6 and β_7 were both significant and less than 0 then the non firearm mortality trend decreased after the implementation of legislation, but the firearm mortality trend decreased by a greater amount. If β_6 and β_7 were both significant but β_6 was less than 0 and β_7 was greater than 0 then the non firearm mortality trend decreased after legislation, but the firearm mortality trend decreased by less or even increased. If β_6 and β_7 were both significant and greater than 0, then both non firearm and firearm mortality trends increased after legislation with the firearm mortality trend increasing by a greater amount. If β_6 and β_7 were both significant but β_6 was greater than 0 and β_7 was less than 0, then the non firearm mortality trend increased after legislation, but the firearm mortality trend decreased or increased by less than the non firearm trend.

Linear combinations of the coefficients were calculated to give an estimate of the annual change in the mortality rate before and after legislation was implemented, and in the case of the DiD coefficient, this was expressed as a rate ratio of the additional rate of firearm mortality

post legislation [18]. In addition, the comparisons of post effect trends to account for substitution effects were performed using linear combinations and expressed as rate ratios.

Analysis was conducted over the years 1981 to 2016. 1981 was chosen as a start year as prior legislation came into effect in 1980 and prior years were excluded in order to avoid any effect of these laws. Impacts were set at years 1991, 1994, and 2001 in order to test for the effects of the implementation of each legislation and to conduct sensitivity analysis to account for gradual implementation. Years prior to impacts were coded as 0 and years post impact were coded as 1. The year 1991 was chosen as the implementation of background and reference checks, safe storage regulations, magazine capacity restrictions, mandatory training and the prohibition of a number of firearm types were all implemented at that time. The year 1994 was selected as it was the first year the implementation of the psychological questionnaire was added to background checks. Finally, 2001 was chosen as it was the year that all firearms owners were required to have a firearms license rather than just a certificate to acquire firearms.

A second categorical model was constructed to determine if an association existed between the percentage of the population holding firearms licenses in each Canadian Province or Territory and the rates of suicide by all methods, firearms, and non-firearms methods using negative binomial regression. Suicide rates were examined over the years 2011 to 2016. While licensing in Canada was implemented in 2001, it is estimated that there would be a period of time after implementation where firearms owners would not have obtained a license and that gradual increases in licensing rates would simply be people who already own firearms who have finally obtained a license[19]. Moreover, data on license holders was only sporadically reported by the Canadian Firearms Program and reported during the years up to 2011.

Model 1 was constructed containing a factorial dummy variable for each province or territory to account for intra-provincial effects, a dummy variable for each year, and then a variable for percent license holders. Model 2 contained the variables in Model 1 plus variables for alcohol consumption, unemployment rates, percent aboriginal population, and percentage of low income persons. These variables were examined as they have been included in regression models in previous studies as potentially associated with suicide rates [9,10,20]. The procedure of principal components was used to create a single variable containing the three variables as there existed a high degree of collinearity between variables. The equation is written as follows with population, n_i, used in the model as an offset to ensure changes in population were accounted, and the intercept term is indicated by α.

$$\ln(\text{suicide}) = \alpha + \ln(n_i) + \beta_1 \text{Year} + \beta_2 \text{Province} + \beta_3 \text{Percent\_Licence} + \beta_4 \text{Variable}$$

Negative Binomial Regression with standard errors estimated by bootstrapping in Stata/IC version 14 (StataCorp LP, College Station, Texas) was used for statistical analysis. The acceptance level of statistical significance used in the analysis was a p value ss than 0.05 and 95% confidence intervals (CI). False discovery rates were calculated using the Benjamini-Hochberg procedure[21].

Results

Fig 1A–1D display the suicide rates over 1981 to 2016 by aggregate suicide by firearms, aggregate suicide by hanging, total aggregate suicide, as well as by gender. (See S2 Table for suicide numbers and rates from 1981 to 2016 by gender and age brackets). There has been a gradual trend of an increase in suicide by hanging from 1981 onwards with a decrease in suicide by firearm in both sexes. In 1981 the male suicide rate by hanging and firearms were 5.12 per 100,000 and 8.74 per 100,000 respectively, while in 2016 the rates were 8.22 per 100,000 and 3.04 per 100,000 respectively. In females the rates are substantially lower than in males. In

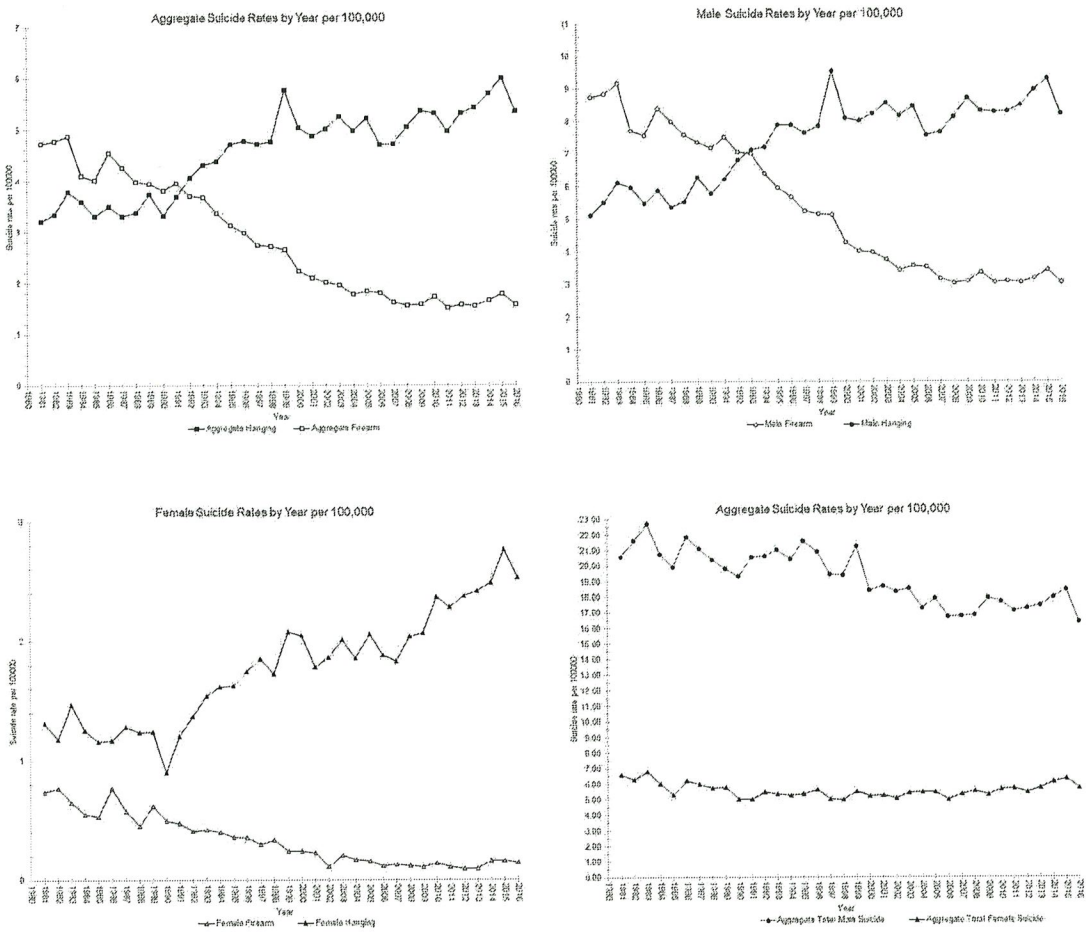

Fig 1. A–D: Suicide Rate by Year per 100,000.

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1981 the rates by hanging and firearms were 1.32 per 100,000 and 0.74 per 100,000 respectively, while in 2016 the rates were 2.53 per 100,000 and 0.14 per 100,000 respectively.

Fig 2A and 2B show the homicide rates over 1981 to 2016 for male and female homicide victims. (See S2 Table for numbers and rates of homicide by year and gender from 1981 to 2016). Both homicide rates by firearm and non-firearm have been declining over time for males and females. In 1981 in males the rate of homicide by firearm and non-firearm were 1.02 per 100,000 and 1.78 per 100,000 respectively, while in 2016 the rates were 0.68 per 100,000 and 1.02 per 100,000 respectively. In 1981 in females the rate of homicide by firearm and non-firearm were 0.46 per 100,000 and 1.26 per 100,000 respectively, while in 2016 the rates were 0.09 per 100,000 and 0.42 per 100,000 respectively. Males are more often the victim of homicide than females.

To examine for associated effects of firearms legislation on suicide the DiD regression analysis was applied to male and female suicide data separately. In addition, male suicide rates were examined in separate age cohorts as it is possible that gun control may affect different age groups, e.g.: younger males may be prevented from acquiring firearms whereas older males may already have firearms and thus be unaffected by certain legislative changes that prevent acquisition. Female suicide rates were not separated into cohorts as many years had cohorts

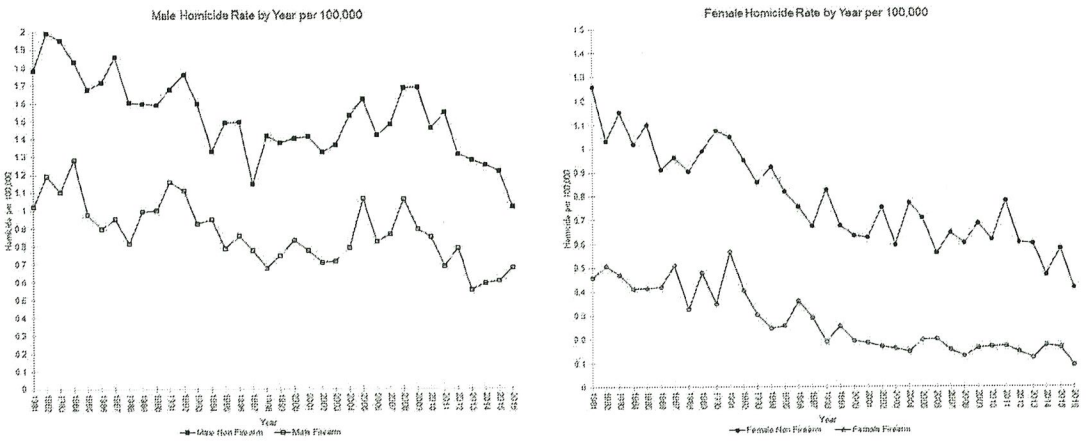

Fig 2. Homicide rate by year per 100,000.

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with very small to zero numbers of female suicide by firearm and thus could not be examined by the above method.

Finally, three separate legislative impacts time points were examined, which included changes to background checks and education as well as safe storage regulations enacted in 1991, background checks that involved psychiatric questionnaires implemented in 1994, and licensing implemented in 2001.

Table 1 contains the results from the analysis of suicide rates by hanging or firearm as a rate ratio for the additional change in firearm mortality after legislation as compared to the other rates. A rate ratio of less than 1 suggests that the rate of firearms suicide is declining by more than hanging over time, while a rate ratio greater than 1 suggests that the rate of suicide by firearm is increasing compared to hanging. (See S4 Table for the regression coefficients as well as the percent change per year of hanging and firearms suicide).

Table 1. Trend of firearm mortality after legislation.

Age and Gender Cohort by Effect Year	Suicide Rate Ratio[1] (95% CI)	Homicide Rate Ratio[2] (95% CI)
Aggregate Male		
1991 Safe Storage		
firearm mortality after law[3]	0.987 (0.970, 1.005)	0.989 (0.952, 1.027)
1994 Psychiatric Questionnaire		
firearm mortality after law[3]	1.000 (0.984, 1.016)	0.990 (0.962, 1.019)
2001 Licensing		
firearm mortality after law[3]	1.040 (1.026, 1.055)	0.997 (0.974, 1.021)
Male Age 15 to 29		
1991 Safe Storage		
firearm mortality after law[3]	1.005 (0.974, 1.037)	
1994 Psychiatric Questionnaire		
firearm mortality after law[3]	1.013 (0.988, 1.038)	
2001 Licensing		
firearm mortality after law[3]	1.076 (1.048, 1.105)	
Male Age 30 to 44		
1991 Safe Storage		

(*Continued*)

Table 1. (Continued)

Age and Gender Cohort by Effect Year	Suicide Rate Ratio[1] (95% CI)	Homicide Rate Ratio[2] (95% CI)
firearm mortality after law[3]	0.984 (0.964, 1.004)	
1994 Psychiatric Questionnaire		
firearm mortality after law[3]	1.000 (0.983, 1.022)	
2001 Licensing		
firearm mortality after law[3]	1.050 (1.031, 1.069)	
Male Age 45 to 59		
1991 Safe Storage		
firearm mortality after law[3]	0.945 (0.916, 0.975)	
1994 Psychiatric Questionnaire		
firearm mortality after law[3]	0.963 (0.936, 0.991)	
2001 Licensing		
firearm mortality after law[3]	1.000 (0.981, 1.019)	
Male Age 60 plus		
1991 Safe Storage		
firearm mortality after law[3]	0.946 (0.915, 0.978)	
1994 Psychiatric Questionnaire		
firearm mortality after law[3]	0.953 (0.931, 0.977)	
2001 Licensing		
firearm mortality after law[3]	0.977 (0.959, 0.996)	
Aggregate Female		
1991 Safe Storage		
firearm mortality after law[3]	0.947 (0.911, 0.984)	0.971 (0.930, 1.014)
1994 Psychiatric Questionnaire		
firearm mortality after law[3]	0.974 (0.941, 1.009)	0.983 (0.950, 1.018)
2001 Licensing		
firearm mortality after law[3]	1.036 (0.996, 1.077)	1.017 (0.986, 1.048)

[1]The rate ratio of the trend of firearm mortality after each year of legislation implementation which is the difference-in-difference regression result. A rate ratio greater than 1 suggests that the trend of firearm mortality by suicide increased greater than the trend in suicide by hanging while a ratio less than 1 suggests there is a decrease in the trend of suicide by firearm compared to hanging.

[2]The rate ratio of the trend of firearm mortality after each year of legislation implementation which is the difference-in-difference regression result. A rate ratio greater than 1 suggests that the trend of firearm mortality by homicide increased greater than the trend in homicide by other methods while a ratio less than 1 suggests there is a decrease in the trend of homicide by firearm compared to other methods.

[3]Additional change in trend.

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Prior to 1991 the trend of aggregate male suicide by hanging was increasing at a very slow rate, [percent change per year was 0.738% (95% CI, -0.494%, 1.994%)] while suicide by firearm was declining [-2.277% (95% CI, -3.238%, -1.325%)]. The trend in aggregate male suicide rates by hanging was not statistically different after 1991 [0.360% (95% CI, 0.001%, 0.719%)] nor was the trend in suicide rates by firearm [-3.981% (95% CI, -4.753%, -3.215%)]. The rate ratio between the change of rate of firearms suicide vs hanging after 1991 was 0.987 (95% CI, 0.970, 1.005) and therefore suggested no benefit of the legislation of firearms on suicide by firearms. These results were similar after the implementation of the 1994 psychiatric questionnaire in that there is no associated beneficial effect on suicide by firearms.

Prior to 2001, aggregate male suicide by hanging was increasing at a rate of 2.453% (95% CI, 1.802%, 3.099%) while aggregate male suicide by firearm decreased at a rate of -3.597% (95% CI, -4.275%, -2.923%). After the implementation of licensing in 2001, the trend of aggregate male suicide rates by hanging decreased to a new rate of -0.284% (95% CI, -0.267%, 0.831%) however the trend of suicide by firearm increased to a new rate of -1.787% (95% CI, -2.672%, -0.909%). The rate ratio between the change of rate of firearms suicide vs hanging after 2001 was 1.040 (95% CI, 1.026, 1.055) and therefore demonstrated an increase in firearms suicide compared to hanging.

For males age 15 to 29 years, the only significant change in trend of suicide by firearms occurred in 2001, and it resulted in an increase in the trend. For males age 30 to 44 years of age a similar result was also found.

In males age 45 to 59 years there is an increase in the regression coefficient indicating the trend of suicide by hanging increased in 1991 and 1994 by 0.051 (95% CI, 0.025, 0.077), and 0.030 (95% CI, 0.004, 0.057), respectively (S4 Table). The additional change in trend in suicide by firearm for those years as indicated by the regression coefficient was -0.057 (95% CI, -0.088, -0.026), and -0.038 (95% CI, -0.067, -0.009). What could be occurring is that as suicide by firearms decreases, suicide by hanging increases by a similar amount. Linear combinations of the regression coefficients was used to test if the parameters were equal and these were expressed as a rate ratio. This resulted in a combined rate ratio of 0.994 (95% CI, 0.978, 1.010) for 1991 and 0.993 (95% CI, 0.980, 1.005) for 1994, suggesting that as the rate of suicide by firearms decreased, an equivalent increase in suicide by hanging occurred. For males aged 60 years and over a similar substitution effect was also seen for years 1991, 1994, and 2001, Table 2.

Similar results are shown on Table 1 for aggregate female suicide with no decrease in a change in the trend of suicide after 1994 and 2001. In 1991 an increase in the change in trend of hanging accompanied by a decrease in the change in trend of suicide by firearms resulted in no overall change in suicide rates.

Sensitivity tests were performed using all non-firearm and firearm suicide data in the model to test whether a switch from methods other than hanging into hanging was responsible for the increase in hanging found in the above substitution effect. S5 Table demonstrates similar results to Table 2. This supports the results of a substitution effect from suicide by firearm to hanging in those cohorts and not a switch into hanging from other methods of suicide. A second round of sensitivity tests were performed using non-firearm-non-hanging data for males and suicide by jumping from a high place data for females. For all intervention years, no associated decreased in the rate of suicide by firearm was found in males 45 years and older,

Table 2. Rate ratio of the post effect trends of suicide by hanging and firearms.

Variable	Combination of post effect trend, rate ratio (95% CI)	P
Suicide		
Male Age 45 to 59, 1991	0.994 (0.978, 1.010)	0.46
Male Age 45 to 59, 1994	0.993 (0.980, 1.005)	0.25
Male Age 60+, 1991	0.989 (0.971, 1.008)	0.28
Male Age 60+, 1994	0.994 (0.979, 1.010)	0.40
Male Age 60+, 2001	1.010 (0.998, 1.022)	0.09
Female, 1991	0.983 (0.956, 1.010)	0.21

Results of linear combination calculations of post effect rate ratios for hanging and firearms suicide demonstrating method substitution of firearm suicide with hanging. Linear combinations of the addition of the regression coefficients, expressed as rate ratios.

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Table 3. Risk associated between firearm prevalence and suicide rates.

Variable	Univariate Rate Ratio (95% CI)	Model 1 Rate Ratio (95% CI)	Model 2 Rate Ratio (95% CI)
All Suicide			
Firearms License	-	1.084 (0.975, 1.206)	1.053 (0.941, 1.180)
Regression Factor[a]	1.239 (0.988, 1.554)*	-	1.189 (0.932, 1.517)
Aboriginal Population Rate	1.084 (0.942, 1.247)		
Unemployment Rate	1.029 (0.993, 1.067)*		
Alcohol Volume Per Capita	1.045 (0.933, 1.171)		
Low Income Rate	1.044 (0.988, 1.104)*		
Suicide by Firearm			
Firearms License	-	1.092 (0.935, 1.276)	1.031 (0.875, 1.215)
Regression Factor[a]	1.476 (1.043, 2.087)**	-	1.437 (0.987, 2.093)*
Aboriginal Population Rate	1.151 (0.945, 1.401)		
Unemployment Rate	1.050 (0.995, 1.107)*		
Alcohol Volume Per Capita	1.083 (0.901, 1.302)		
Low Income Rate	1.086 (0.995, 1.185)*		
Suicide by Other Method			
Firearms License	-	1.081 (0.963, 1.214)	1.057 (0.934, 1.196)
Regression Factor[a]	1.195 (0.936, 1.525)	-	1.145 (0.881, 1.488)
Aboriginal Population Rate	1.067 (0.916, 1.244)		
Unemployment Rate	1.025 (0.986, 1.065)		
Alcohol Volume Per Capita	1.038 (0.921, 1.170)		
Low Income Rate	1.036 (0.977, 1.100)		

Regression results of suicide rates by Province and Territory by Model 1, firearm licensing rates per Province/Territory, and Model 2 including unemployment, aboriginal population rate, and low-income population rate.

* = $P \leq 0.10$

** = $P \leq 0.05$

[a] Regression Factor is a principal factor component created from Unemployment, Aboriginal Population, and Percentage of Population Low Income.

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and all females, suggesting that suicide by hanging had replaced firearms as a method, and that the trend of suicide by firearm had not changed (S6 Table).

Table 1 reproduces the results from the DiD analysis of homicide by non-firearms and firearms for males and females. Population age cohorts were included in the model to account for variations by age composition. Separate regressions were also conducted for legislative changes in 1991, 1994, and 2001 for both male and female homicide victims. As can be seen, none of the post legislative trends resulted in a decline in firearms homicide in any of the models. (See S7 Table for the regression coefficients as well as the percent change per year of non-firearms and firearms homicide).

Table 3 displays the results of the categorical regression model of suicide broken down by province and territory. The suicide rate averaged over 2011 to 2016 per Canadian Province charted against the average rate of firearms licensing per Province is depicted in Fig 3.

Model 1 demonstrates no significant association between the percent number of license holders per population in each province and territory and the rates of suicide by all methods, firearms, and non-firearms. Interestingly, in the univariate analysis and in Model 2, a variable composed of the principal components of three variables: unemployment rates, percent component of aboriginal population of each province or territory, and percentage of the population of each province or territory in low income brackets, demonstrated a positive association with the rates of suicide in each province by all methods and by firearm.

Fig 3. Suicide rate by firearm or other method per Canadian Province or territory by rate of firearms licensing. BC = British Columbia, AB = Alberta, SK = Saskatchewan, MB = Manitoba, ON = Ontario, QC = Quebec, NB = New Brunswick, NS = Nova Scotia, PEI = Prince Edward Island, NL = Newfoundland and Labrador, YT = Yukon, NT = Northwest Territories, NU = Nunuvat.

https://doi.org/10.1371/journal.pone.0234457.g003

Discussion

There is considerable debate whether limiting the exposure of people to a highly potent method of suicide, firearms, will decrease overall suicide rates. It is hypothesized that even if people have to switch to another method, the decreased lethality of such methods will result in failed suicide attempts and the possibility of an intervention that will prevent future events [22]. However, hanging, a method that is relatively simple to procure and implement, is shown in some studies to be as lethal as a firearm with an effectiveness of 82% vs firearms effectiveness of 83% [14].

A previous Canadian study examining 7 years pre and post legislation in 1995 showed an associated reduction in suicide that was partially compensated for with an increase in suicide by other methods [13]. However, that study did not break suicide rates down into age cohorts.

This study is the first to examine overall suicide rates over time in Canada and break rates down into cohorts by sex and age. Overall, at the aggregate male level there does not appear to be a reduction in suicide associated with firearms legislation and regulation. Within age cohorts there does appear to be a shift in firearm suicide rates found for males over the age of 45 years to an increase in hanging rates suggesting a complete method substitution effect. Sensitivity tests demonstrating no change in firearm suicide associated with legislation, using non-hanging-non-firearms methods as a control, and jumping from a high place as a control in the female population, suggested that there may be another reason for the shift to suicide by hanging in these cohorts that is unrelated to legislation. Why no effect was seen in the younger aged cohorts may be due to more prevalent firearms ownership in older men as new and more restrictive legislation may have made acquisitions of firearms by new owners more difficult. The finding that suicide by hanging accounted for any deaths saved by potential reductions in suicide by firearms is in agreement with other Canadian studies [6,7]. A recent study on

Australian gun control showed similar results in terms of a lack of beneficial association between legislation and suicide after taking into account trends in non firearm related suicide [18].

No associated reduction in homicide with firearm legislation and regulation was found. Studies on Canadian legislation and firearm homicide have produced mixed results, but a larger number have found limited effect [23]. Previous work by Leenaars and Lester found that although legislation enacted in 1977 was associated with a reduction in homicide by firearm, after reanalysis and factoring in social and economic variables the association disappeared [24]. Mauser and Holmes also found no association with this legislation and firearm homicide [25]. Examination of all three legislative efforts by Langmann resulted in no finding of any beneficial association with overall firearm homicide and spousal homicide by firearm, and McPhedran and Mauser found no association between legislation and homicide of female spouses by firearms [11,12]. The results from this study largely confirms the previous work while using a DiD approach to control for confounding variables.

Firearms licensing in Canada provided an opportunity to use that as a proxy for firearms prevalence in each Canadian Province, and while this study found a slightly increasing association between the percentage of firearms license holders per province and territory and firearms suicide, it was not statistically significant at the cut off values used in this study. A previous examination using accidental rates of firearms injury as a proxy for firearm prevalence per Province found an associated increase in suicide by firearm as these rates increased, compensated with a decrease in rates of suicide by other method suggesting a substitution effect [26]. This is the first use of licensing data to examine the relationship between firearms prevalence and suicide in Canada, however many categorical studies demonstrating a relationship have been produced in the United States [23]. For instance, Knopov et al. using survey data as a proxy for prevalence determined an association between firearms prevalence and youth suicide rates after controlling for a number of social economic factors [9]. There is considerable debate about the validity of proxies used for firearm prevalence in the United States and this may affect the validity of the results depending on the measure used [27,28]. It is probable that licensing is a more accurate proxy for firearms prevalence than other methods such as surveys or suicide rates by firearm, as it is a mandatory requirement for owning firearms in Canada.

More notable was that firearms suicide and overall suicide rates were associated with intra-provincial and territorial rates of variables such as unemployment, low income rates, and the rates of aboriginal population. Other studies have shown an association between an increase in suicide rates and an increase in rates of poverty, alcohol consumption, and unemployment [10]. Interestingly, Knopov et al. also found a positive association between suicide rates and the percentage of Aboriginal population per State in the United States [9]. In Canada, suicide rates amongst aboriginal people are 2 to 3 times higher than non-Indigenous Canadians and suicide rates amongst the Inuit in Northern Canada are the highest in the world at 10 times the overall rate for Canada [29].

This study has several limitations. Data for suicide could not be disaggregated by age and Province/Territory due to small numbers, Statistics Canada could not release the data under confidentiality regulations, thus regional associations could not be analysed. Another issue is that firearm suicide and homicide are low base-rate events, and therefore changes in response to specific interventions may not have the statistical power necessary to resolve using regression models. Bias may also result from the misclassification of cause of death by coroners. While it is not possible to determine the number of accidental deaths misclassified as suicide or vice versa, the numbers of accidental deaths by firearms and suffocation per age category are in the low single digit ranges in data obtainable from Statistics Canada.

The multiple regressions performed in this study increased the risk of Type 1 errors, known as the multiple testing error. A false discovery rate of 5%, q-value of 0.05, was calculated for the number of regressions executed. In general, null results were found, however males over the age of 45 did have some associated reduction in suicide with firearms legislation. The multiple number of regressions enhances the possibility this is an error, but the fact that it is conserved in the two oldest age cohorts suggests that there may be an underlying effect in that demographic.

During the years 2001 to 2012 Canada had implemented registration of all firearms, as prior to this registration certificates were only required for handguns and some types of rifles and shotguns. This policy existed temporarily and it is therefore difficult to test this for effect due to the small number of data points as well as there being only 4 years of data post cancellation available. While there was a beneficial association of suicide reduction seen in the 45 and older cohort, this effect may dissipate as years progress if registration rather than the psychiatric questionnaire and licensing was the cause.

Conclusions

The finding of an association between unemployment, low income rates, the rates of aboriginal population, and provinces with a higher rate of suicide underscores and suggests areas for directed public health and harm reduction programs. No overall mortality reduction, but a shift from suicide by firearm in females and males age 45 and older to hanging, associated with current gun control programs, was found. This suggests that gun control methods to reduce suicide by firearms may have benefits but further actions to reduce suicide by controlling for other methods and suicide prevention programs could lower suicide rates in Canada. No associated reductions in homicide with increasing firearms regulations suggests alternative approaches are necessary to reduce homicide by firearm.

Real action towards reducing the number of firearm deaths is necessary and calls to reduce firearms prevalence in the country have once again become a social and political issue [30,31]. Multifaceted strategies to reduce mortality associated with firearms may be required. Steps to reduce youth gang membership and violence through diversion and educational programs have shown promising results [32]. As well community based suicide prevention programs such as training of family physicians in the detection and treatment of depression and discussions about firearms, campaigns aimed at increasing awareness about depression, and follow-up of individuals who attempted suicide may result in lives saved [33]. Outreach to groups for which access to care may be a particular issue, such as Aboriginals, is of primary concern [34].

Supporting information

S1 Table. Timeline and description of Canadian firearms legislation. Year legislation enacted and implemented as well as a brief description of legislation and regulations.
(DOCX)

S2 Table. Suicide by method by year.
(DOCX)

S3 Table. Homicide by method by year.
(DOCX)

S4 Table. Suicide difference-in-differences results. Results of regression model are expressed as regression coefficients, percentage change per year of suicide rates.
(DOCX)

S5 Table. Rate ratio of the post effect trends of suicide by non-firearm and firearms. Results of linear combination calculations of post effect rate ratios for non-firearm and firearms suicide demonstrating method substitution of firearm suicide with hanging. Linear combinations of the addition of the regression coefficients, if statistically equal, should result in a rate ratio of ~1.0 with confidence intervals crossing 1.0.
(DOCX)

S6 Table. Trend of suicide by firearm, suicide by non hanging non firearm, and suicide by jumping after intervention. Results of sensitivity tests performed using non hanging non firearm data for males and suicide by jumping data for females. No associated decreased in the rate of suicide by firearm was found in males 45 years and older and all females after 1991 suggesting that suicide by hanging had replaced firearms as a method in the cohorts and interventions where an effect was found in the DiD model. [1]The rate ratio of the trend of firearm mortality after each year of legislation implementation which is the difference-in-difference regression result. A rate ratio greater than 1 suggests that firearm mortality by suicide or homicide is increasing greater than mortality by other methods, while a ratio less than 1 suggests there is a decrease greater than other methods. [2]Additional change in trend.
(DOCX)

S7 Table. Homicide difference-in-differences results. Results of regression model are expressed as regression coefficients, percentage change per year of homicide rates.
(DOCX)

Author Contributions

Conceptualization: Caillin Langmann.

Data curation: Caillin Langmann.

Formal analysis: Caillin Langmann.

Funding acquisition: Caillin Langmann.

Investigation: Caillin Langmann.

Methodology: Caillin Langmann.

Project administration: Caillin Langmann.

Resources: Caillin Langmann.

Software: Caillin Langmann.

Supervision: Caillin Langmann.

Validation: Caillin Langmann.

Visualization: Caillin Langmann.

Writing – original draft: Caillin Langmann.

Writing – review & editing: Caillin Langmann.

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This is **Exhibit "D"** referred to in the Affidavit of Dr. Caillin Langmann, sworn before me this 25 day of August, 2020.

A Notary Public or a Commissioner of Oaths
in and for the Province of Ontario

DR. CAILLIN LANGMANN'S CRITICISM OF: FIREARM LEGISLATION AND FIREARM-RELATED FATALITIES IN THE UNITED STATES

(0)

DR. CAILLIN LANGMANN'S CRITICISM OF:

Firearm Legislation and Firearm-Related Fatalities in the United States

By Eric W. Fleegler, MD, MPH; Lois K. Lee, MD, MPH; Michael C. Monuteaux, ScD; David Hemenway, PhD; Rebekah Mannix, MD, MPH

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As published online March 6, 2013 http://archinte.jamanetwork.com/article.aspx?articleid=1661390

KEY POINTS:

- The study by Fleegler, et al.,:

- Does not actually conclude that States with higher gun laws have less homicide or suicide, in fact shows no association
- Demonstrates Assault Weapon bans have no effect on homicide
- Demonstrates Laws that prohibit guns in public places have no effect on homicide

- The study is simplistic with only limited analysis or conclusions
- It only examines a single time period which is an inferior method of demonstrating association
- It suffers from potential data selection bias by leaving out relevant information to achieve a biased result, ie: District of Columbia with high gun laws and high homicide rates is left out
- The scoring of laws is highly suspect and is an unvalidated scoring system

This study in JAMA is a very simple study with very limited and basic analysis. Even so, it actually demonstrates several interesting conclusions, two of which are that Assault Weapons have no effect on homicide, nor do laws that allow guns in public places, such as Conceal Carry Licenses. Moreover it does not actually conclude that States with higher gun laws have less homicide or suicide.

There are some problems with the study. This study only looks at a single shot in time, these are the worst epidemiological studies in terms of determining an association. For example I might take two States, one with more TVs and one with less and compare cancer rates. I might find an association between more TVs and higher cancer rates. However the real question is, is cancer really related to TV's or some other factor? Has cancer or the number of TV's been increasing or decreasing over time? What were cancer rates in these States before TVs, could it have been higher in the high cancer State before TVs?

Better studies look at what happens over time. Do changes in laws actually change the rates of homicide or suicide? Do changes in the number of TVs increase cancer or decrease? Those are the more valid studies, and many have been published showing no effects from these laws. For instance John R Lott and several other independent authors have published studies in this area looking at the effects of guns over time in a large sample of counties and find, as his book is called, "More Guns, Less Crime". The other question is: are there more guns in some States because there is more crime and people respond by aquiring guns to defend themselves. Gary Kleck looks at this issue in a much more rigorous statistical analysis and finds that once one takes into account that factor, one finds that higher gun

ownership decreases homicide rates. I looked at a closed system, Canada, for changes in homicide and spousal homicide using a time based analysis to take into account prior trends unrelated to legislative effects and also concluded that there was no association between Canada's gun laws and homicide or spousal homicide as well as crimes such as discharge of firearm with intent.

http://papers.ssrn.com/sol3/papers.cfm?abstract_id=878132
http://www.iza.org/en/papers/202_30012007.pdf
http://jiv.sagepub.com/content/27/12/2303.abstract

Let's actually look at the study. The first issue is the categorization of gun laws into a scoring system. This is what we call an unvalidated scoring system. In other words why do certain laws get more points in the system? Does it mean a certain law is more effective? How do they know that? What basis are laws assigned more points? An honest peer reviewer would ask the question: did you give more points to certain laws to increase your chances of finding a statistical result at the end? For example I want to determine the effects of several drugs on cancer rates. I assign the drug I like 5 points and the drug I don't like 1 point. Then I run my regression and of course weighting the drug I like higher causes it to provide a stronger effect. In this paper what one could do is take a state with a low rate of homicide and arbitrarily give it a very high score compared to other states until one found a difference in your statistical analysis. This is what could be happening in Figure 2 of their paper.

Moreover, in Figure 2, when one includes both independent and dependent variables in one's regression one will end up with a relationship. In this case they include suicide by firearm/total suicide in the regression as an independent or causal factor and then determine that it is related to gun deaths. Of course it would be, just like if I included automobile accidents/any accident as a causal factor and then related it to the result of death.

Second let's take look at the conclusions from the results. When writing a paper one has to be conscious of bias of interpretation of results. When you write a paper you have to ask yourself could the results be interpreted to make an entirely opposite conclusion? Could one conclude that firearms laws are having no effect?

Looking at Table 3 in the paper, one looks at Model 3 because it has the most other socioeconomic factors in it like poverty, etc. to account for other causes of homicide rates as

well as firearms ownership. In the model 3 column under suicide: no significant association is found.

Under homicide it appears states with the highest number of laws have no statistical association, contradicting the conclusion that higher laws is associated with less homicide. The only significant result is that a State with some laws has some effect. However if you look at the confidence intervals, the range approaches 0.93 which means that its very close to not having an association at all. (1 would be no association).

Looking at Table 4 raises some questions. They conclude that Brady checks decrease suicide and homicide but the Confidence Intervals near 1, which means that the association is very weak or possibly not associated at all. One would never prescribe a drug if it had these results. As part of analysis, we should also apply a logic test to science whenever we look at correlations. For example it seems unclear logically why an assault weapon would increase your risk of suicide? I mean you only need one bullet for that. It should increase the risk of homicide but it doesn't. Same with the guns in public places, one would question how it affects suicide? However from their results it doesn't cause homicide rates to increase.

The next thing to examine is what is known as selection bias; that is when one leaves out data it could cause a different result. In this study they leave out North Dakota, which has an extremely low homicide rate like Hawaii and a low number of gun laws. Moreover, they also leave out the District of Columbia which has the highest number of gun laws as well as an extremely high homicide rate of 12.5/100,000. If one excludes Louisiana from the analysis, as an outlier with a very high homicide rate and a low gun law value, one finds that homicide rates are lower in the States with lower numbers of gun laws. Conversely if one adds the District of Columbia and North Dakota to the data one finds again that the States with lower gun laws have lower homicide rates. Excluding data is a dangerous step to take in any scientific analysis.

A rigorous scientist would look at these results and conclude that there is possibly no association between laws and homicide and suicide. Moreover one would also conclude that Assault weapons are not associated with homicide nor is guns in public places, ie: guns on campus or Conceal Carry laws. That final conclusion has been documented in multiple studies, including the National Academy of Sciences analysis of Firearms.
http://www.nap.edu/openbook.php?isbn=0309091241

By
Dr. Caillin Langmann, M.D., Ph.D.
Div. Emergency Medicine
McMaster University
Hamilton ON

This is **Exhibit "E"** referred to in the Affidavit of Dr. Caillin Langmann, sworn before me this 25 day of August, 2020.

A Notary Public or a Commissioner of Oaths
in and for the Province of Ontario

An Excerpt Pertaining to the Long Gun Registry from the Peer Reviewed Study:
"Canadian Firearms Legislation and Effects on Homicide 1974 to 2008"

An Analysis of the Association Between the Long Gun Registry and Suicide by Firearm

November 2011

Caillin Langmann MD PhD
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Significance of the Study: *"Canadian Firearms Legislation and Effects on Homicide 1974 to 2008"*

- The research has been peer reviewed and accepted for publication in the *Journal of Interpersonal Violence*
- It is the only study examining those effects over the years 1974 to 2008
- It is the only study to use three different statistical methods to confirm results
- It is the only study that examines both immediate and gradual effects as legislation is often implemented over several years

Executive Summary

- The rate of homicide has been declining in Canada since 1974, prior to federal legislation
- The registration of long guns began in 1999
- The majority of long guns were registered in 2002
- Interrupted time series regression analysis fails to show a legislation associated statistically significant beneficial effect on firearms homicide, homicide by long gun and spousal homicide by long gun
- ARIMA analysis of both immediate or gradual effects of legislation demonstrated no beneficial associated effects on firearms homicide, homicide by long gun and spousal homicide by long gun
- Joinpoint analysis demonstrated no beneficial associated change in the trend of firearms homicide, homicide by long gun and spousal homicide by long gun
- There were no beneficial associations between legislation and the criminal charge of "Discharge of a Firearm with Intent"
- Time series regression demonstrates no statistically significant beneficial association between the long gun registry, suicide and suicide by firearms
- Anti-depressant medication, SSRIs, were introduced in 1989 at the same time point firearm legislation in Canada was introduced
- Suicide rates rapidly decline in 1989 and in 1995 as more antidepressant medications are introduced
- Suicide studies that do not include the use of anti-depressant medication to control for effects are questionable

Recommendations

- The results of the peer reviewed study suggest that the discontinuation of the registration of non-restricted firearms will not result in an increase in homicide or spousal homicide rates by long gun
- The discontinuation of the registration of non-restricted firearms is not likely to result in an increase in suicide rate by long gun

Introduction

The following brief contains excerpts relevant to the long gun registry (LGR) contained in the peer reviewed study: *Langmann, C. "Canadian Firearms Legislation and Effects on Homicide 1974 to 2008." Journal of Interpersonal Violence. 2012 Feb 10. [Epub ahead of print].* Some figures are included here to provide a visual representation of the results found in the study for those not familiar with statistical interpretation.

Included in the **Executive Summary** are the main results found in the original study.

As well an examination of the effects of the LGR on suicide rates in Canada has been included.

Publication agreement between Dr. Langmann and the Journal of Interpersonal Violence prohibits submission of the original study as submissions to the Committee are published by Parliament for public access. Those wishing to view the original publication can schedule a viewing with Dr. Langmann and all methods are available on request, or can obtain a copy from the Journal of Interpersonal Violence.

Relevant Timeline of the Long Gun Registry

Prior to 1998 non-restricted firearms commonly known as long-guns, generally consisting of rifles and shotguns meeting minimum length criteria, were not registered. The 1995 Firearms Act required the registration of all firearms, and this was finally implemented on December 1998 [1]. By 2003 it would be mandatory that all firearms would be registered.

Registration of firearms in the Canadian Firearms Registration System (CFRS) began slowly after 1998 and most registration occurred in late 2002 [2].

Methodology

All data were obtained from Statistics Canada Juristat Database and CANSIM for the years 1974 to 2008. In the original study three methods typically utilized in epidemiology were used to examine for effects of the implementation of legislation: interrupted time series regression, autoregressive integrated moving average (ARIMA), and Joinpoint regression software (http://surveillance.cancer.gov/joinpoint/. The following figures or graphs will depict a 2 dimensional visualization of the regression analysis meant for non-statistical experts.

In the original study multiple years post legislation and potential gradual effects due to implementation over a sequence of years are investigated for beneficial effects on homicide. No other study currently exists utilizing these methods.

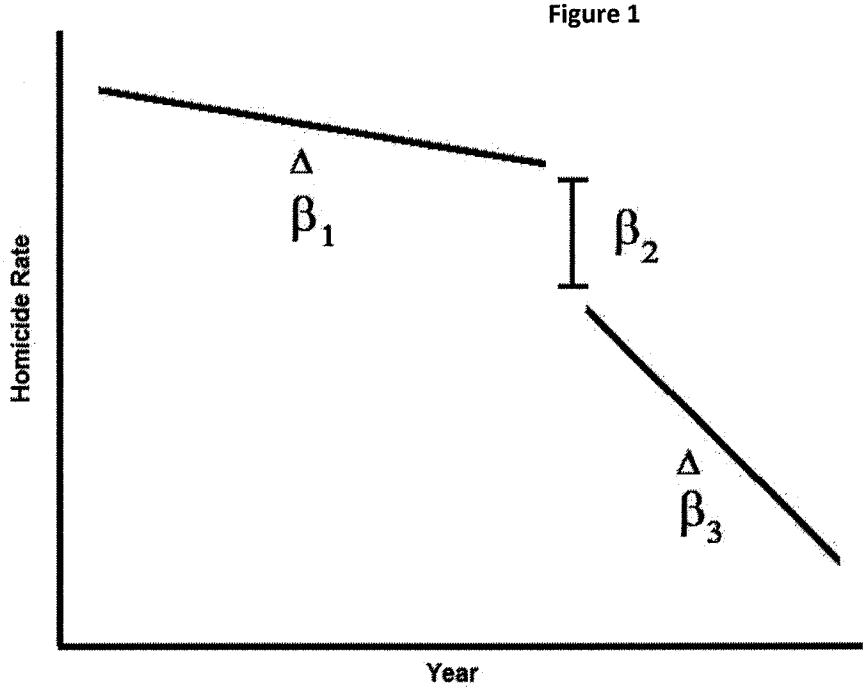
When indicated multiple regression included variables in the literature found to be associated with criminality obtained from available data: the median age of population, population attributed to immigration, population per police officers, the rate of prison incarceration, the rate of unemployment, the percent of the age 15 to 24 year old population in the low income bracket, percent of the total population in the low income bracket, and the GINI index of equality [3-7].

Understanding Interrupted Time Series Regression

This form of analysis looks for both immediate impact effects of legislation on homicide as well as a change in the trend of homicide post implementation of legislation. A solid line is generated by regression analysis to statistically predict the homicide rate expected at each year due to contributing factors such as unemployment or the age of the population. The break in the line represents the year of implementation of legislation. The immediate reduction impact of legislation, also known as a "step effect" is represented by the gap, β_2, on the following graph (Figure 1), while the change in the trend is represented by β_3.

As homicide has been declining prior to legislation it is important to account for, and determine if there has been a change in this trend due to legislation. A statistical test is performed that determines whether the size of the impact effect and/or change in the trend is larger than what would occur simply due to chance or yearly variation. For example in the graph below legislation has caused an immediate reduction, β_2, in the rate of homicide and an increasing speed in the declining trend β_3, of homicide rates.

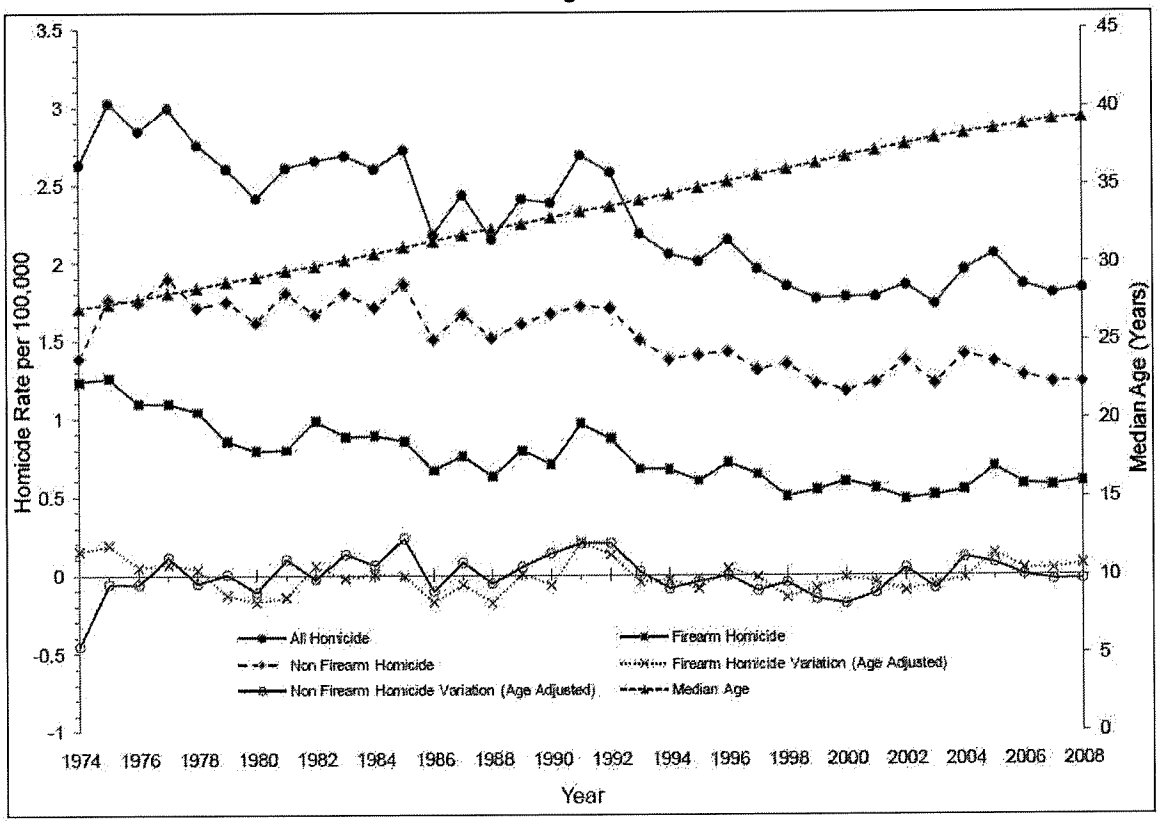
Figure 1



Results of Analysis

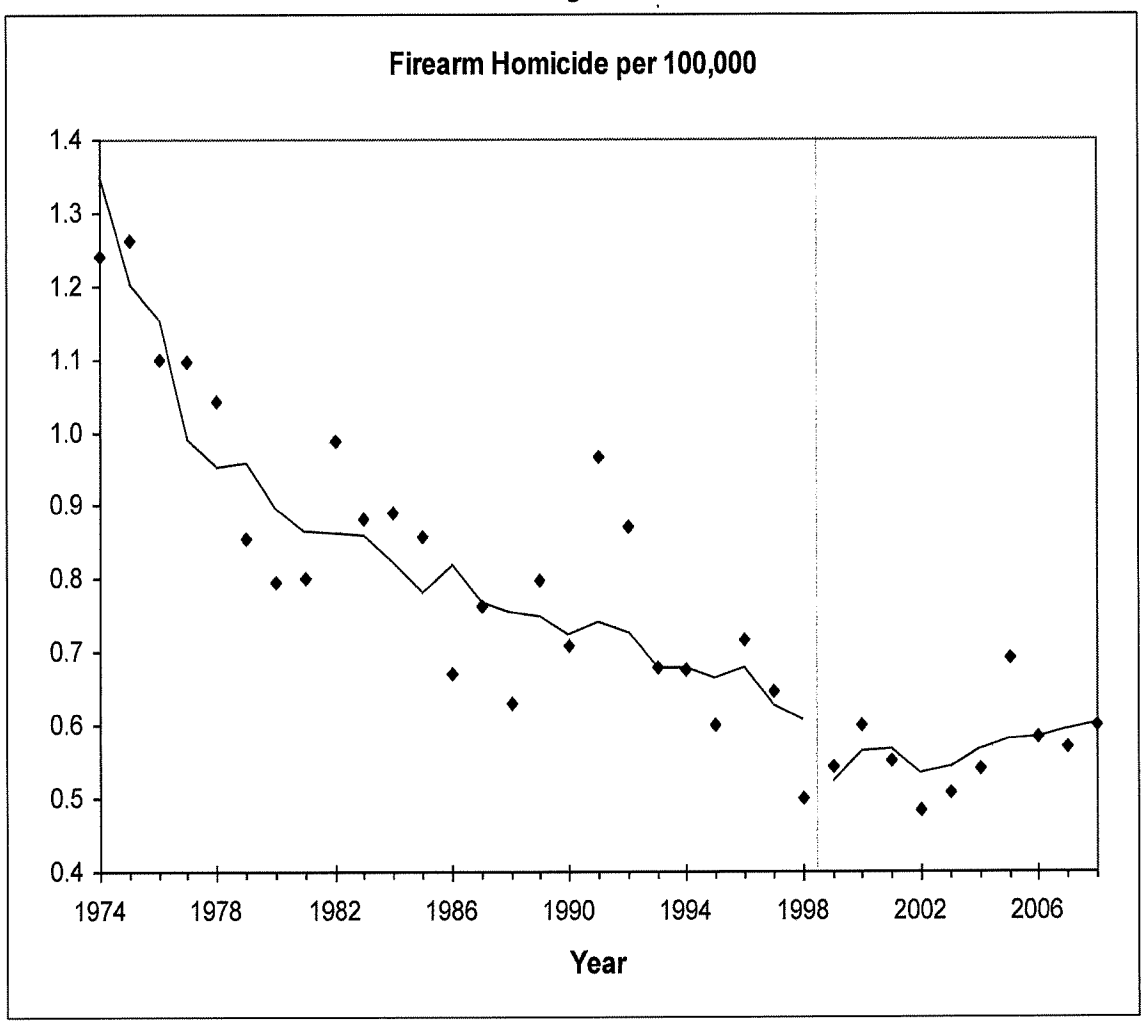
Initial analysis demonstrates that as the population ages, there has been an associated decline in the homicide rate by firearm since 1974 (Figure 2). When the effect of the aging population is taken into account, the homicide rate by firearm is constant.

Figure 2



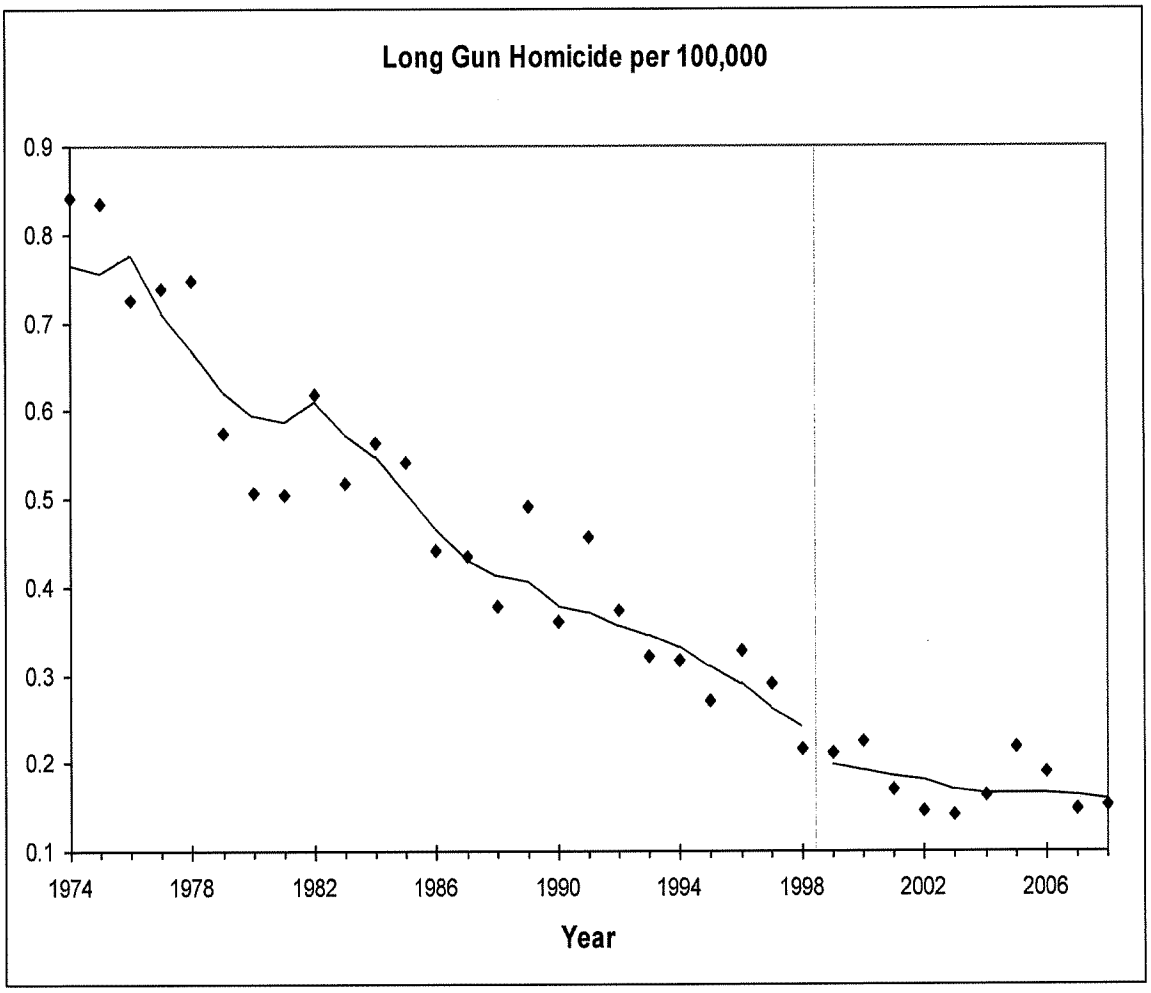
The first regression analysis looks at the effects of the LGR implemented in 1999 on the effects of the overall firearm homicide rate. Solid dots represent the actual homicide rate in each year. As depicted by the calculated regression (solid line) in Figure 3, there has been a consistent decline in homicide rates since 1974 that began prior to federal legislation, and in 1999 there is no statistically significant beneficial associated impact or trend effect on homicide rates due to the LGR. This analysis also includes the effects of the aging population, incarceration rate, immigration, police, and GINI which have been shown to be statistically associated with firearm homicide.

Figure 3



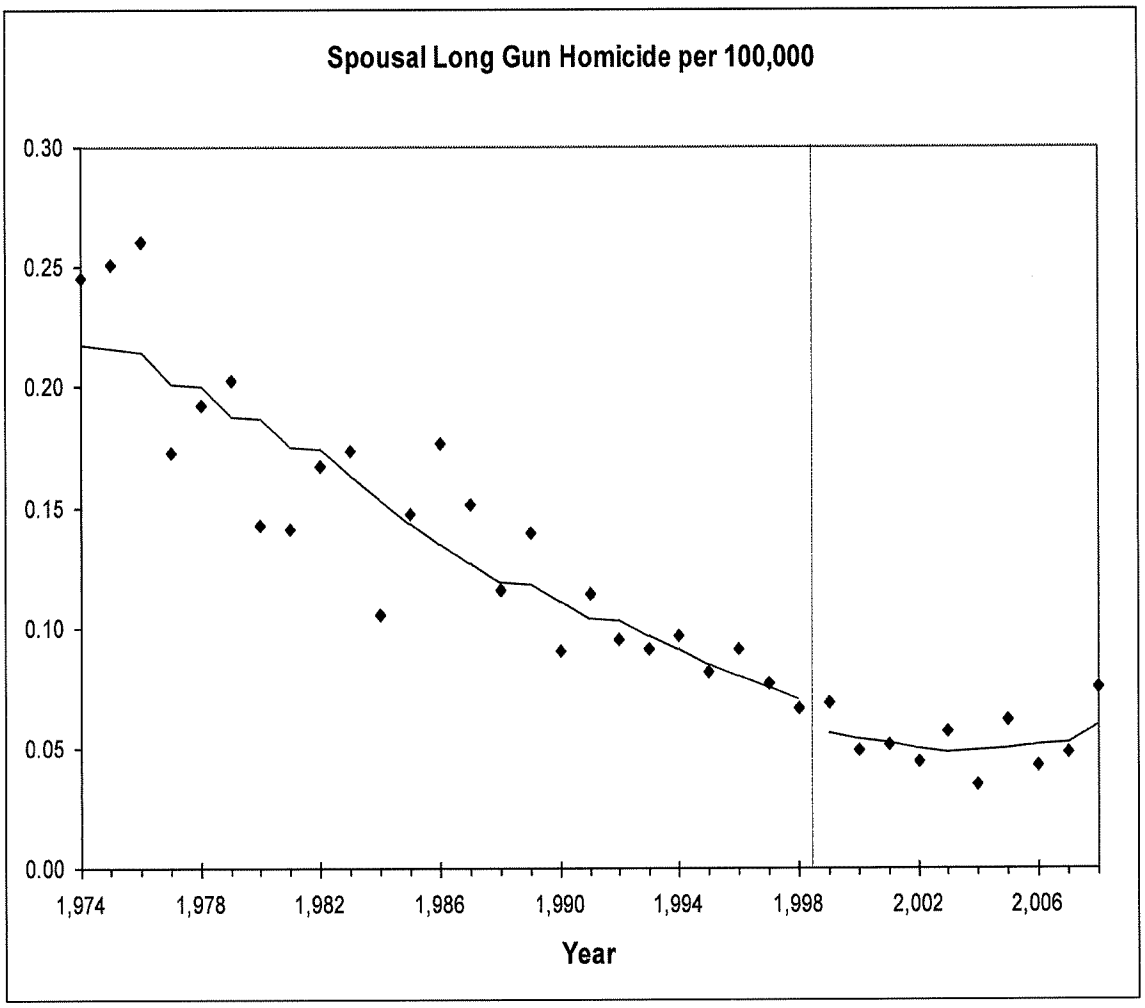
Next an analysis of the homicide rate by long gun is depicted in Figure 4. No statistically significant beneficial effects were found due to the LGR. The aging population and incarceration rates shown to be statistically associated with homicide rates by long gun are also included in the analysis.

Figure 4



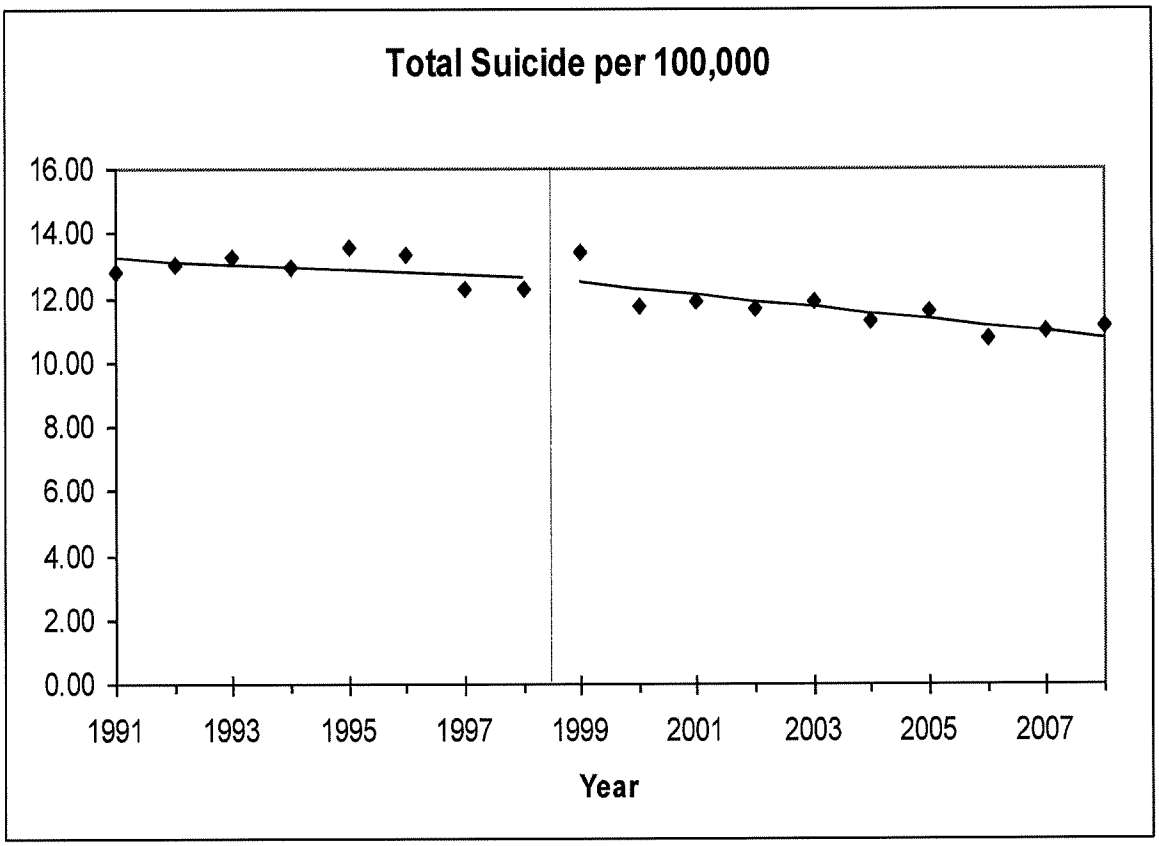
No beneficial effects on spousal homicide by long guns are depicted in Figure 5. The effects of the aging population is also included in the analysis.

Figure 5



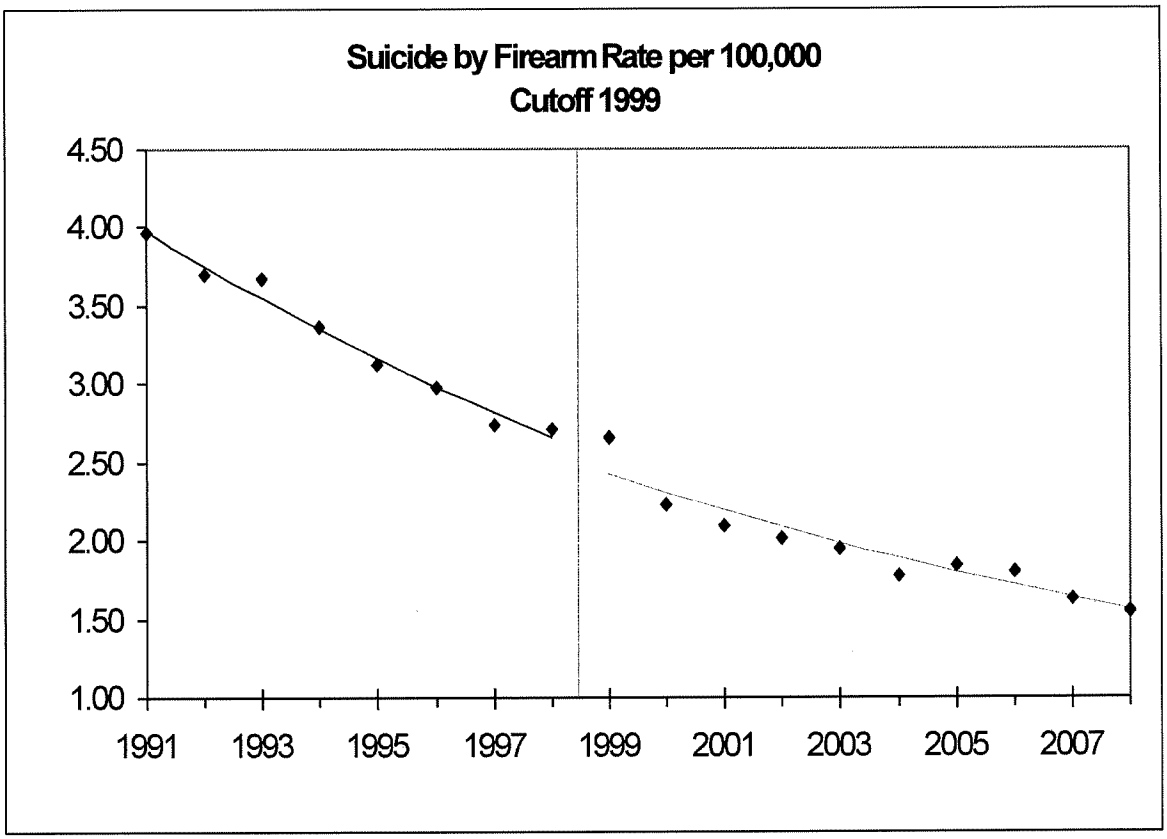
The same methodology used above is applied to the total suicide rate over the years 1991 to 2008. Only the years 1991 to 2008 were examined to account or control for any background effects from legislation implemented in 1991 and 1995. As can be seen when the LGR is implemented in 1999 there is no significant effect on total suicide in Figure 6. Moreover the overall suicide rate has remained relatively steady during this time.

Figure 6



No significant effects are associated with the implementation of the LGR in 1999 are seen on suicide rate by long gun in Figure 7.

Figure 7



Recommendations

The results of the peer reviewed study suggest that the discontinuation of registration of non-restricted firearms will not result in an increase in homicide or spousal homicide rates through the utilization of long guns. Moreover the discontinuation of the registration of non-restricted firearms is not likely to result in an increase in the aggregate suicide rate by long gun.

Further Research on Suicide

Further analysis of suicide is complicated by the fact that medication effective in the prevention of suicide known as SSRIs were introduced in 1989 and dramatically increased in use in 1996 [8, 9]. This event occurs at the same time as firearms legislation is introduced in 1991 and 1995. Therefore in order to properly evaluate the effects on suicide by firearms legislation, the beneficial effects due to SSRI medication must be accounted for. In other words any beneficial effects on suicide may be simply due to the introduction of SSRI medication and not firearm legislation.

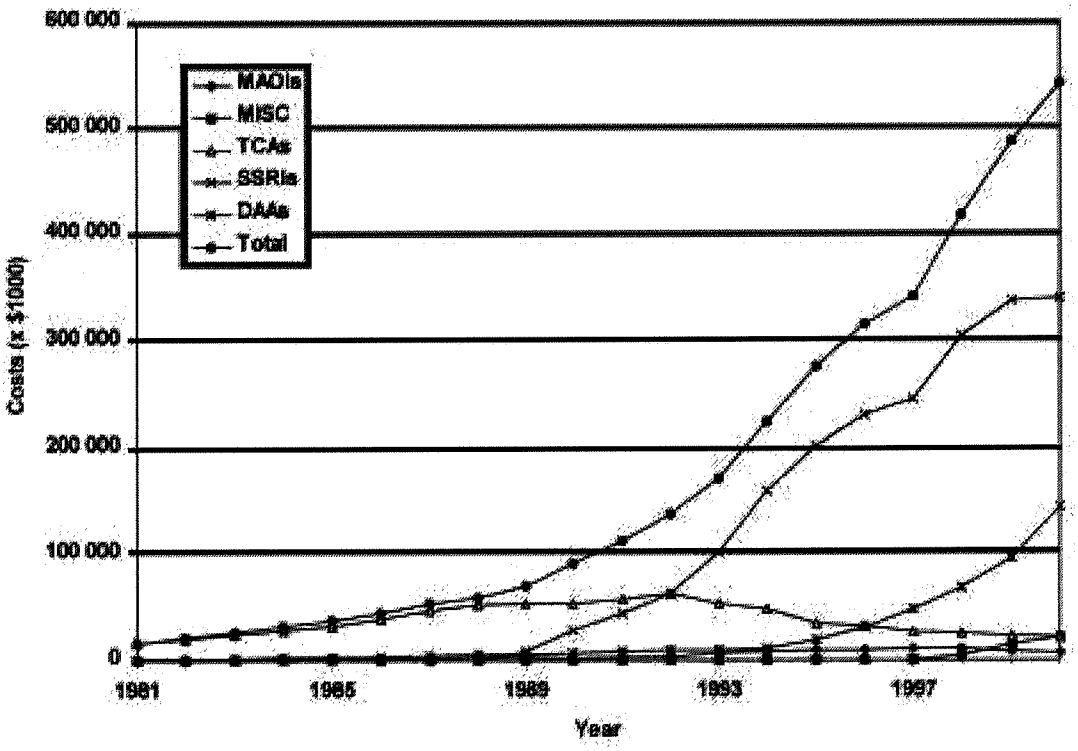
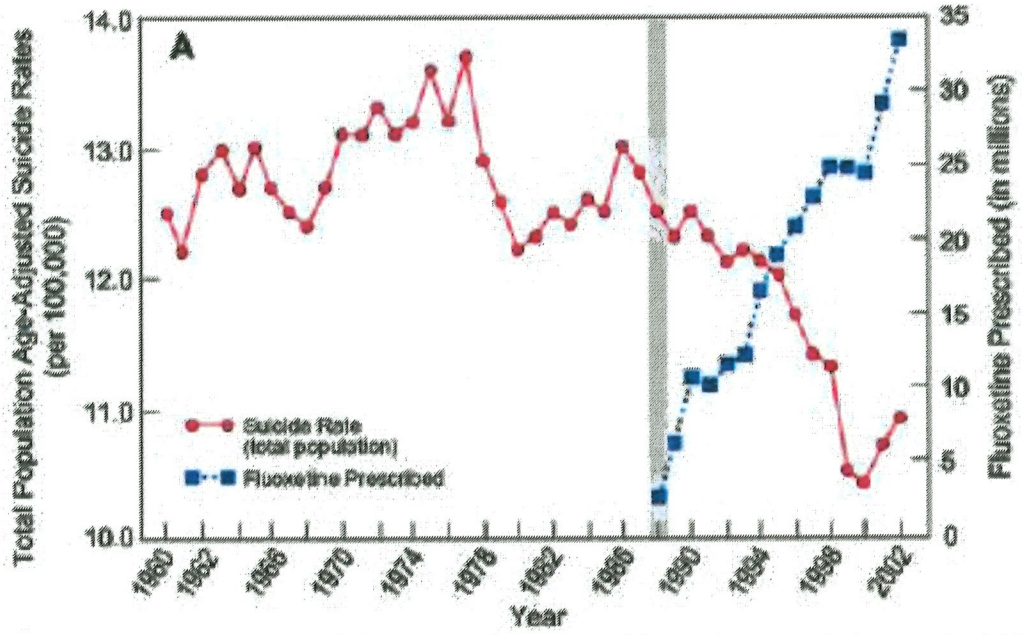


Figure 1. Total number of prescriptions by pharmacotherapeutic class. DAAs = dual action antidepressants; MAOIs = monoamine oxidase inhibitors; MISC = miscellaneous antidepressants; SSRIs = selective serotonin-reuptake inhibitors; TCAs = tricyclic antidepressants.

Hemels, M.E., G. Koren, and T.R. Einarson, *Increased use of antidepressants in Canada: 1981-2000*. Ann Pharmacother, 2002. 36(9): p. 1375-9.



Milane, M.S., et al., *Modeling of the temporal patterns of fluoxetine prescriptions and suicide rates in the United States*. PLoS Med, 2006. 3(6): p. e190.

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5. Mauser, G. and R.A. Holmes, *An evaluation of the 1977 Canadian firearms legislation.* Evaluation Review, 1992(16): p. 603-617.
6. Nadanovsky, P. and J. Cunha-Cruz, *The relative contribution of income inequality and imprisonment to the variation in homicide rates among Developed (OECD), South and Central American countries.* Social Science and Medicine, 2009. **69**(9): p. 1343-1350.
7. Ouimet, *Crime in Canada and the United States: A comparative analysis.* Sociology and Anthropology, 1999. **36**: p. 389-408.
8. Hemels, M.E., G. Koren, and T.R. Einarson, *Increased use of antidepressants in Canada: 1981-2000.* Ann Pharmacother, 2002. **36**(9): p. 1375-9.
9. Milane, M.S., et al., *Modeling of the temporal patterns of fluoxetine prescriptions and suicide rates in the United States.* PLoS Med, 2006. **3**(6): p. e190.

This is **Exhibit "F"** referred to in the Affidavit of Dr. Caillin Langmann, sworn before me this 25 day of August, 2020.

A Notary Public or a Commissioner of Oaths
in and for the Province of Ontario

Brief to Standing Committee on Public Safety and National Security
Re: Bill C-71 An Act to amend certain Acts and Regulations in relation to firearms

April 2018

Caillin Langmann, M.D., Ph.D., FRCPC, ABEM
Assistant Clinical Professor
Department of Medicine
McMaster University

Executive Summary:

- Background checks increased beyond 5 years will not result in decreased homicide or suicide by firearm and should not be performed. As well questions involving past suicide, depression and emotional problems, divorce, separation job loss, and bankruptcy should be removed as per the Privacy Act.

- Vendor sales records and license verification should not be implemented as the proposed verification system will not result in reduced homicide by firearm.

- The ATT should be repealed as a costly and redundant control of firearms, and replaced with an excuse allowing transport of all firearms to a location where such is safe and permitted to store, repair, sell or discharge.

- The evidence suggests that classification of firearms results in no public safety benefit and should be discontinued.

- Strategies that target youth offenders and gangs are more likely to result in beneficial effects.

The following amendments to the Firearms Act are considered and found to be unnecessary and ineffective.

Enhanced Background Checks

The current bill seeks to expand background checks from the previous 5 years to full lifetime. According to current research background checks do not appear to have any impact on homicide and spousal homicide rates using firearms (1), (2). In 1991 and in 1995 firearms legislation, Bill C-17 and Bill C-68, required expanded background checks, a spousal questionnaire as well as mental health questionnaire for potential firearms owners. Multi-variate analysis of Canadian firearms legislation and homicide rates was found to have no significant relationship after controlling for socio-economic factors (Figure 1) (1).

A more recent analysis of homicide was produced using a difference in difference model, which looks for associated effects with legislation while controlling for variables such as unemployment, alcohol abuse, etc. by using non firearm homicide as a control cohort. No beneficial effect associated with legislation that included background checks was found for total firearm homicide, long gun homicide and hand gun homicide (Figure 2, Table 1).

These results are not unusual in the scientific literature. The evidence for background checks and a reduction in homicide using firearms generally results in no positive associations (3).

Mass Homicide, defined as three or more victims in a single event, is a relatively rare occurrence in Canada, but the scale of tragedy has caused the implementation of legislation in the hope of preventing or limiting the severity and number of events (Figure 3.) (4). This legislation appears to have been based on the presumption that increased background checks, psychological background checks, and reductions in magazine capacity (the number of bullets a firearm can hold) as well as restriction of ownership of firearms considered more dangerous such as the AR-15 semi auto rifle would reduce mass homicide numbers.

No associated effects were found between legislation and methods used in mass homicide when a difference-in-difference model was used to look for associated effects between legislation and mass homicide (Table 2.).

Minister Goodale recently reported in the House that the firearm related crimes have been increasing (5). The association between the criminal charge of "discharge of a firearm with intent" and legislation was examined and found to have no associated effect (1). Statistics were also obtained from Statistics Canada on the three most common charges associated with violent criminal use of firearm and there does not

appear to be any increase in "discharge of firearm with intent", "using a firearm in the commission of an offence", and "pointing a firearm" when aggregated (Figure 4).

The collection of personal information places the privacy of an individual at risk. Moreover the increase in timespan of the information collected to a lifetime not only increases the exposure of an individual but also begs the question of what happens to current firearms license holders who have had licenses for 5 years without infractions and are subject to renewal will they require a broader background check? What further expense will this occur, and will an event that occurred a decade or more ago such as PTSD in a Veteran of the Canadian Armed Forces suddenly cause revocation of a license?

The Office of the Privacy Commissioner of Canada undertook a review of the use of personal information in the Canadian Firearms Program in 2001 (6). The application form for a Firearms Possession and Acquisition License asks several personal questions, in particular:

- During the past five (5) years, have you threatened or attempted suicide, or have you suffered from or been diagnosed or treated by a medical practitioner for: depression; alcohol, drug or substance abuse; behavioural problems; or emotional problems?
- During the past five (5) years, do you know if you have been reported to the police or social services for violence, threatened or attempted violence, or other conflict in your home or elsewhere?
- During the past two (2) years, have you experienced a divorce, a separation, a breakdown of a significant relationship, job loss or bankruptcy?

The review of the Office of Privacy focussed on the above questions subject to the Privacy Act that states no information shall be collected by a government institution unless it relates directly to an operating program or activity of the institution and that there must be a demonstrable need for each piece of information.

The conclusion of the Office of Privacy was that the information collected, in particular previous suicide attempts, treatment for depression, unemployment, and drug use are not risk factors for firearm violence. As well previous suicide attempts or treatment for depression are not necessarily associated with a suicide attempt with a firearm.

As these questions did not meet the "demonstrable need test" the office recommended that this information not be collected and furthermore this information should be eliminated. If this is the recommendation for a 5-year period, then collection of this data over a wider timeframe serves no further benefit.

It is hypothesized that psychiatric background checks could reduce suicide. As suicide by firearm is 83% effective, it is supposed that if a firearm were not available, a person choosing a substitute, and presumably less effective method would enable an intervention to be made preventing other future attempts (7). Unfortunately the most common other method, hanging, is equally as effective, 82%, as by firearm and much

more difficult to control. Regression analysis was performed comparing suicide by method, firearm and non-firearm. There was an impact effect resulting in a reduction of firearm suicide associated with the implementation of C-17 in 1991, possibly due to a reduction in firearm numbers or even a shift in culture. However there was an equal increase in use of non-firearm suicide methods resulting in no overall decrease in suicide (Table 3.). Moreover as the number of firearms licenses has increased slightly, there is no association with suicide by firearm (Table 4.).

Recommendation: Background checks increased beyond 5 years will not result in decreased homicide or suicide by firearm and should not be performed. As well questions involving past suicide, depression and emotional problems, divorce, separation job loss, and bankruptcy should be removed as per the Privacy Act.

Vendor Sales Records and License Verification

In 1999 the Long Gun Registry was implemented, requiring the registration of all non restricted firearms in Canada. This was repealed in 2012. An impact of registration of long guns was examined and found to have no effect on homicide by long gun as well as discharge of firearm with intent (1).

The requirement of vendors to keep sales records will recreate a quasi-registry that will be less informative than the Federal Long Gun Registry. As the Federal registry was demonstrably not beneficial in preventing homicide, neither will a less effective registry be expected to result in any harm reduction.

A significant concern is that vendor registries will be open to breaches of personal privacy as there will be no controls on data protection. This could provide a "shopping list" of firearms and their location to criminal elements. From 1995 to 2017 there were 6,926 breaches of the Canadian Police Information Center database that contains the identity of firearms license holders (8). While this is concerning negative side effect of licensing as it can provide criminal elements with a source of potential firearms, if this protected data base can be breached one can only expect vendor records to be much more vulnerable.

In the same way that licensing has not been associated with a reduction in firearm violence and homicide, license verification is also not associated with such a reduction. Fake or reproduced licenses are easily made and obtained from legitimate private sales of firearms and as such can be readily passed off at firearms dealers in the same manner. The fraudulent holder of the license will be able to pass any call-in check as s/he can assume the identity of a legitimate license holder (including the licence number and name) so the licence will be judged as valid by the Canadian Firearms Program.

Recommendation: Vendor sales records and license verification should not be implemented as the proposed verification system will not result in reduced homicide by firearm.

Long Term Automatic Authorization to Transport Firearms

Currently firearms classified as restricted require authorization to transport (ATT) approvals by the Chief Firearms Officer. Due to the regulatory hurdle of issuing this every time a firearms owner transports a firearm, a general and automatic authorization is issued to all owners of restricted firearms. After all they have already passed their background checks and thus the system is essentially redundant.

The authorization to transport historically predates licensing by decades and assumes that requiring authorization to transport to specific locations would prevent people from continuously transporting firearms to any non permissible location. The police are concerned that if an ATT was too broadly worded a person could use it to hypothetically excuse improper transport by claiming they were on their way to a permitted location. Finally the ATT provides the Federal government with a location of every restricted firearm presumably should confiscation be required.

There is currently no empirical evidence demonstrating the effectiveness of the ATT. The fact is that the vast majority of legitimate gun owners do not use their firearms for illegal purposes let alone to cause harm (9) (10). The ATT has been modified with each legislative round and not associated with beneficial effects (1).

Recommendation: The ATT should be repealed as a costly and redundant control of firearms, and replaced with an excuse allowing transport of all firearms to a location where such is safe and permitted to store, repair, sell or discharge.

The Classification of Firearms and the Prohibition of Certain Firearms such as the CZ and Swiss Arms Rifle

What is becoming clear from current research is that the type of firearm, and control of certain types of firearms or magazine size restrictions results in no reduction in firearm homicide or suicide (3). Extensive analysis of mass homicide events demonstrates that mass killers can use a wide variety of firearm types, even firearms with small magazine capacities, to cause a significant number of deaths. There does not appear to be an association with magazine capacity and death as the shooter often appears to have enough time between shots to reload (11).

In Canada in the 1990s a large number of firearms were restricted or prohibited by law as well magazine capacities were limited. No associated reduction in homicide was found (Table 2.) (1).

There has been some concern that an increase in legitimate ownership of restricted firearms, in particular handguns, have increased availability to criminal elements and consequently an increase in homicide (12). However regression analysis of the number

of registered restricted firearms demonstrates no association between an increase in ownership and homicide (Figure 6.) (Table 5.).

Recommendation: The evidence suggests that classification of firearms results in no public safety benefit and should be discontinued.

What Can Be Done?

As previously stated, legal firearms owners in Canada are much less likely to engage in criminal behavior than average citizens (10). Hence targeting this group will not result in any significant reduction in firearms violence and homicide, and will not result in a reduction in suicide (1) (3). It also appears that there is a possible underlying rise in gang related firearm homicide in Canada thus necessitating strategies that will target gangs (13).

Resources can better be placed in some promising programs that could help reduce violence and criminality overall. In fact the Department of Public Safety has already conducted analysis of possible interventions including gang deterrence, intervention, and collaboration, as well as geographical targeting of criminal behaviour (14) (15). A meta-analysis demonstrated that diversion programs targeting youth offenders reduces recidivism at a greater rate than traditional justice systems (16).

It is beyond the scope of this review to go into further detail regarding reduction in criminal behaviour, but it is more likely that such programs will have a greater effect on firearms violence and homicide than further restrictions on an already very safe cohort of Canadian citizens especially as increases in gang related homicides are the concern. As resources are scarce, allocation towards areas of actual impact are imperative.

Recommendation: Strategies that target youth offenders and gangs are more likely to result in beneficial effects.

Figure 1. Interrupted regression analysis demonstrating no statistically significant impact effects or change in trends after implementation of legislation (1).

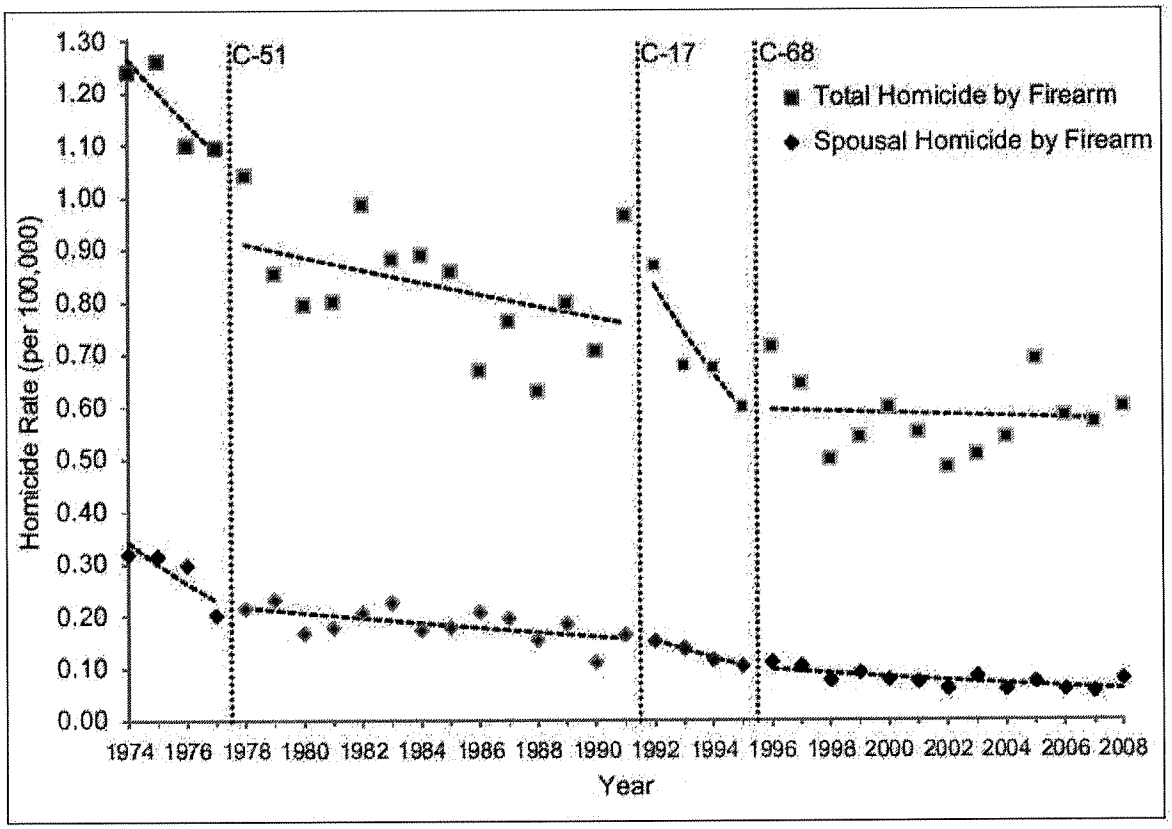

Figure 2. Homicide by method, 1974 – 2016.

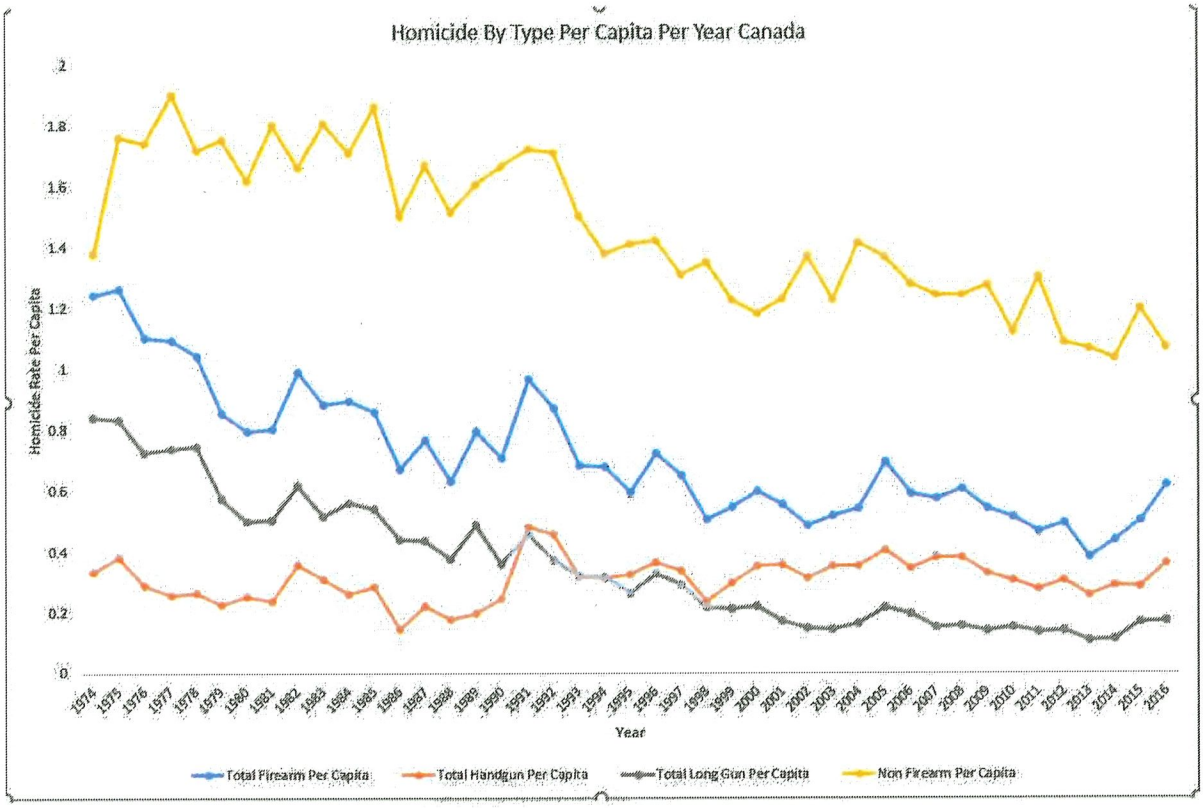

Table 1. Homicide by method, Difference in Difference Analysis 1974 – 2016. The difference in difference model compared Non Firearms Homicide to all Firearms Homicide, Long gun Homicide, and Handgun Homicide. In all cases after licensing homicide rates were not improved.

SPSS Binomial Regression method.

ln (homicide rate) = i + B1Year + B2Firearm_Non_Firearm + B3Step_Function + B4YearxFirearm_Non_Firearm + B5Firearm_Non_FirearmxStep_Function +B6YearxStep_Function + B7YearxFirearm_Non_FirearmxStep_Function
B7 measures the additional change in trend in firearm mortality relative to non firearm mortality

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	6.028	.0475	5.935	6.121	16097.480	1	.000
Year_Count	.002	.0033	-.004	.008	.402	1	.526
Firearm_Yes_No	-.479	.0672	-.611	-.348	50.836	1	.000
C68	-.025	.1699	-.358	.308	.022	1	.883
Firearm_Yes_No * Year_Count	-.016	.0046	-.025	-.007	11.865	1	.001
Firearm_Yes_No * C68	-.383	.2404	-.854	.088	2.540	1	.111
Year_Count * C68	-.002	.0058	-.014	.009	.142	1	.706
Firearm_Yes_No * Year_Count * C68	.017	.0082	.001	.033	4.396	1	.036
(Scale)	365080.177[a]						
(Negative binomial)	1[b]						

Dependent Variable: Total_Firearm
Model: (Intercept), Year_Count, Firearm_Yes_No, C68, Firearm_Yes_No * Year_Count, Firearm_Yes_No * C68, Year_Count * C68, Firearm_Yes_No * Year_Count * C68

a. Computed based on the Pearson chi-square.

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	6.028	.0504	5.929	6.127	14305.205	1	.000
Year_Count	.002	.0035	-.005	.009	.358	1	.550
Firearm_Yes_No	-.790	.0714	-.930	-.650	122.527	1	.000
C68	-.025	.1802	-.378	.328	.019	1	.889
Firearm_Yes_No * Year_Count	-.038	.0049	-.047	-.028	58.539	1	.000
Firearm_Yes_No * C68	-.916	.2558	-1.418	-.415	12.829	1	.000
Year_Count * C68	-.002	.0061	-.014	.010	.126	1	.722
Firearm_Yes_No * Year_Count * C68	.028	.0087	.011	.045	10.347	1	.001
(Scale)	410820.451[a]						
(Negative binomial)	1[b]						

Dependent Variable: Long_Gun
Model: (Intercept), Year_Count, Firearm_Yes_No, C68, Firearm_Yes_No * Year_Count, Firearm_Yes_No * C68, Year_Count * C68, Firearm_Yes_No * Year_Count * C68

a. Computed based on the Pearson chi-square.

b. Fixed at the displayed value.

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	6.028	.0697	5.891	6.165	7472.633	1	.000
Year_Count	.002	.0048	-.007	.011	.187	1	.666
Firearm_Yes_No	-1.909	.0989	-2.103	-1.715	372.445	1	.000
C68	-.025	.2493	-.514	.464	.010	1	.920
Firearm_Yes_No * Year_Count	.016	.0068	.003	.029	5.436	1	.020
Firearm_Yes_No * C68	.577	.3532	-.115	1.269	2.667	1	.102
Year_Count * C68	-.002	.0085	-.019	.014	.066	1	.797
Firearm_Yes_No * Year_Count * C68	-.015	.0120	-.039	.008	1.574	1	.210
(Scale)	786452.485[a]						
(Negative binomial)	1[b]						

Dependent Variable: Handgun
Model: (Intercept), Year_Count, Firearm_Yes_No, C68, Firearm_Yes_No * Year_Count, Firearm_Yes_No * C68, Year_Count * C68, Firearm_Yes_No * Year_Count * C68

a. Computed based on the Pearson chi-square.

b. Fixed at the displayed value.

Figure 3. Mass Homicide Victims by method of homicide, 1974 – 2010.

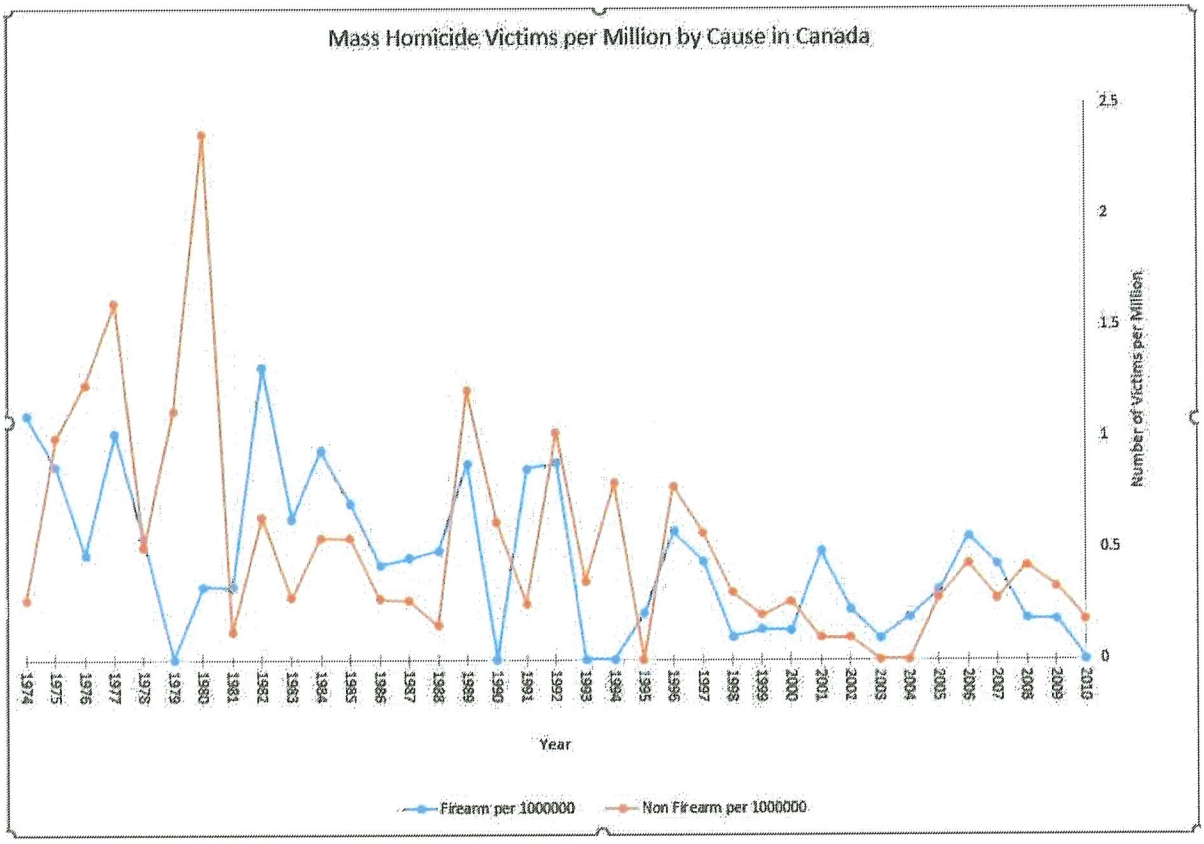

Table 2. Mass Homicide Victims by method of homicide, 1974 – 2010. A difference in difference model was constructed to compare mass homicide with firearm against the control group of mass homicide without firearm. The model shows a sudden drop in the 1990s in both rates of mass homicide (with and without firearm) but the drop and the decline is similar in both groups suggesting a possible cause other than gun control.

SPSS Binomial Regression method.

ln (homicide rate) = i + B1Year + B2Firearm_Non_Firearm + B3Step_Function + B4YearxFirearm_Non_Firearm + B5Firearm_Non_FirearmxStep_Function +B6YearxStep_Function + B7YearxFirearm_Non_FirearmxStep_Function
B7 measures the additional change in trend in firearm mortality relative to non firearm mortality

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	3.119	.2935	2.544	3.695	112.910	1	.000
Year_Count	-.024	.0203	-.063	.016	1.344	1	.246
Firearm_Yes_No	-.132	.4162	-.948	.683	.101	1	.751
C68	-4.005	1.8202	-7.573	-.437	4.841	1	.028
Year_Count * Firearm_Yes_No	-.009	.0288	-.064	.049	.072	1	.789
Firearm_Yes_No * C68	3.301	2.5493	-1.696	8.297	1.676	1	.195
Year_Count * C68	.114	.0615	-.006	.235	3.455	1	.063
Year_Count * Firearm_Yes_No * C68	-.091	.0864	-.260	.079	1.103	1	.294
(Scale)	13287655.4[a]						
(Negative binomial)	1[b]						

Dependent Variable: Victims
Model: (Intercept), Year_Count, Firearm_Yes_No, C68, Year_Count * Firearm_Yes_No, Firearm_Yes_No * C68, Year_Count * C68, Year_Count * Firearm_Yes_No * C68

a. Computed based on the Pearson chi-square.

b. Fixed at the displayed value.

Figure 4. Combine firearms offences. Discharge of Firearm with Intent, Using a Firearm in the Commission of an Offence, And Pointing a Firearm, 1998 - 2016.

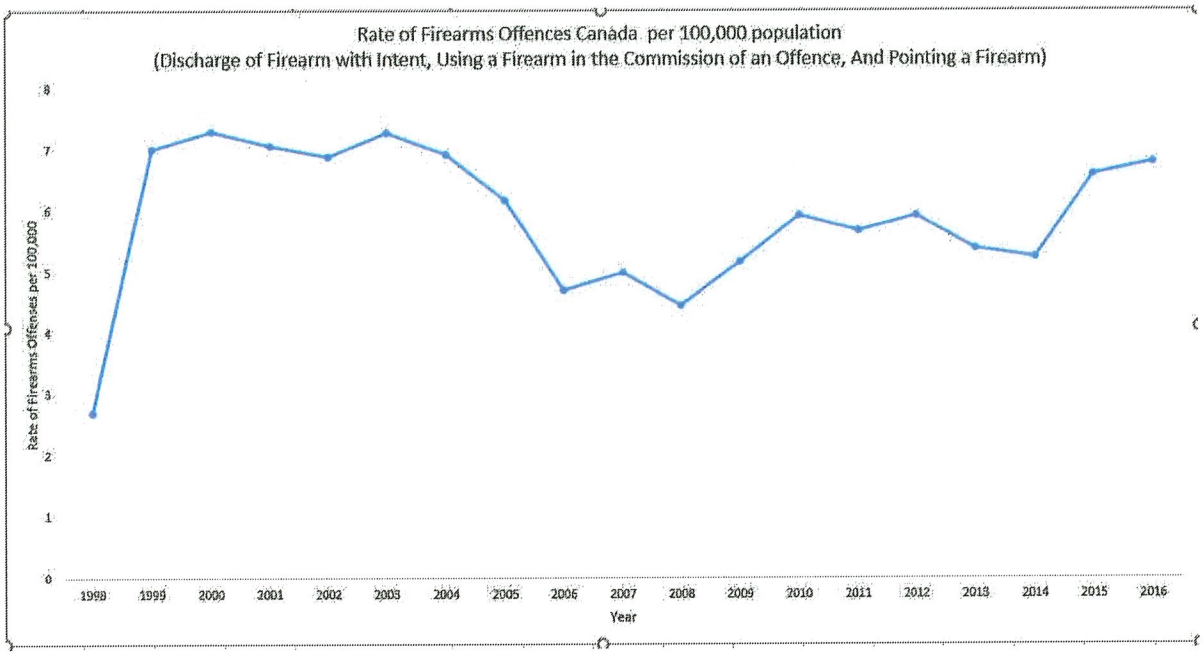

Figure 5. Suicide in Canada, 1981 – 2014.

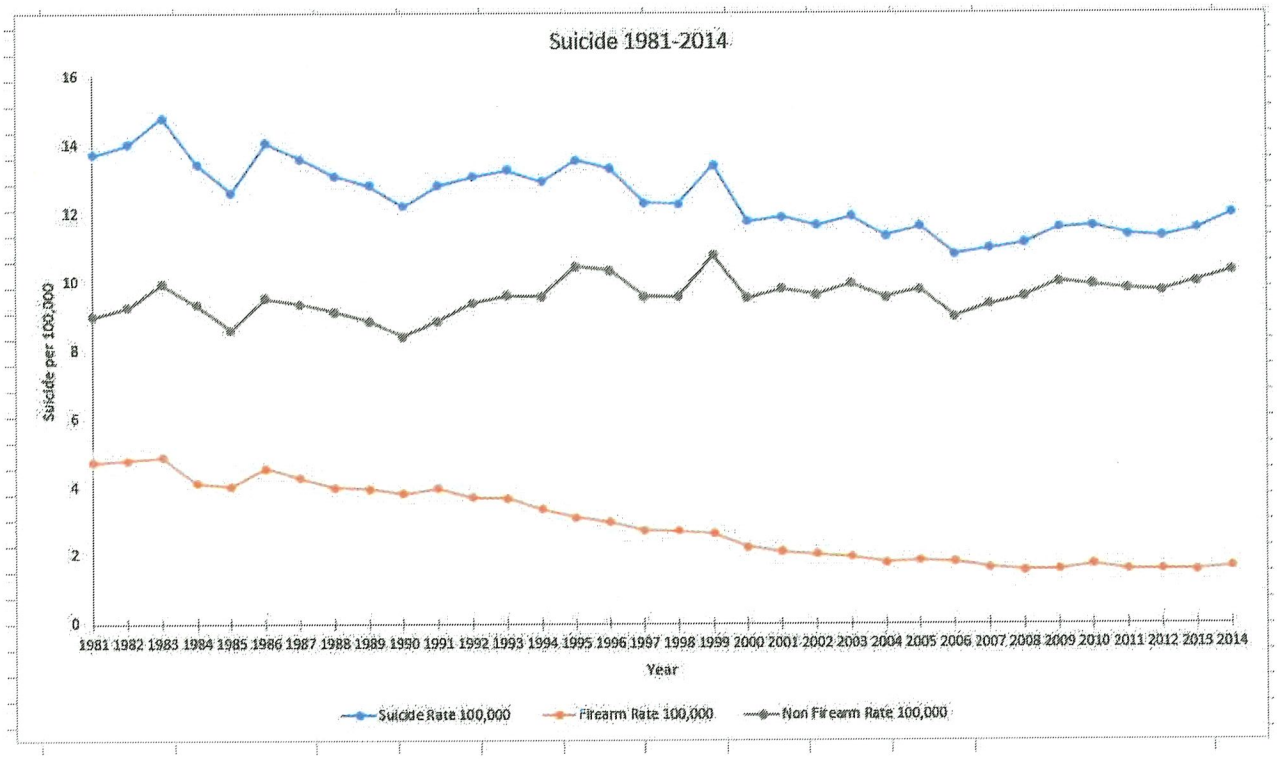

Table 3. Firearms suicide C17 is associated with a -0.113 +/-0.0479 sudden impact reduction per 100,000. While Non-Firearms suicide C17 is associated with a 0.108 +/-0.0285 sudden impact increase per 100,000. Hence there is a direct substitution effect using methods other than firearms resulting in no overall suicide reduction.

SPSS Binomial Regression method.

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	7.208	.1885	6.838	7.577	1462.387	1	.000
Time	.004	.0069	-.009	.017	.348	1	.556
C17	-.113	.0479	-.207	-.019	5.539	1	.019
Post_C17	.011	.0115	-.011	.034	.949	1	.330
Unemployment	.023	.0105	.003	.044	5.007	1	.025
Prescriptions_per_1000_1	-.001	.0003	-.002	.000	12.504	1	.000
(Scale)	119744.653[a]						
(Negative binomial)	1[b]						

Dependent Variable: Firearm_Suicide
Model: (Intercept), Time, C17, Post_C17, Unemployment, Prescriptions_per_1000_1

a. Computed based on the Pearson chi-square.

b. Fixed at the displayed value.

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	7.905	.0665	7.777	8.034	14563.213	1	.000
Time	.009	.0042	.001	.017	4.330	1	.037
C17	.108	.0285	.052	.164	14.409	1	.000
Post_C17	.019	.0067	.006	.032	8.187	1	.004
Prescriptions_per_1000_1	.000	.0002	-.001	.000	6.744	1	.009
(Scale)	45186.642[a]						
(Negative binomial)	1[b]						

Dependent Variable: Non_Firearm_Suicide
Model: (Intercept), Time, C17, Post_C17, Prescriptions_per_1000_1

a. Computed based on the Pearson chi-square.

b. Fixed at the displayed value.

Table 4. Firearm licenses are not associated with an increase in suicide by firearm.

SPSS Binomial Regression Analysis.

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	10.105	1.5783	7.011	13.198	40.988	1	.000
Licenses	-5.157E-007	3.9768E-007	-1.295E-006	2.638E-007	1.681	1	.195
Unemployment_Rate	.015	.0175	-.019	.049	.745	1	.388
Alcohol_Purchased_Rate	-.362	.1092	-.576	-.148	10.981	1	.001
(Scale)	58882.928[a]						
(Negative binomial)	1[b]						

Dependent Variable: Firearms_Suicide
Model: (Intercept), Licenses, Unemployment_Rate, Alcohol_Purchased_Rate

a. Computed based on the Pearson chi-square.

b. Fixed at the displayed value.

Figure 6. Number of restricted and prohibited firearms registered to legitimate owners in Canada and Homicide by firearm and handgun per capita, 1996 – 2016.

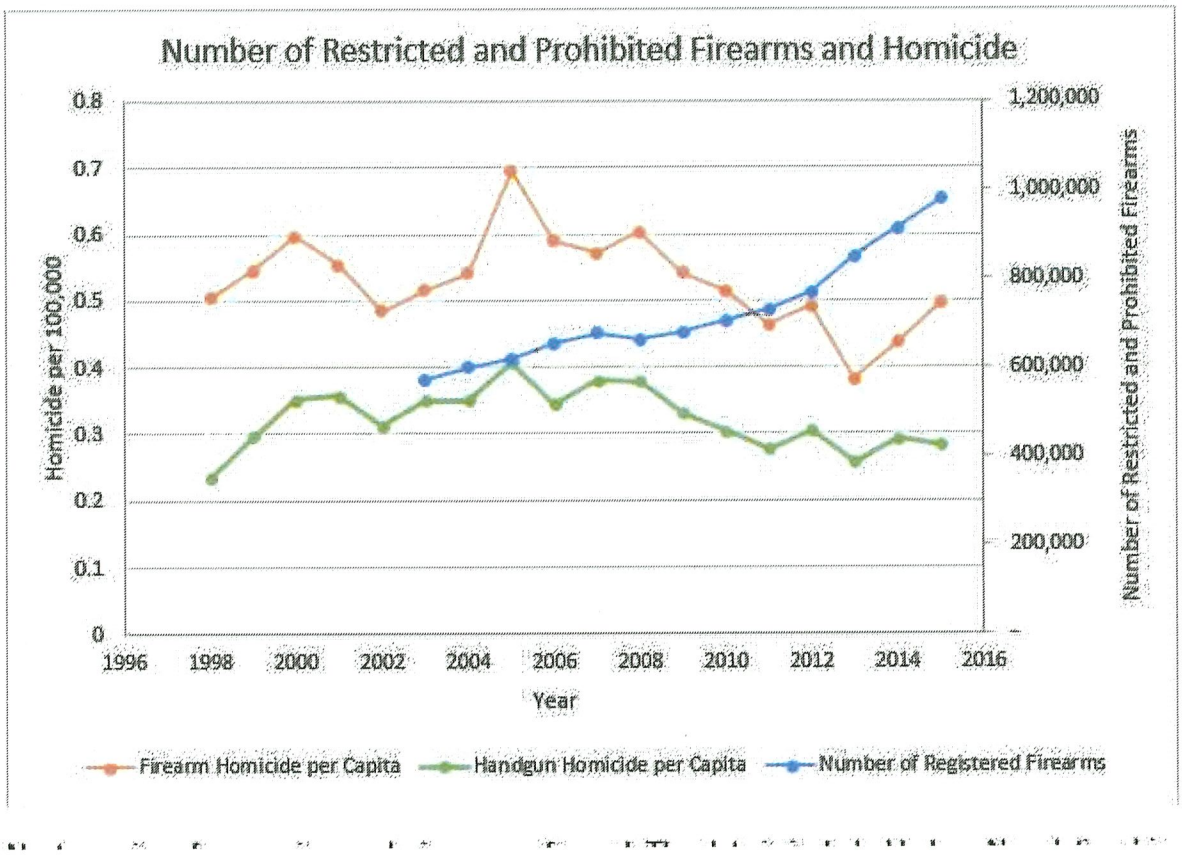

Table 5. Number of restricted and prohibited firearms registered to legitimate owners in Canada and homicide by handgun, 1996 – 2016. No association was found between increasing number of firearms and homicide.

SPSS Binomial Regression Analysis.

Handgun Homicide and the Number of Restricted and Prohibited Firearms

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	20693.952	22632.2211	-23664.386	65052.290	.836	1	.361
median_age	34.677	39.2501	-42.252	111.606	.781	1	.377
unemployment	-6.076	5.6074	-17.066	4.914	1.174	1	.279
immigration	.000	.0002	.000	.000	.376	1	.540
year	-10.937	12.0825	-34.619	12.744	.819	1	.365
num_reg_firearms	5.224E-005	.0001	.000	.000	.124	1	.725
(Scale)	2696709849[a]						

Dependent Variable: Handgun Homicides

Model: (Intercept), median_age, unemployment, immigration, year, num_reg_firearms

a. Computed based on the Pearson chi-square.

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This is **Exhibit "G"** referred to in the Affidavit of Dr. Caillin Langmann, sworn before me this 25 day of August, 2020.

A Notary Public or a Commissioner of Oaths
in and for the Province of Ontario

Figure 1

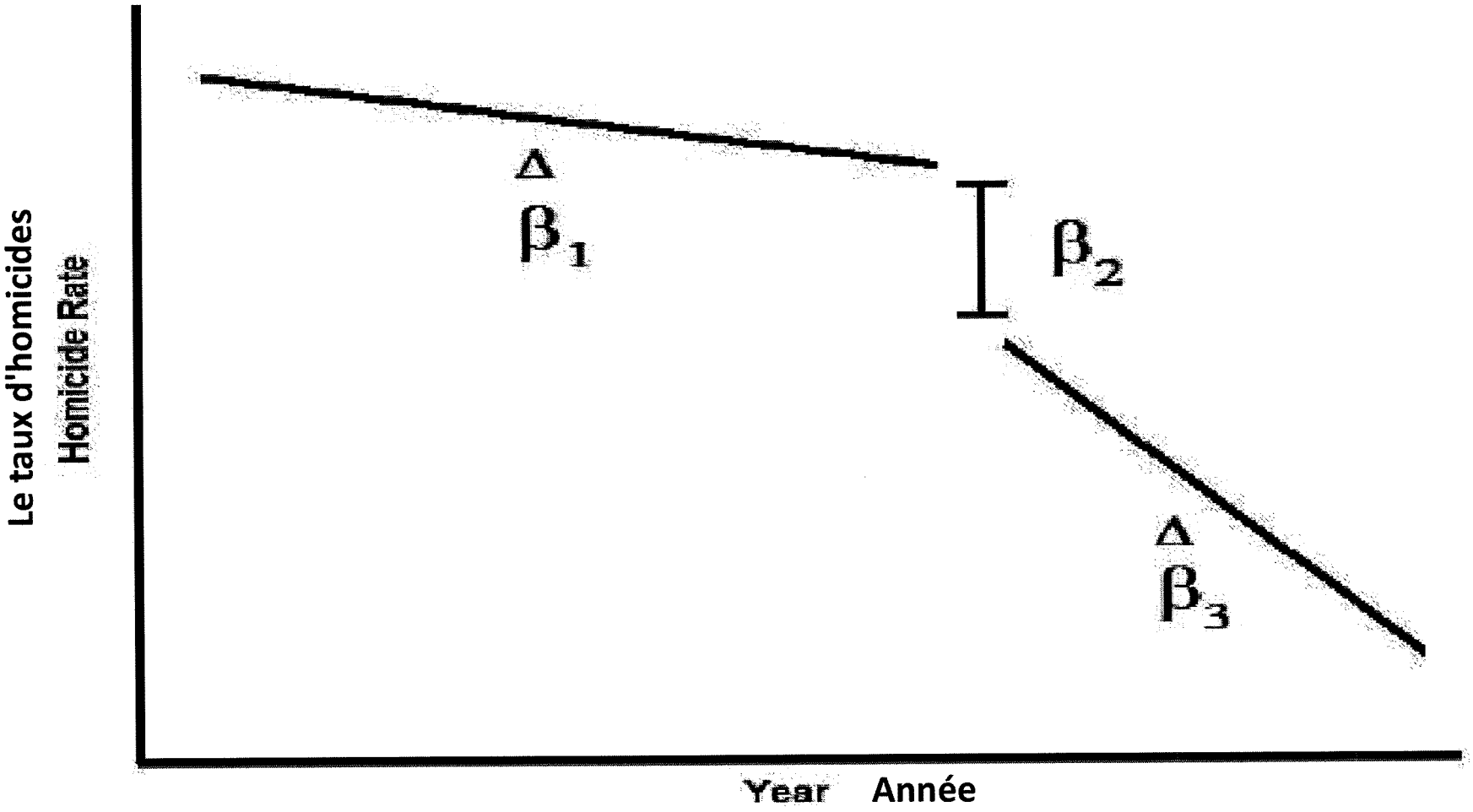


Figure 2

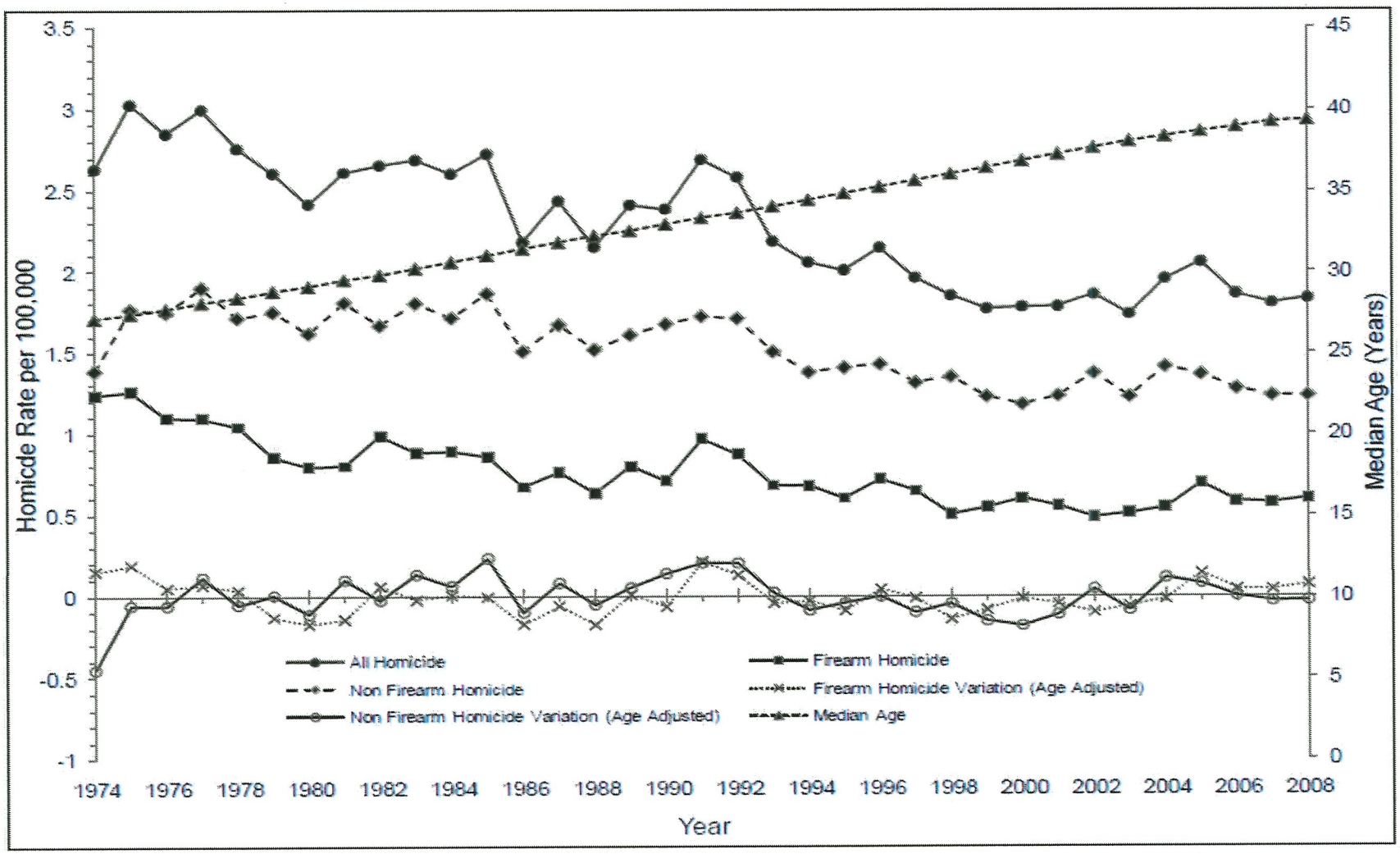

Homicde Rate per 100,000
Median Age (Years)
Year
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
45
40
35
30
25
20
15
10
5
0
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
All Homicide
Firearm Homicide
Non Firearm Homicide
Firearm Homicide Variation (Age Adjusted)
Non Firearm Homicide Variation (Age Adjusted)
Median Age

Figure 3

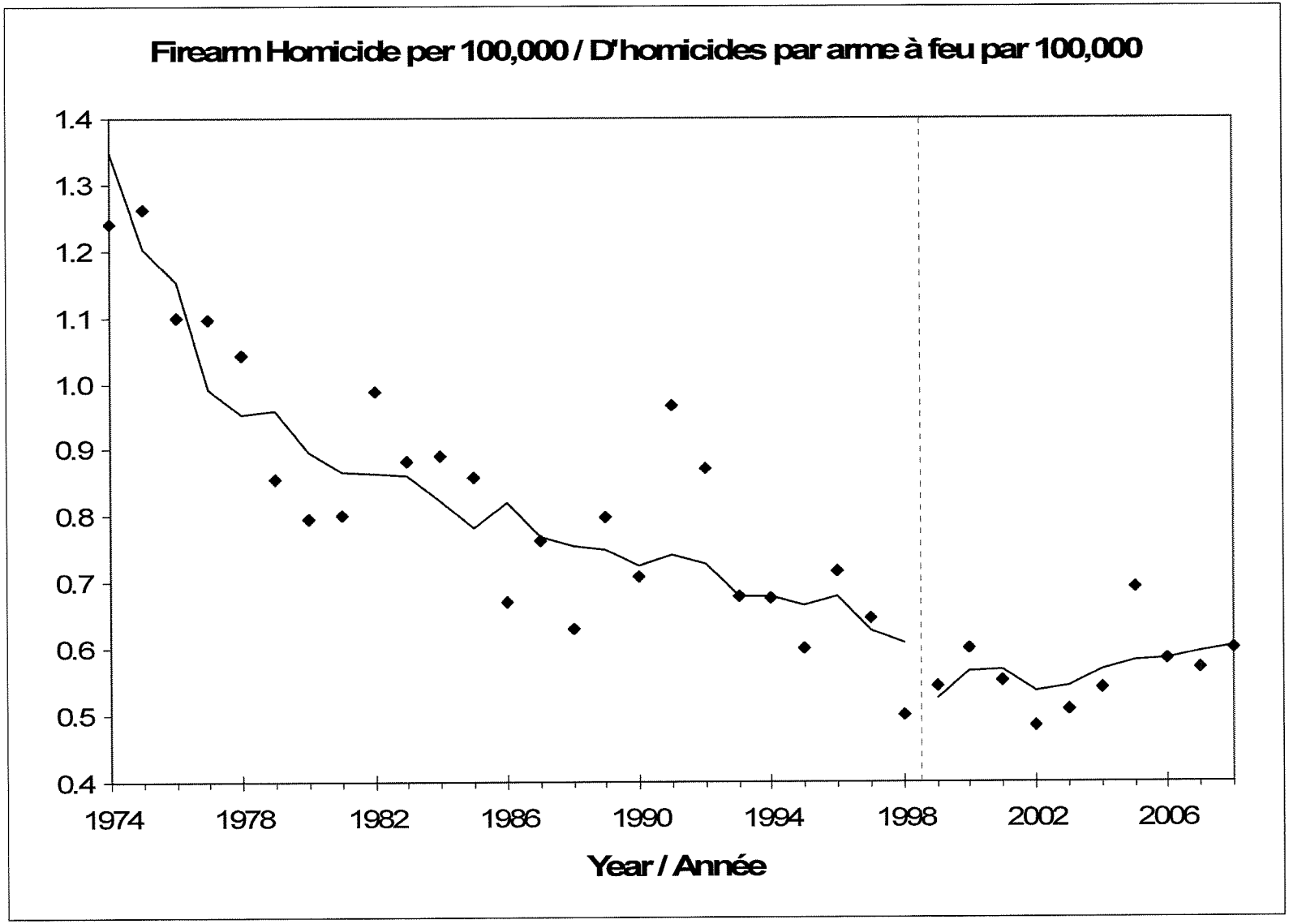

Firearm Homicide per 100,000 / D'homicides par arme à feu par 100,000
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
1974
1978
1982
1986
1990
1994
1998
2002
2006
Year / Année

Figure 4

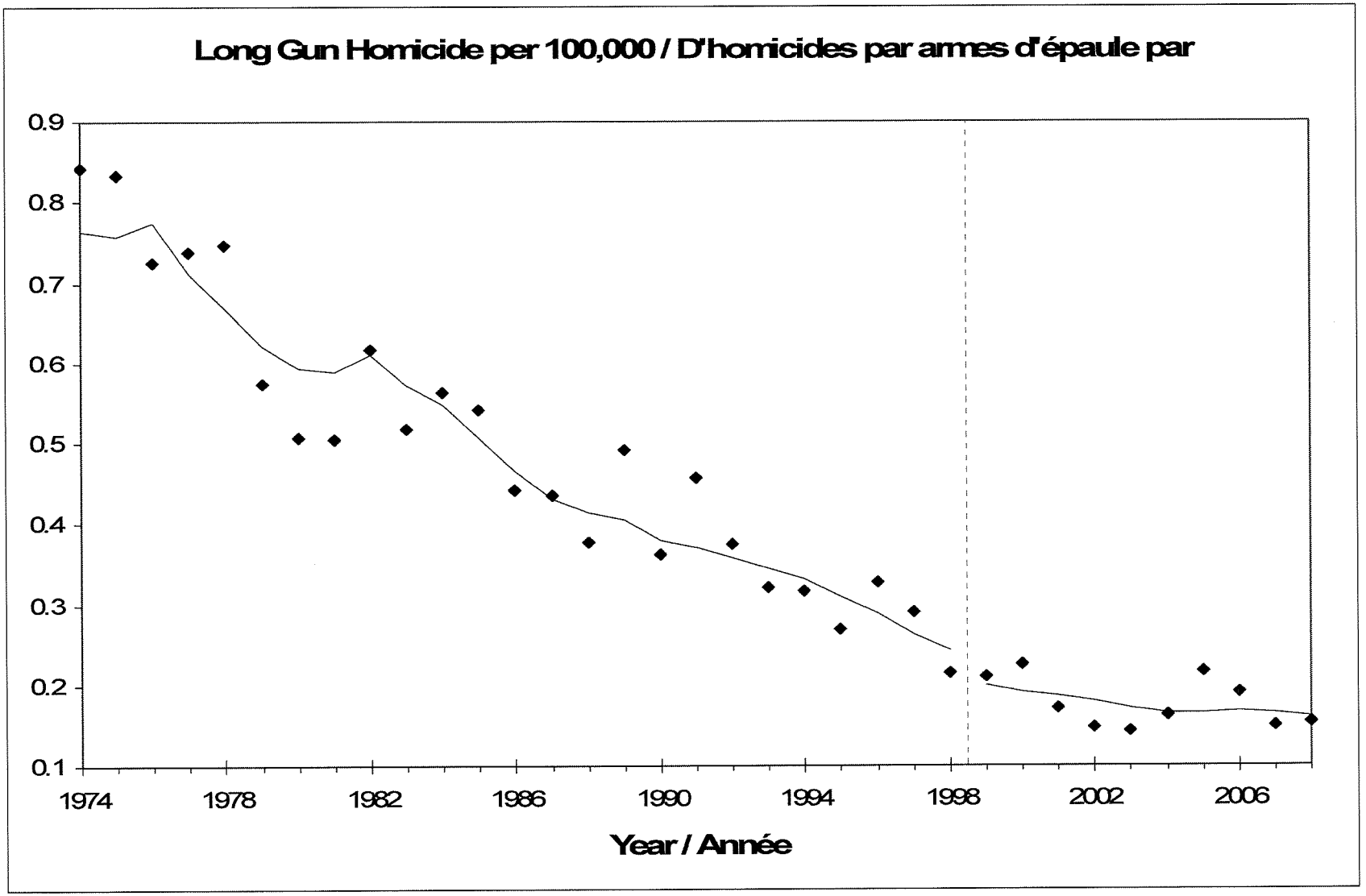

Long Gun Homicide per 100,000 / D'homicides par armes d'épaule par
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1974
1978
1982
1986
1990
1994
1998
2002
2006
Year / Année

Figure 5

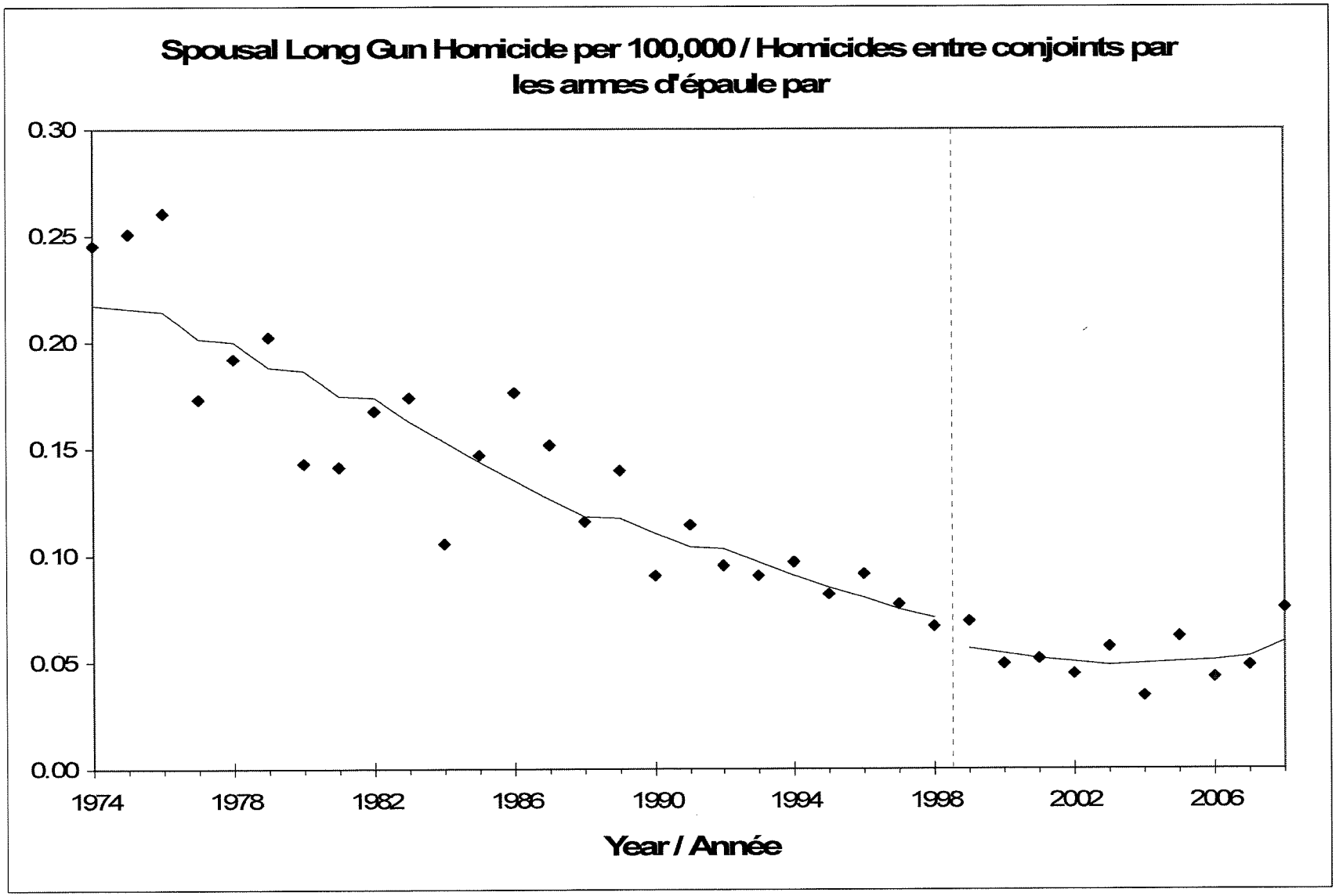

Spousal Long Gun Homicide per 100,000 / Homicides entre conjoints par les armes d'épaule par
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1974
1978
1982
1986
1990
1994
1998
2002
2006
Year / Année

Figure 6

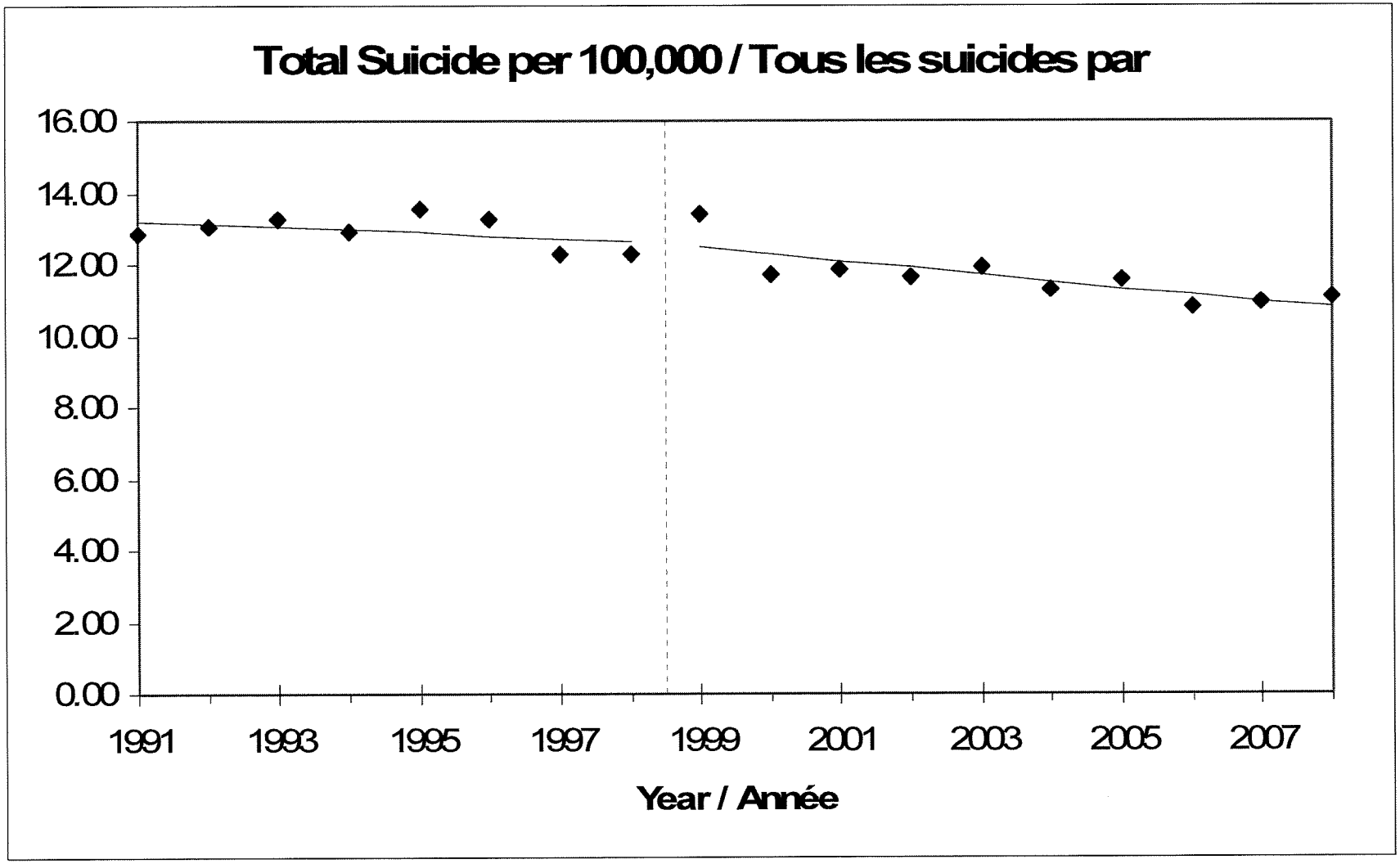
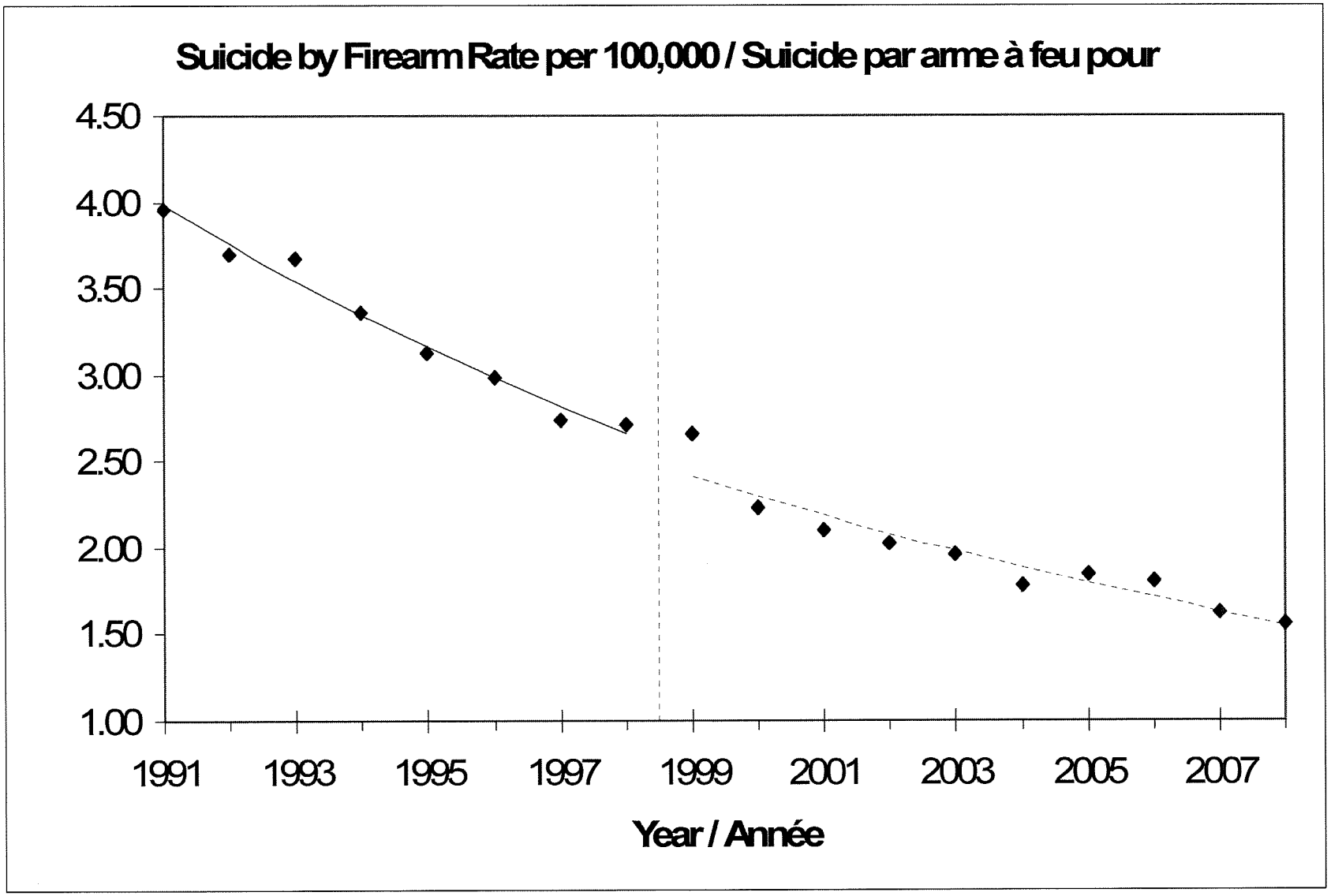

Total Suicide per 100,000 / Tous les suicides par
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1991
1993
1995
1997
1999
2001
2003
2005
2007
Year / Année

Figure 7


Suicide by Firearm Rate per 100,000 / Suicide par arme à feu pour
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
1991
1993
1995
1997
1999
2001
2003
2005
2007
Year / Année

Senate 2019 Figures

Figure 1 – no reduction in homicide from Firearms Act

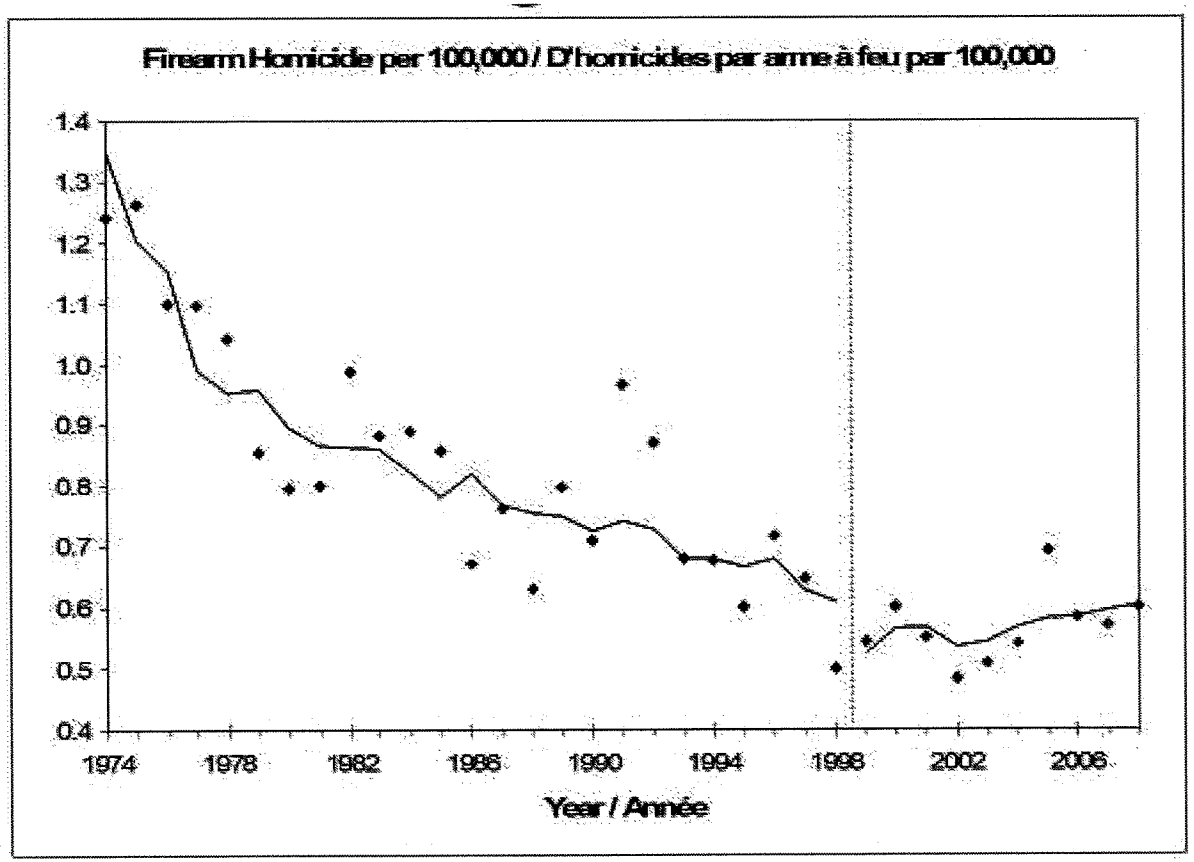


Figure 2

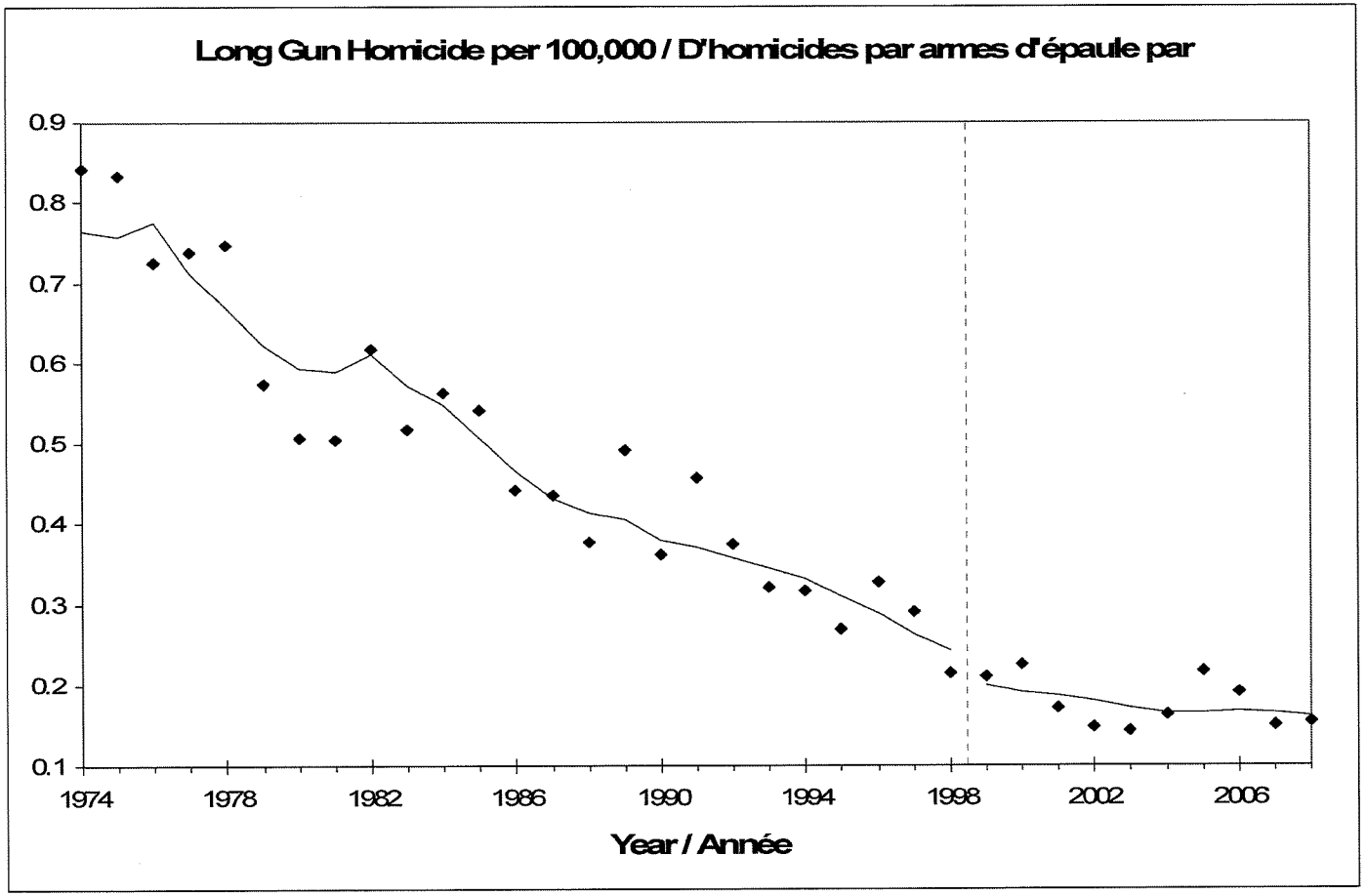

Long Gun Homicide per 100,000 / D'homicides par armes d'épaule par
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1974
1978
1982
1986
1990
1994
1998
2002
2006
Year / Année

Figure 3

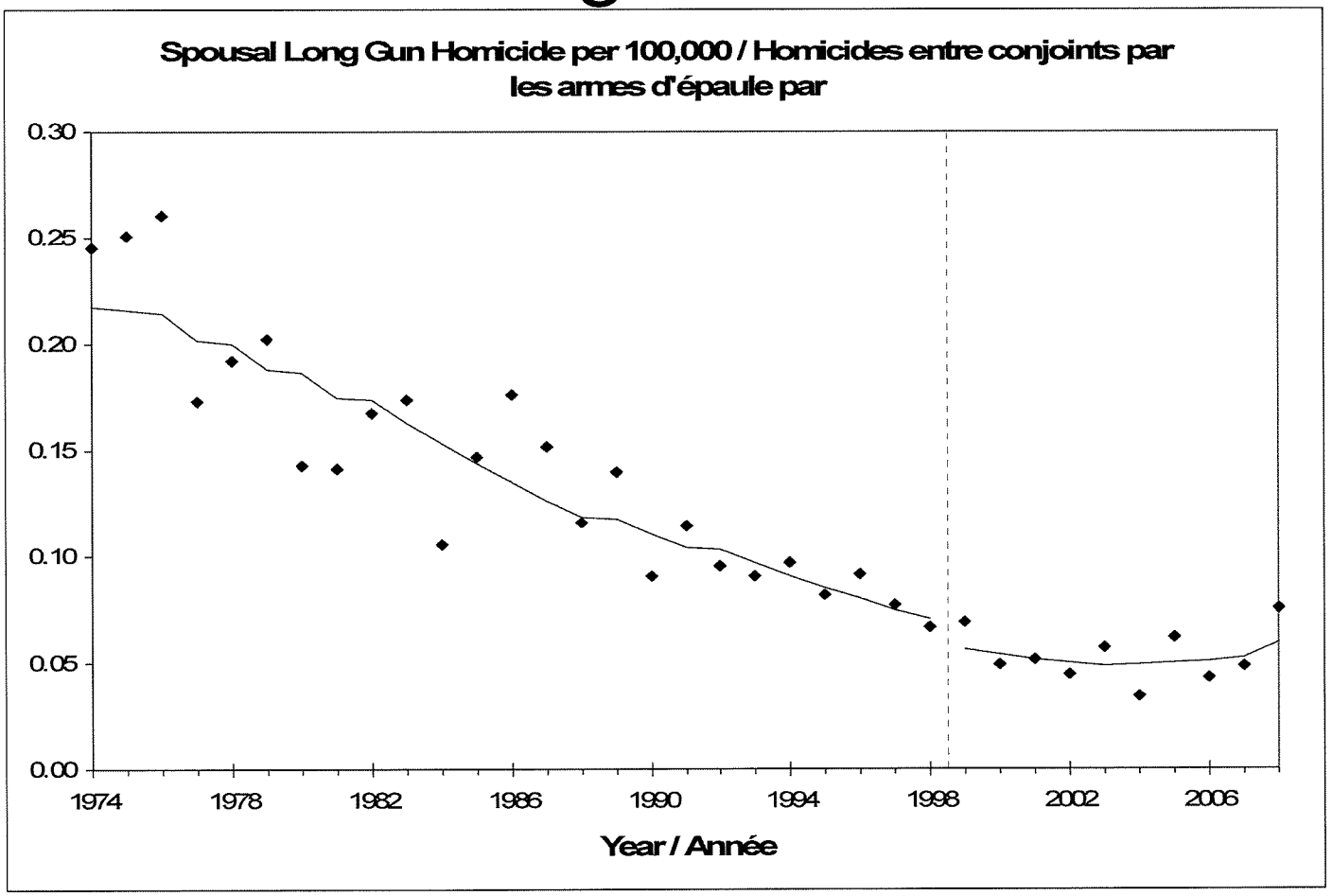

Spousal Long Gun Homicide per 100,000 / Homicides entre conjoints par les armes d'épaule par
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1974
1978
1982
1986
1990
1994
1998
2002
2006
Year / Année

Figure 4 - Typical Data Seen In Publications

Table 2. Adjusted IRRs for firearm suicide and homicide by state firearm background-check levels, individuals aged ≥21, 2002–2004

Background-check level	Firearm suicides[a] IRR (95% CI)	Firearm homicides[b] IRR (95% CI)
Federal	1.0 (ref)	1.0 (ref)
State	0.97 (0.79–1.19)	0.84 (0.65–1.08)
Local	0.73 (0.60–0.89)	0.78 (0.61–1.01)

[a]Adjusted for percent unemployed, robbery rate, income inequality level, percent living in poverty, per capita alcohol consumption, percentage living in metropolitan areas, divorce rate, percent aged ≥65, and percent white

[b]Adjusted for percent unemployed, robbery rate, income inequality level, percent living in poverty, per capita alcohol consumption, percentage living in metropolitan areas, divorce rate, percent aged 15–29, and percent black

IRR, incidence rate ratio

Sumner et al. 2008

Figure 5

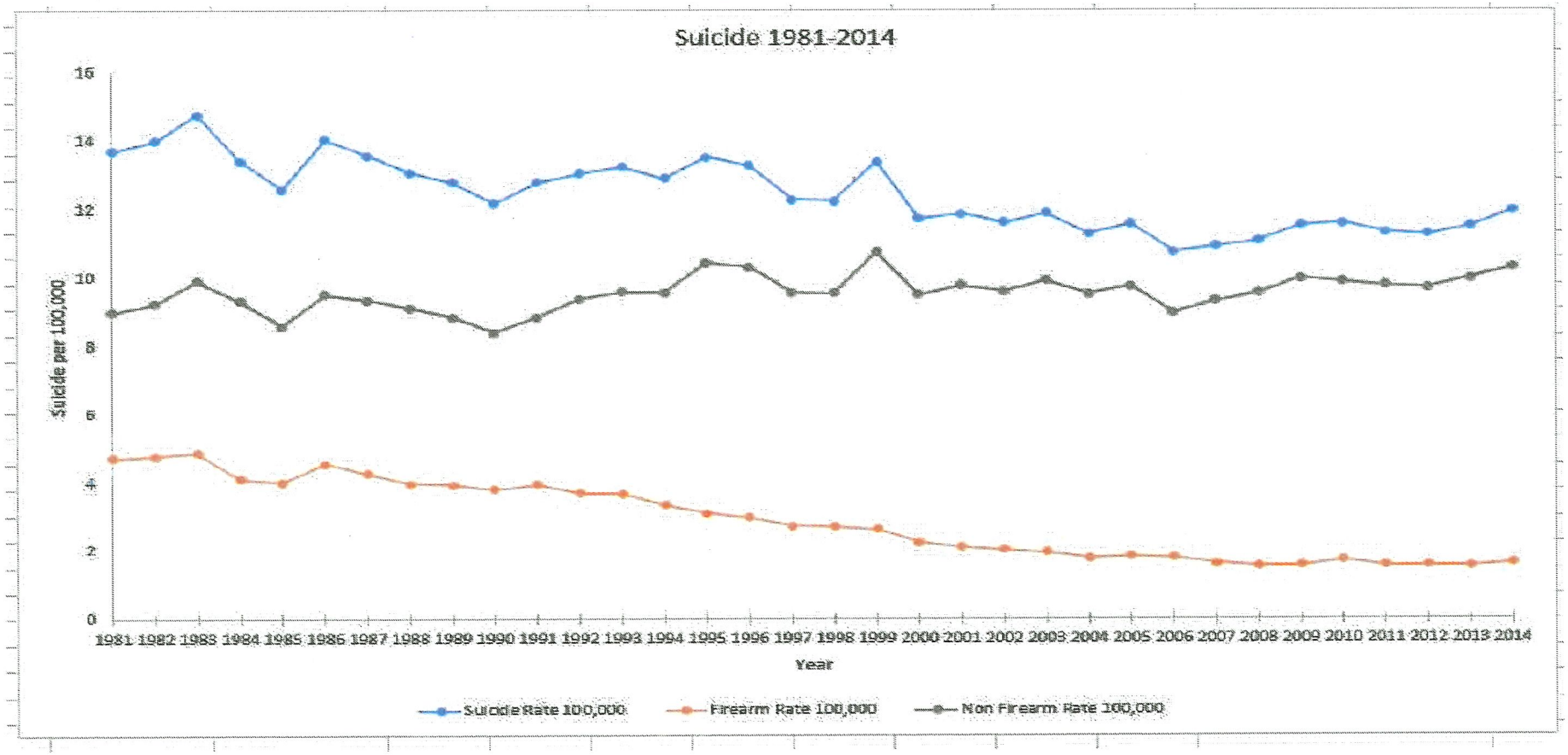

Suicide 1981-2014
Suicide per 100,000
16
14
12
10
8
6
4
2
0
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
Year
Suicide Rate 100,000
Firearm Rate 100,000
Non Firearm Rate 100,000

Figure 6

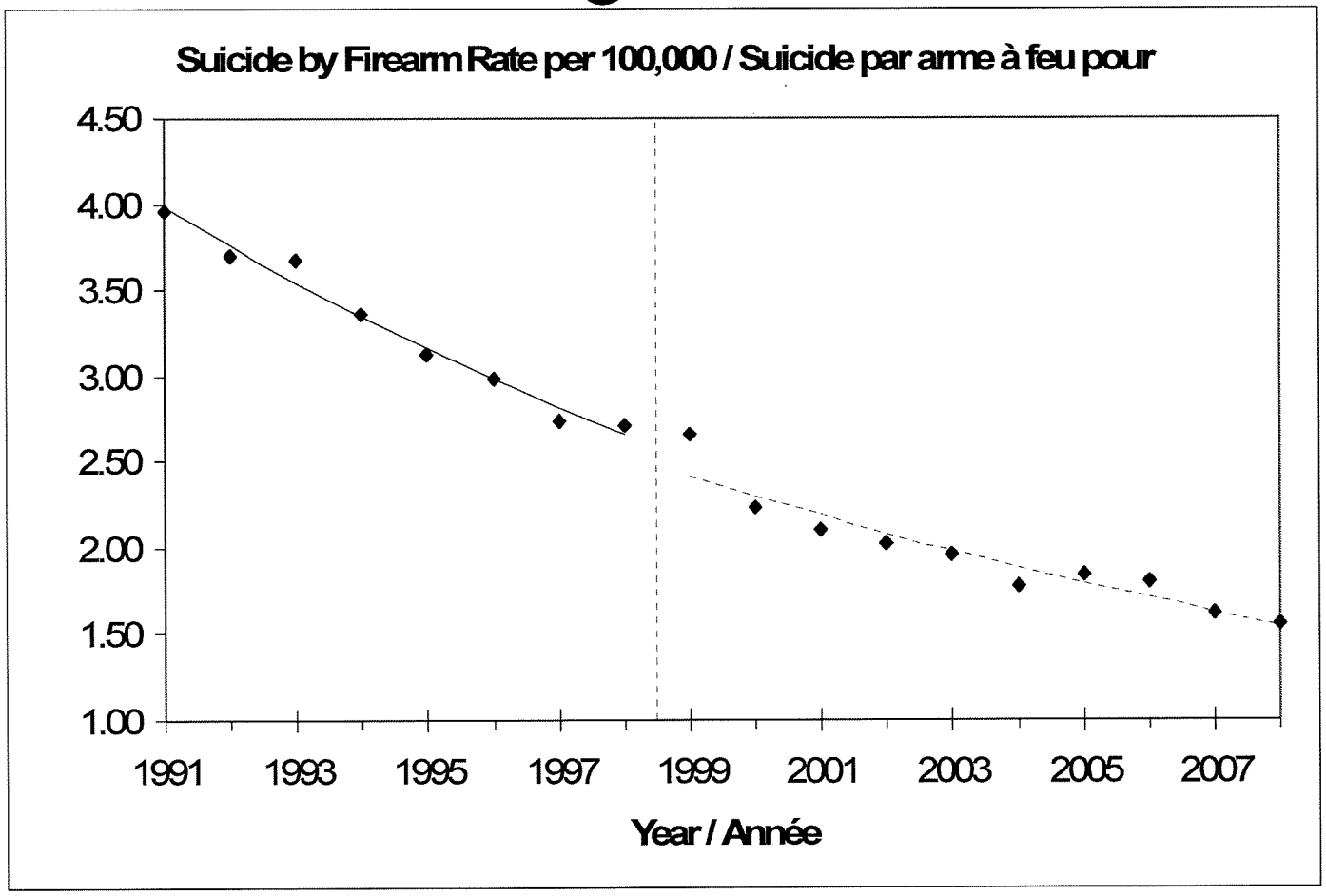
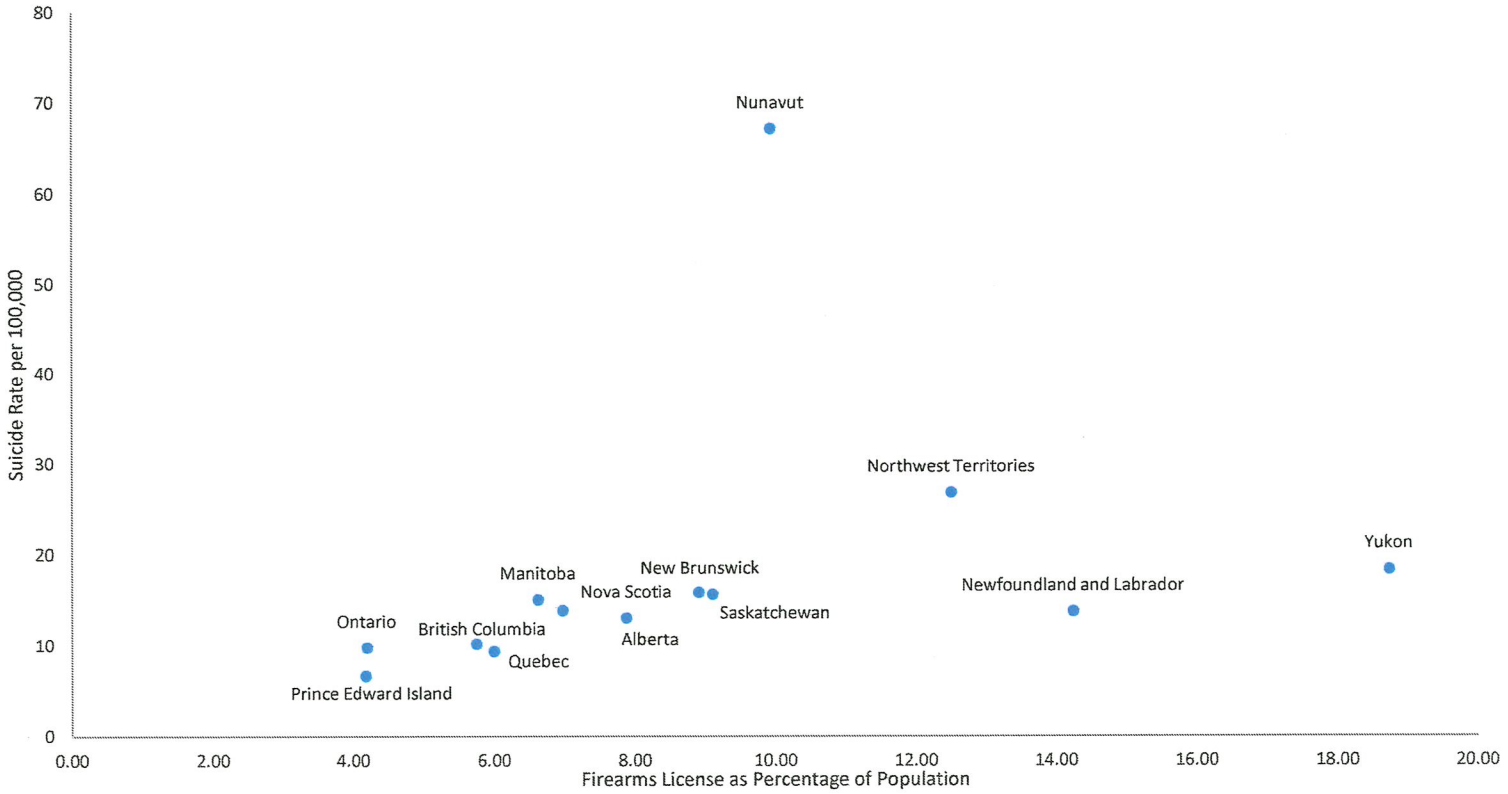
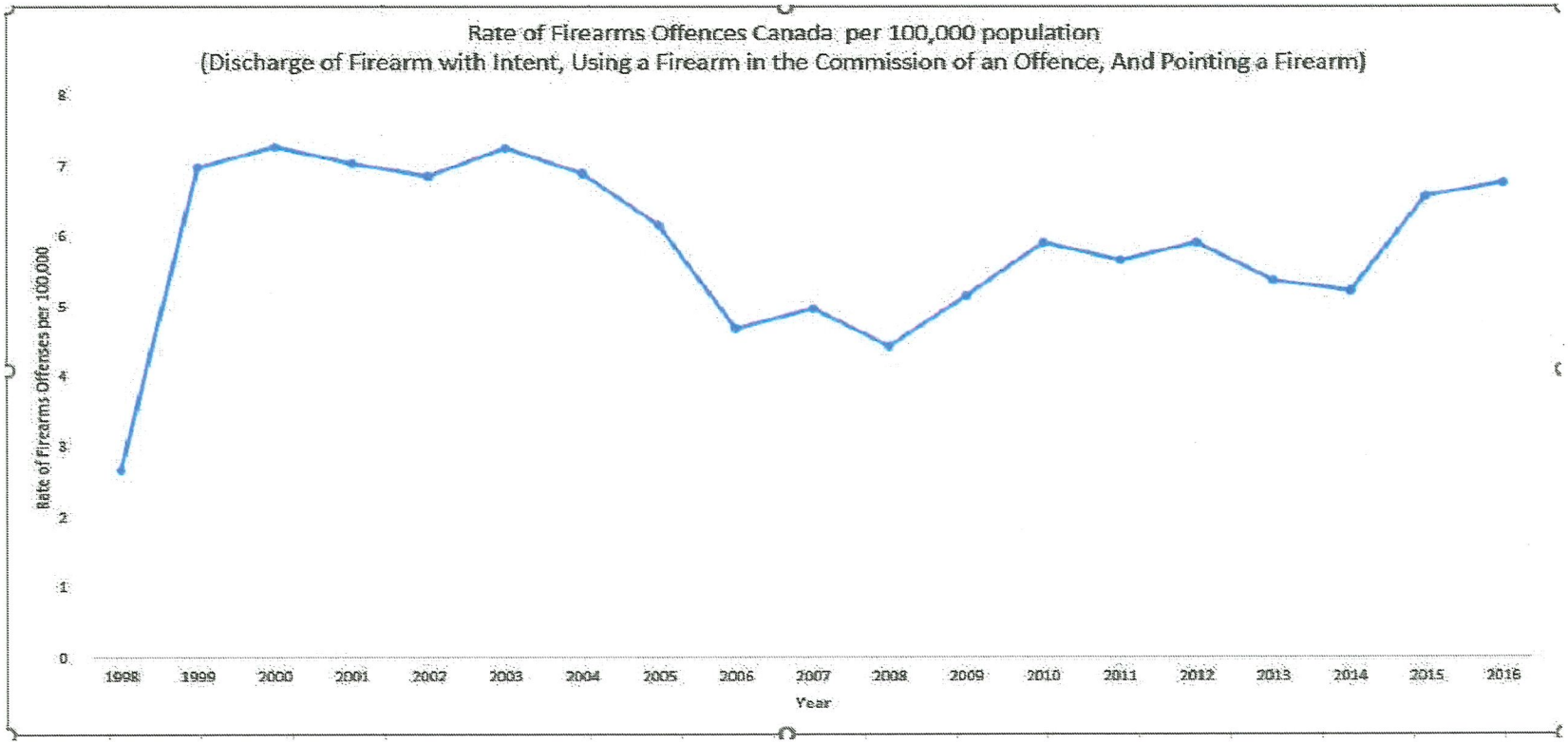

Suicide by Firearm Rate per 100,000 / Suicide par arme à feu pour
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
1991
1993
1995
1997
1999
2001
2003
2005
2007
Year / Année

Figure 7

Suicide Rate Compared to the Percentage of Licensed Firearms Owners by Province



Supplemental 1 – Trends in Firearms Offenses



Supplemental 2 – Increase in Ownership Not Associated With Homicide