



# Suicide, firearms, and legislation: A review of the Canadian evidence

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## ABSTRACT

Suicide accounts for approximately 4000 deaths a year in Canada, of which about 16% of those are suicide using a firearm. Canada has undertaken legislative efforts to regulate and control firearms, Bill C-51 in 1977 and Bills C-17 and C-68 in 1991 and 1995. Regulatory approaches that decrease the availability of firearms are hypothesized to reduce suicide by firearm however the substitution effect suggests it is possible that people may substitute other methods of suicide in place. Canadian studies on associations between legislation, regulation, and suicide rates have been published over the last three decades, and a search revealed thirteen that met the criteria. Seven studies examined the association between Bill C-51 and suicide rates and found that while rates of suicide by firearm appeared to have declined in association with regulations, there appears to be a substitution effect into other methods and no overall change in suicide rates. Six studies examining the effects of Bill C-17 and C-68 revealed a decrease in the rates of suicide by firearms, with a corresponding increase in non-firearms suicide rates and no decrease in overall suicide rates. One study even suggested no associated decrease in firearm suicide rates with an increasing rate of suicide by hanging possibly due to changes in preferences. These results suggest legislation has mixed effects on firearm suicide rates and may not alone reduce overall suicide in Canada.

## 1. Introduction

Suicide accounts for approximately 4000 deaths in Canada a year, a rate that fluctuates between 11 and 12 deaths per 100,000 a year and is a leading cause of death for all Canadians (Navaneelan, 2012). While a significant cause of death for both sexes, the suicide rate for males is three times the rate of females (Fig. 1A, 1B). Death by suicide is a leading cause of mortality amongst 15- to 24-year-old youth, and about 8% of youth attempt suicide (Bennett et al., 2015). However, Canadians between the ages of 40 to 59 have the highest rates (Navaneelan, 2012). Prior to European contact, suicide amongst Indigenous people was probably low, however current rates of suicide are three times higher compared to the general rate in the Canadian population with indigenous youth suicide rates the highest (Kumar and Tjepkema, 2019). Suicide rates amongst Indigenous populations vary widely with 60% of bands having a rate of 0 reported cases a year, and on the other extreme some bands showing rates as high as 633 per 100,000. Inuit rates are the highest at 9 times higher than the non-indigenous rates. There is a great deal of evidence that these rates are related to cultural genocide inflicted on Indigenous people in Canada (Leenaars, 2000).

Hanging is the most common method of death by suicide accounting for 44% of deaths, whereas 16% of suicides are the result of firearm uses (Navaneelan, 2012). Males are much more likely to use firearms in 20%

of suicides while females only use firearms in 3%. Firearms and hanging are more likely to be used in rural areas, whereas jumping and poisoning are more likely in urban areas (Burrows et al., 2013).

Reducing suicide rates in Canada has been an increasing public health concern since the LaLonde White Paper, 1974, when it became apparent that suicide was a significant primary cause of death before the age of 70 (Leenaars, 2000). One strategy proposed to reduce suicide rates is the utilization of the *availability hypothesis*, which suggests that limiting the availability of lethal methods of suicide can reduce suicide rates in the community (Marzuk et al., 1992). There is evidence for harm reduction by decreasing or controlling availability of lethal methods such as detoxification of domestic gas and car emissions, and controlling the sales of toxic substances (Pruss-Ustun et al., 2016). In the case of firearms, it is hypothesized that reducing or controlling availability during a time when a person is at risk of suicide may prevent an attempt by allowing time for the situation to resolve or cause a switch to a less lethal method.

However the *substitution hypothesis* suggests that people will switch to alternative methods if certain methods are not available possibly attenuating or even negating any benefit (Stengel, 1964). This effect, also known as dispersion, could potentially be problematic in terms of harm reduction in Canada where the majority of male suicides utilize hanging, a method easy to procure and implement, and in serious

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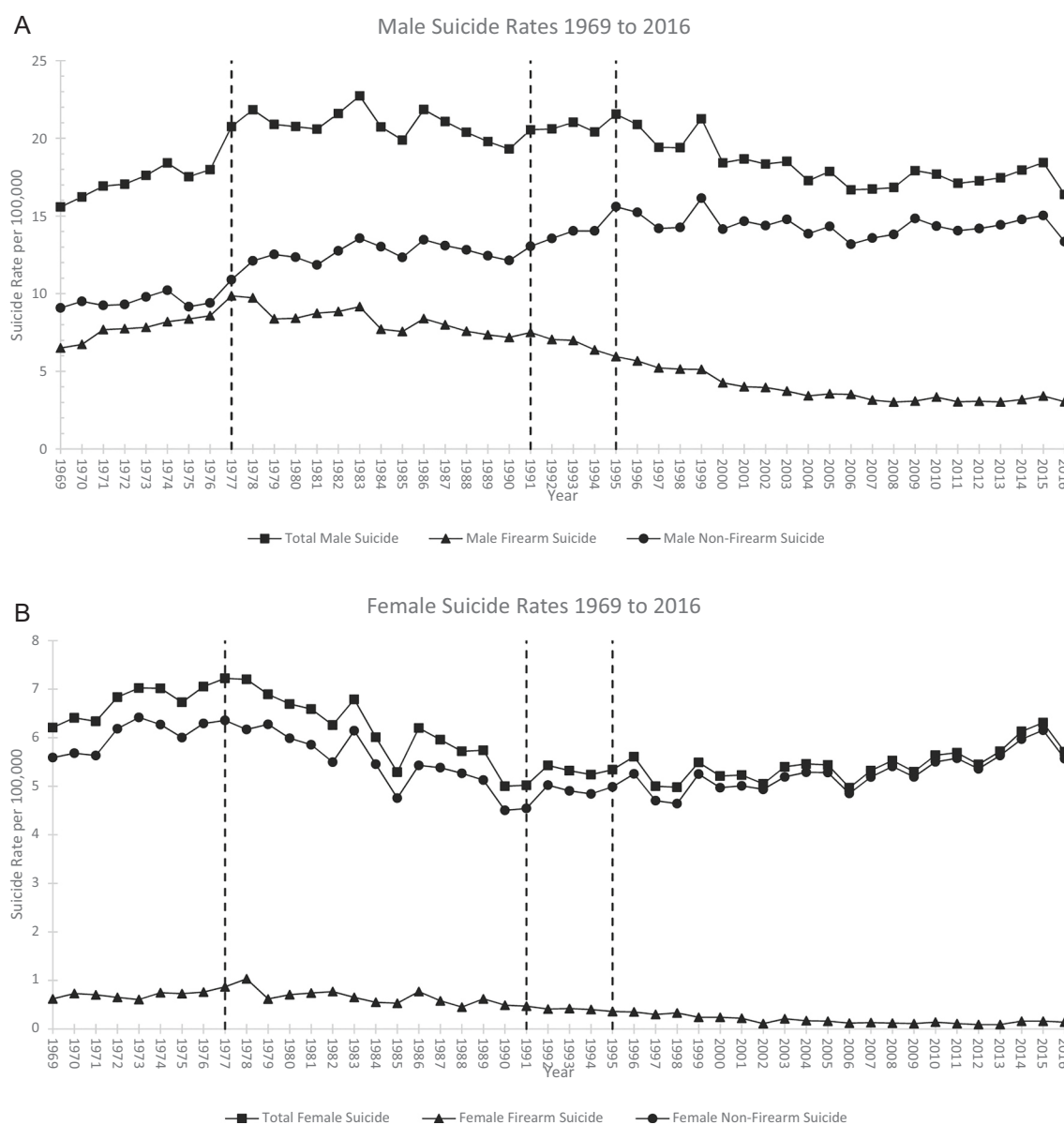
attempts can result in a lethality rate of 82% compared to a rate of 83% by firearms (Beautrais et al., 1996; Gunnell et al., 2005).

### 1.1. History of Canadian legislation

While suicide was initially recognized in Canada as a significant health issue in the early 1970s, legislative efforts addressing firearms and suicide largely appear to be afterthoughts attached to legislation tackling homicide (Leenaars, 2000). The regulation and control of firearms in Canada is primarily the responsibility of the Federal Government, though some exceptions exist such as the Province of Quebec having implemented the registration of long guns in 2019 (Royal Canadian Mounted Police, 2021). In 1977 the Canadian Parliament passed Bill C-51 requiring all firearm purchasers to undergo a criminal record check and obtain a Firearms Acquisition Certificate (FAC) prior to purchasing a firearm. These regulations remained in place for a decade until mounting pressure after a mass homicide at the Polytechnique Institute in Montreal, Quebec caused Parliament to completely redesign Canadian gun control and Canada enacted significant legislation in 1991 (C-

17) and 1995 (C-68). C-17, passed in 1991, added personal reference checks, photo identification, safety training, 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.

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.



**Fig. 1.** (A) Canadian Male Suicide Rates 1969 to 2016. Bill C-51 (1977), Bill C-17 (1991), and Bill C-68 (1995) are indicated by dashed lines. (B) Canadian Female Suicide Rates 1969 to 2016. Bill C-51 (1977), Bill C-17 (1991), and Bill C-68 (1995) are indicated by dashed lines.

Firearm control is a common topic in public health policy and a contentious issue in Canada as the government is currently considering new legislation (Canadian Broadcasting Corporation, 2020). While this topic has been reviewed in other countries, in particular the United States, Canada represents an interesting model to study the effects of gun control legislation as the regulations are applied homogeneously across the country at the federal level (Siegel et al., 2019). Unlike the United States, where many studies examine different State level regulations, studies on Canada are not subject to confounding effects of the ease of movement between States with widely differing firearms controls. Canada has a spectrum of firearms regulations, implemented across different time periods, and no comprehensive review exists that specifically examines and critiques the complete Canadian research base.

In this review, a search was performed for studies examining firearm control in Canada and rates of suicide by firearm to answer the question as to whether legislation and regulation is associated with a reduction in suicide by firearm. As well studies were searched for evidence of a substitution or dispersion effect from firearm suicide to other methods of suicide, to consider if such a policy would be effective in reducing overall suicide rates. Methods used in each study were discussed and if possible critiqued on reliability.

## 2. Methods

Mortality data was obtained from Statistics Canada publications "Causes of Death" (Statistics Canada, 2021). Suicide was defined based on International Classification of Diseases codes appropriate to the era (ICD-81969–1978: Suicide and Self Inflicted Injury E950 - E959, Firearms and Explosives E955; ICD-91979–1999: Suicide and Self Inflicted Injury E950 - E959, Suicide and Self Inflicted Injury by Firearms E955.0 - E955.4; ICD-102000–2016: Intentional Self Harm X60 - X84, 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 1969 to 2016 were obtained from Statistics Canada and CANSIM table 051–0001. Total suicide rates, rates by firearm, and non-firearm, were constructed from this data.

Peer-reviewed published studies from 1980 to 2020 were reviewed. PubMed, Scopus, and Web of Knowledge databases were searched to capture studies across fields. Prior literature reviews and cited studies were also identified in the initial search. Studies written in English and French, the national languages of Canada, were selected. Keywords used were combinations of 1) firearms, gun, handgun; 2) legislation, regulation, control, education; 3) suicide, self-harm; and 4) Canada, or its Provinces or Territories. Included studies were observational ecological studies that examined the association between an intervention such as firearm legislation, education, or regulations and suicide by firearms in Canada or one of its provinces, territories or cities.

The inclusion suitability and methodological quality of studies were assessed using the same procedures as described in prior firearms review articles as well as Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) (Briss et al., 2000; Zaza et al., 2000; Santaella-Tenorio et al., 2016; Moher et al., 2009).

Unfortunately, due to the heterogeneity of different statistical methods used in these studies, comparison methods such as a forest and funnel plots, could not be constructed. Each study was examined for associated effects of legislation and regulation and possible immediate impacts or changes in trends of suicide rates over time. As well studies were examined for any evidence of substitution of suicide methods.

## 3. Results

A total of 171 studies were retrieved using keyword terms in the following search engines: PubMed ( $n = 55$ ), Scopus ( $n = 37$ ), and Web of Knowledge ( $n = 79$ ). After exclusion of duplicates ( $n = 99$ ) studies remained. Of this ( $n = 13$ ) studies fit the criteria of studies examining the association between an intervention and suicide by firearms in Canada,

and its sub regions. All of these found studies were observational ecological longitudinal studies. As would be expected there are no randomized controlled trials. A summary of these studies is listed in Table 1.

### 3.1. Effects of legislation

#### 3.1.1. Bill C51

Overall, seven studies were found that examined the association between Bill C-51, 1977, and firearm suicide. Bill C-51 was never designed specifically to mitigate suicide by firearms, however due to legislation requiring a FAC to purchase, registration of all handguns, and designating automatic firearms as prohibited, it is possible that the numbers of firearms and the level of ownership of firearms would decrease. There is evidence that thousands of firearms were surrendered to the police in Canada's largest provinces by population, Ontario (Rich et al., 1990). With a reduction in firearms prevalence, a subsequent reduction in suicide by firearm and possibly an overall reduction in suicide could occur. One of the initial research groups to test this was Rich et al. (1990), who examined the association of Bill C-51 with suicide in the largest city in Canada, Toronto, over the 5 years preceding and after 1978 (Rich et al., 1990). It should be noted that while the FAC was not implemented until 1979, firearms were surrendered and some provinces had implemented firearms safety and hunting safety courses (Royal Canadian Mounted Police, 2021; Rich et al., 1990). Mean suicide rates for all suicide, shooting, and leaping (jumping from height) as well as time series analysis of pre- and post-changes over time for Toronto and the Province of Ontario were compared. While there was a decrease in mean suicide by firearms rates this was counteracted by an equal shift into leaping, and overall suicide rates were statistically unchanged. Moreover, the rate of change over time of suicide by firearms pre- and post-1978 did not change significantly in both Toronto and Ontario. See Table 1 for a summary of all results. The conclusion was that while Bill C-51 was associated with a drop in suicide by firearm rates, there was a substitution to other methods with no overall change in suicide rates.

Carrington and Moyer (1994), expanded on the Ontario study above by extending out the years examined both pre and post 1978 to the time periods 1965–1977 and 1979–1989 (Carrington and Moyer, 1994). Time series regression of rates in the pre-Bill C-51 period were compared to rates in the post period using simple  $t$ -tests. The authors found that there was a negative change in the pre-post regression slopes of suicide by firearms, a negative change in non-firearm suicide rates, and a negative change in overall suicide rates. It is hard to draw a conclusion from these results, as while Bill C-51 is associated with a negative rate change in suicide by firearms, suicide by other methods declined at a greater rate. It is possible during this time there were alternative causes responsible for declining suicide rates, precluding assessment of the effects of firearms legislation.

The issue of Canada as a whole was first addressed by Lester and Leenaars (1993), when they examined using pre- and post- average suicide rates and linear regression over the years 1969–1976 and 1977–1985 (Lester and Leenaars, 1993). In the pre-Bill C-51 years the total suicide rate, the suicide by firearm rate, and the non-firearm suicide rate were all increasing. After Bill C-51 all three rates decreased. Unfortunately, this study does not use statistical methods to compare the pre- and post- rates to determine if the change in rates is significant. The authors note that while there appears to be a decline in suicide by firearms associated with Bill C-51 there may be a substitution into other methods, however this was not quantified.

Leenaars and Lester, 1996, then examined for specific effects in male and female cohorts in Canada using the same methodology described above over identical time periods (Leenaars and Lester, 1996). In the pre-Bill C-51 years, the male total suicide rate, the male suicide by firearm rate, and the male non-firearm suicide rate were increasing. After Bill C-51 the male total suicide rate and the male suicide by firearms rate changed to a decline, while the male non-firearm suicide rate

**Table 1**

Summary of results and findings by study.

Study	Associated legislation	Study population	Methods	Findings	Dispersion effect
Rich et al. (1990)	Bill C-51	Toronto, and Ontario male suicide rates 1973–1983	Comparison of pre- post- means, and comparison of time series pre- post- linear regressions	<ul style="list-style-type: none"> <li>Decrease in male suicide by firearm with a substitution into other methods such as leaping</li> <li>Difference in Toronto mean male suicide rate 0.6 (SE 0.5 <math>p = 0.30</math>)</li> <li>Decrease in Toronto mean shooting 7.0% (<math>p &lt; 0.001</math>)</li> <li>Increase in Toronto mean leaping 6.8% (<math>p &lt; 0.001</math>)</li> <li>No difference in pre- post- suicide rate in Toronto using time series regression</li> <li>No difference in Ontario mean suicide rate 15.6 vs 15.2 <math>p = 0.13</math></li> </ul>	Yes
Lester and Leenaars (1993)	Bill C-51	Canadian suicide rates 1969–1985	Comparison of pre- post- means, and non statistical comparison of pre- post- time series linear regression	<ul style="list-style-type: none"> <li>Decreases in linear trends of all types of suicide</li> </ul> <i>Pre-1977:</i> <ul style="list-style-type: none"> <li>Total suicide 0.261 (SE 0.054) suicides per 100,000 per year (DHTY)</li> <li>Firearm suicide 0.162 (SE 0.022) DHTY</li> <li>Non-firearm suicide 0.097 (SE 0.046) DHTY</li> </ul> <i>Post-1977:</i> <ul style="list-style-type: none"> <li>Total suicide <math>-0.150</math> (SE 0.096) DHTY</li> <li>Firearm suicide <math>-0.131</math> (SE 0.050) DHTY</li> <li>Non-firearm suicide <math>-0.019</math> (SE 0.063) DHTY</li> </ul>	Yes
Carrington and Moyer (1994)	Bill C-51	Ontario suicide rates 1965–1989	Comparison of pre- post- time series linear regression	<ul style="list-style-type: none"> <li>Decrease in linear trends of all types of suicide</li> <li>Change in pre- post- firearm suicide slope <math>-0.13</math> (SE 0.03) DHTY</li> <li>Change in non-firearm suicide <math>-0.33</math> (SE 0.07) DHTY</li> <li>Change overall suicide <math>-0.47</math> (SE 0.08) DHTY</li> </ul>	N/A
Leenaars and Lester (1996)	Bill C-51	Canadian male and female suicide rate cohorts 1969–1985	Comparison of pre- post- means, and non statistical comparison of pre- post- time series linear regression	<ul style="list-style-type: none"> <li>Decreases in male suicide by firearm rate, increase in male non-firearm suicide rate, decrease in all female rates</li> </ul> <i>Linear trends:</i> <ul style="list-style-type: none"> <li>Pre- 1977 male total suicide rate 0.40 DHTY</li> <li>Post- 1977 male total suicide rate <math>-0.07</math> DHTY</li> <li>Pre- 1977 male firearm suicide rate 0.32 DHTY</li> <li>Post- 1977 male firearm suicide rate <math>-0.021</math> DHTY</li> <li>Pre- 1977 male non-firearm rate 0.08 DHTY</li> <li>Post- 1977 male non-firearm rate 0.14 DHTY</li> <li>Pre- 1977 female total suicide rate 0.13 DHTY</li> <li>Post- 1977 female total suicide rate <math>-0.21</math> DHTY</li> <li>Pre- 1977 female firearm suicide rate 0.01 DHTY</li> <li>Post- 1977 female firearm suicide rate <math>-0.05</math> DHTY</li> <li>Pre- 1977 female non-firearm rate 0.12 DHTY</li> <li>Post- 1977 female non-firearm rate <math>-0.16</math> DHTY</li> </ul>	Yes
Leenaars and Lester (1997)	Bill C-51	Canadian suicide rate age cohorts 1969–1985	Comparison of pre- post- means, and non statistical comparison of pre- post- time series linear regression	<ul style="list-style-type: none"> <li>Reduction in firearm suicide rates in ages 15–64 with substitution into other methods</li> </ul> <i>Statistically significant linear trends:</i> <ul style="list-style-type: none"> <li>Age 15–24: Firearm suicide <math>-0.25</math> DHTY</li> <li>Age 25–34: Firearm suicide <math>-0.33</math> DHTY</li> <li>Age 35–44: Firearm suicide <math>-0.32</math> DHTY</li> </ul> <i>Statistically significant mean rates:</i> <ul style="list-style-type: none"> <li>Age 35–44: Pre-1977 mean 6.22, Post-1977 mean 5.53 deaths per 100,000 (DHT)</li> <li>Age 45–54: Pre-1977 mean 6.69, Post-1977 mean 6.19 DHT</li> <li>Age 55–64: Pre-1977 mean 6.58, Post-1977 mean 5.67 DHT</li> </ul>	Yes
Carrington (1999)	Bill C-51			<ul style="list-style-type: none"> <li>Male total suicides and suicide by firearm rates dropped, while non-firearm suicides</li> </ul>	No

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Table 1 (continued)

Study	Associated legislation	Study population	Methods	Findings	Dispersion effect
		Canadian male and female suicide rate cohorts 1969–1985	Comparison of pre- post- means, and statistical comparison of pre- post- time series linear regression	<p>remained same, in females suicide rates dropped in all categories</p> <p><i>Change in linear trends post-1977:</i></p> <ul style="list-style-type: none"> <li>• Male total suicide –0.47 (SE 0.17) DHTY</li> <li>• Male firearm suicide –0.52 (SE 0.10) DHTY</li> <li>• Male non-firearm suicide 0.05 (SE 0.10) DHTY</li> <li>• Female total suicide –0.35 (SE 0.06) DHTY</li> <li>• Female firearm suicide –0.06 (SE 0.02) DHTY</li> <li>• Female non-firearm suicide –0.28 (SE 0.06) DHTY</li> </ul>	
Leenaars et al. (2003)	Bill C-51	Canadian male and female suicide rate cohorts 1969–1985	Interrupted time series regression, multivariate regression: Percent of young males in a population, birth rates, marriage rates, divorce rates, unemployment rates, and median family income	<ul style="list-style-type: none"> <li>• In males a reduction in suicide by firearm over time, with an immediate shift to non-firearm suicide.</li> <li>• Female suicide rates dropped in all categories</li> <li>• Total male suicide rate – 0.61 (SE 0.17) <math>p &lt; 0.01</math> DHTY</li> <li>• Total male suicide immediate impact 1.45 (SE 0.84)</li> <li>• Male firearm suicide rate – 0.58 (SE 0.09) <math>p &lt; 0.01</math> DHTY</li> <li>• Male firearm immediate impact –0.44 (SE 0.45)</li> <li>• Male non-firearm suicide rate – 0.02 (SE 0.11) DHTY</li> <li>• Male non-firearm immediate impact 1.89 (SE 0.51) <math>p &lt; 0.01</math></li> <li>• Total female suicide rate – 0.34 (SE 0.05) <math>p &lt; 0.01</math> DHTY</li> <li>• Total female suicide immediate impact –0.13 (SE 0.26)</li> <li>• Female firearm suicide rate – 0.07 (SE 0.02) <math>p &lt; 0.01</math> DHTY</li> <li>• Female firearm immediate impact 0.06 (SE 0.09)</li> <li>• Female non-firearm suicide rate – 0.27 (SE 0.06) <math>p &lt; 0.01</math> DHTY</li> <li>• Female non-firearm immediate impact –0.19 (SE 0.28) <math>p &lt; 0.01</math></li> </ul> <p><i>Multivariate regression:</i></p> <ul style="list-style-type: none"> <li>• Reduction in male suicide by firearm with an equivalent increase in suicide by non-firearm</li> <li>• Reduction in female suicide by firearm and a non-significant reduction in non-firearm suicide</li> <li>• Male total suicide rate 0.19 DHTY</li> <li>• Male firearm suicide rate – 1.21 DHTY <math>p &lt; 0.05</math></li> <li>• Male non-firearm suicide rate 1.39 DHTY <math>p &lt; 0.05</math></li> <li>• Female total suicide rate – 0.65 DHTY <math>p &lt; 0.1</math></li> <li>• Female firearm suicide rate – 0.23 DHTY <math>p &lt; 0.05</math></li> <li>• Female non-firearm suicide rate – 0.40 DHTY</li> <li>• Total suicide rates remain unchanged, with suicide by firearm rates declining and non-firearm suicide rates increasing</li> </ul> <p><i>Pre-1991 linear rate:</i></p> <ul style="list-style-type: none"> <li>• Total suicide rate – 0.15 (SE 0.11) DHTY</li> <li>• Firearm suicide rate – 0.06 (SE 0.04) DHTY</li> <li>• Non-firearm suicide rate – 0.10 (SE 0.08) DHTY</li> </ul> <p><i>Post-1991 linear rate:</i></p> <ul style="list-style-type: none"> <li>• Total suicide rate – 0.15 (SE 0.08) DHTY</li> <li>• Firearm suicide rate – 0.19 (SE 0.02) <math>p &lt; 0.001</math> DHTY</li> <li>• Non-firearm suicide rate 0.04 (SE 0.01) DHTY</li> <li>• No change in overall suicide rate, with a decrease in suicide by firearm, and increase in non-firearm suicide, in particular people under the age of 45</li> </ul>	Yes
Bridges (2004)	Bill C-17	Canadian suicide rates 1984–1998	Comparison of pre- post- means, and non statistical comparison of pre- post- time series linear regression	<p><i>Pre-1991 linear rate:</i></p> <ul style="list-style-type: none"> <li>• Total suicide rate – 0.15 (SE 0.11) DHTY</li> <li>• Firearm suicide rate – 0.06 (SE 0.04) DHTY</li> <li>• Non-firearm suicide rate – 0.10 (SE 0.08) DHTY</li> </ul> <p><i>Post-1991 linear rate:</i></p> <ul style="list-style-type: none"> <li>• Total suicide rate – 0.15 (SE 0.08) DHTY</li> <li>• Firearm suicide rate – 0.19 (SE 0.02) <math>p &lt; 0.001</math> DHTY</li> <li>• Non-firearm suicide rate 0.04 (SE 0.01) DHTY</li> </ul>	Yes
Caron (2004)	Bill C-17	Indigenous suicide rate on Abitibi-Témiscamingue reserve 1986–1996	Comparison of pre- post- means	<ul style="list-style-type: none"> <li>• No change in overall suicide rate, with a decrease in suicide by firearm, and increase in non-firearm suicide, in particular people under the age of 45</li> </ul>	Yes

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Table 1 (continued)

Study	Associated legislation	Study population	Methods	Findings	Dispersion effect
				<i>Pre-1991:</i>	
				<ul style="list-style-type: none"> <li>• Overall suicide rate 24.5 DHTY</li> <li>• Firearm suicide rate 12.7 DHTY</li> <li>• Non-firearm suicide rate 11.8 DHTY</li> </ul>	
				<i>Post-1991</i>	
				<ul style="list-style-type: none"> <li>• Overall suicide rate 26.8 DHTY</li> <li>• Firearm suicide rate 10.0 DHTY</li> <li>• Non-firearm suicide rate 16.8 DHTY</li> <li>• Reduction in firearms rates with an increase in hanging rates, no change in overall rates</li> </ul>	Yes
Cheung and Dewa (2005)	Bill C-17	Canadian suicide rates ages 15–19 years 1979–1999	Interrupted time series regression	<i>Post-1991:</i>	
				<ul style="list-style-type: none"> <li>• Firearm suicide −0.296 (95% CI −0.441–0.150) DHTY</li> <li>• Hanging 0.193 (95% CI 0.348–0.368) DHTY</li> <li>• No significant change in suicide rates, however a switch from suicide by firearm to hanging was found</li> </ul>	Yes
				<i>Post-1991:</i>	
				<ul style="list-style-type: none"> <li>• Male total suicide immediate effects 4.61 DHT <math>p = 0.094</math></li> <li>• Male total suicide rate 0.381 DHTY <math>p = 0.598</math></li> <li>• Male firearm suicide immediate effects 0.690 DHT <math>p = 0.282</math></li> <li>• Male firearm suicide rate −0.034 DHTY <math>p = 0.845</math></li> <li>• Male hanging suicide immediate effects 1.123 DHT <math>p = 0.594</math></li> <li>• Male hanging suicide rate 0.079 DHTY <math>p = 0.893</math></li> <li>• Female total suicide immediate effects 2.718 DHT <math>p = 0.004</math></li> <li>• Female total suicide rate 0.485 DHTY <math>p = 0.042</math></li> <li>• Female firearm suicide immediate effects −0.087 DHT <math>p = 0.658</math></li> <li>• Female firearm suicide rate 0.011 DHTY <math>p = 0.844</math></li> <li>• Female hanging suicide immediate effects 1.045 DHT <math>p = 0.054</math></li> <li>• Female hanging suicide rate 0.232 DHTY <math>p = 0.113</math></li> </ul>	
Caron et al. (2008)	Bill C-17	Suicide rates in Quebec 1987–2001	Interrupted time series analysis	<ul style="list-style-type: none"> <li>• A decrease in suicide by firearm rates in males ages 15 to 34 and 35 to 64 starting in 1996 and 1997 with a similar decline in suicide by hanging and total suicide rates</li> </ul>	N/A
				<i>Joinpoint:</i>	
				<ul style="list-style-type: none"> <li>• Male suicide age 15–34:</li> <li>• Firearm 1996: −11.1 Annual Percent Change (APC) (95% CI −14.8 - -7.2)</li> <li>• Hanging 1999: −7.1 APC (95% CI −10.4 - -3.6)</li> <li>• Male suicide age 35–64:</li> <li>• Firearm 1997: −5.6 APC (95% CI −7.6 - -3.6)</li> <li>• Hanging 1999: −3.9 APC (95% CI −6.5 - -1.3)</li> </ul>	
				<i>Interrupted time series regression:</i>	
				<i>1992 male suicide:</i>	
				<ul style="list-style-type: none"> <li>• Overall immediate impact 24.1% (95% CI 12.3% - 37.2%) <math>p &lt; 0.05</math></li> <li>• Overall APC −1.3% (95% CI −2.7% - 0.1%)</li> <li>• Firearm immediate impact 9.6% (95% CI −6.3% - 28.3%)</li> <li>• Firearm APC −3.7% APC (95% CI −5.8% - −1.5%) <math>p &lt; 0.05</math></li> <li>• Hanging immediate impact 26.9% APC (95% CI 6.3% - 51.6%) <math>p &lt; 0.05</math></li> <li>• Hanging APC −1.0% (95% CI −3.5% - 1.6%)</li> </ul>	

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Table 1 (continued)

Study	Associated legislation	Study population	Methods	Findings	Dispersion effect
Langmann (2020)	Bill C-17, C-68	Canadian suicide rates 1981–2016	Difference-in-differences	<p>1995 male suicide:</p> <ul style="list-style-type: none"> <li>• Overall immediate impact 31.7% APC (95% CI 19.0% - 45.7%) <math>p &lt; 0.05</math></li> <li>• Overall APC -3.7% (95% CI -4.9% - -2.4%) <math>p &lt; 0.05</math></li> <li>• Firearm immediate impact 22.4% APC (95% CI 2.9% - 45.5%) <math>p &lt; 0.05</math></li> <li>• Firearm APC -4.9% APC (95% CI -7.0% - -2.7%) <math>p &lt; 0.05</math></li> <li>• Hanging immediate impact 39.9% APC (95% CI 17.2% - 67.0%) <math>p &lt; 0.05</math></li> <li>• Hanging APC -3.9% (95% CI -6.1% - -1.7%) <math>p &lt; 0.05</math></li> <li>• Reductions in suicide by firearm rates in males age 45 to 49 in 1991 and 1994, males 60 and older in years 1991, 1994, 2001, and females year 1991. Sensitivity testing suggests an overall increase in hanging.</li> </ul> <p>Firearm suicide rate ratio after intervention:</p> <p>Males:</p> <ul style="list-style-type: none"> <li>• Age 45–59,1991: 0.945 (0.916–0.075)</li> <li>• Age 45–59,1994: 0.963 (0.936–0.991)</li> <li>• Age 60 plus 1991: 0.946 (0.915–0.978)</li> <li>• Age 60 plus 1994: 0.953 (0.931–0.977)</li> <li>• Age 60 plus 2001: 0.977 (0.959–0.996)</li> </ul> <p>Females:</p> <ul style="list-style-type: none"> <li>• 1991: 0.947 (0.911–0.984)</li> </ul> <p>Rate ratio hanging: Firearm suicide after intervention:</p> <p>Males:</p> <ul style="list-style-type: none"> <li>• Age 45–59,1991: 0.994 (0.978–1.010)</li> <li>• Age 45–59,1994: 0.993 (0.980–1.005)</li> <li>• Age 60 plus 1991: 0.989 (0.971–1.008)</li> <li>• Age 60 plus 1994: 0.994 (0.979–1.010)</li> <li>• Age 60 plus 2001: 1.010 (0.998–1.022)</li> </ul> <p>Females:</p> <ul style="list-style-type: none"> <li>• 1991: 0.983 (0.956–1.010)</li> </ul>	Yes

\*DHT = deaths per hundred thousand, DHTY = deaths per hundred thousand per year.

increased. In females in the pre-C-51 years the total suicide rate, the suicide by firearm rate, and the non-firearm suicide rate were increasing. After Bill C-51 all the suicide rates changed to a decline. From these results the authors conclude that suicide by firearms decreased in males but there was a switch to the use of other methods, while females saw a decrease in all methods.

Leenaars and Lester, 1997, attempted to quantify rate changes and means in different age groups and found the reduction in suicide by firearm occurs in ages 15–64 years (Leenaars and Lester, 1997). The authors argue that younger people tend to be more impulsive while elderly people tend to have chronic suicidal symptoms with a greater intent to die and are less inclined to be dissuaded by difficulty in obtaining their preferred method for suicide. It may also be that the changes in regulations restricted access to new acquisitions of firearms but that the people currently in possession of firearms tended to be older and have already acquired firearms before the regulations were implemented.

Carrington, 1999, reanalysed the data and time frames reported by Leenaars and Lester, 1996, for male and female suicide (Carrington, 1999). As Carrington points out, Lester and Leenaars do not perform calculations on pre- and post- legislation trends to determine if the differences are statistically significant and hence it is difficult to draw conclusions from their findings. Carrington calculated difference-of-slopes  $t$ -tests for pre-post comparisons of trends and find a significant reduction in suicide by firearm in males that is not matched by a change

in suicide by other methods (Carrington, 1999). For males there was a negative difference in suicide rates post Bill-C51 that was almost entirely driven by suicide by firearm. Females also saw a negative difference post Bill C-51 however this was almost entirely accounted for by a decrease in non-firearm suicide rates. This was the first publication to not only demonstrate a reduction in suicide by firearms, in the male subset, associated with Bill C-51 but also to have no sign of method substitution. However, the decline in non-firearm suicide in females during this time frame suggests a possible underlying confounder, and not legislation, that may be responsible for this effect.

Issues and criticisms of previous methodology used in these studies still persisted and therefore Leenaars et al., 2003, constructed an interrupted time series analysis of the same timeframe as well as included analysis of other variables associated with suicide (Leenaars et al., 2003). The study is divided into two studies, Study 1 is an interrupted time series regression, while Study 2 adds the other independent variables.

The results of Study 1 are noteworthy. Males demonstrate a reduction in suicide rates by firearm over time, and a non-significant immediate impact. However, male non-firearm suicide rates demonstrate an immediate impact effect of an increase in suicide and a non-significant change in rate over time. As the authors explain, this suggests that there is a substitution effect, a reduction firearm suicide rates over time and an immediate shift in male suicide to non-firearm methods associated with Bill C-51. Regarding female suicide, there is a much larger

reduction in non-firearm suicide rates than firearm suicide rates associated with Bill C-51 and no specific inferences can be made on the size of any effect on female suicide from Bill C-51.

Study 2 included a multivariate regression using other independent variables to account for possible contributors to suicide rates. In males there remained a significant reduction in suicide by firearm rates but this was countered by an increase in non-firearm suicide suggesting that while Bill-C51 may be associated with a reduction in firearm suicide there was a switch to non-firearm methods. For females there was a significant reduction in suicide by firearm and a non-significant reduction in non-firearm suicide.

Of the seven studies found, three of these studies, [Lester and Leenaars, 1993](#); [Leenaars and Lester, 1996, 1997](#), utilized a basic descriptive comparison of pre- post- linear regressions as well as a comparison of pre- post- means using *t*-tests ([Lester and Leenaars, 1993](#); [Leenaars and Lester, 1996](#); [Leenaars and Lester, 1997](#)). Comparisons of means alone is a poor method to analyse effects as it is not informative of whether the trend of a rate is increasing or decreasing over time. The addition of pre- and post- trends is more informative but without calculating their differences and determining statistical significance it is hard to make conclusions, if any, of associated changes after an intervention. Nonetheless, it does appear that suicide by firearm rates increased before 1977 and then decreased afterwards, particularly for males less than the age of 65. The question of whether this is associated with Bill C-51 or whether it is due to a confounding variable is difficult to conclude from these results, as there is no attempt to include other independent variables. The best that can be done is to compare the results to non-firearm suicide rates. Overall suicide rates and non-firearm suicide rates also decreased after 1977, possibly responding to a confounding variable as it would be unlikely Bill C-51 would have any direct effect on non firearm methods of suicide. Male non-firearm suicide rates increased after 1977 and the authors of these studies conclude that this may have occurred from a decline in male suicide by firearm due to reduced availability and subsequent substitution into alternative methods.

The most reliable results were provided by [Leenaars et al. \(2003\)](#), using interrupted time series analysis. That methodology allowed for the examination of immediate impacts of an intervention as well as changes that occur over time, is currently a well accepted method applied in the social sciences for analysis of interventions, and superior to the previous methods applied ([Leenaars et al., 2003](#); [Bernal et al., 2017](#)). They demonstrated a reduction in male suicide by firearm associated with legislation, but at the same time report a substitution to other methods resulting in no change in overall suicide rates after multivariate regression.

Considering all the studies currently available regarding Bill C-51 it appears that there is an associated decline of suicide by firearms but there is a substitution effect at work negating some, if not all, of the benefits.

### 3.1.2. Bill C-17 and C-68

It was not until a decade later that gun control was revisited in Canada on a Federal level at which point two Bills were passed in rapid succession. This legislation did include some provisions to attempt to mitigate suicide by firearms including education, safe storage regulations (1992), psychological screening questionnaires (1994), licensing to possess firearms (1999), and background checks ([Royal Canadian Mounted Police, 2021](#)). Licenses could be thereafter revoked if concerns regarding mental health became an issue.

Bridges, 2004, was one of the first to examine for associated effects on suicide from these changes using the same methods described in [Lester and Leenaars \(1993\)](#), using data from the years 1984–1990 and 1992–1998 ([Bridges, 2004](#)). In the pre-1991-time frame, total suicide rates, suicide by firearms, and non-firearms suicide were declining. Post 1991, the total suicide rate appears to remain unchanged, while suicide by firearms decreased, and non-firearm suicide increased each by a

similar amount. Based on this the author concludes that there was a switch to suicide methods that do not use firearms with no overall beneficial effect on suicide rates.

[Caron \(2004\)](#), examined the rates of suicide in the indigenous population on the Abitibi-Témiscamingue reserve during the years 1986–1991 and 1992–1996 ([Caron, 2004](#)). The Abitibi-Témiscamingue reserve was chosen as it had at the time one of the highest rates of suicide in Quebec, Canada, and this was thought to be due to a high rate of firearms ownership for hunting. The author attempted to address whether firearms storage regulations were associated with a decrease in suicide rates and used chi-square and likelihood ratio tests on suicide rates in the pre- and post- periods. The suicide by firearm rate decreased significantly between time periods, while the non-firearm suicide rate increased significantly. The overall rate of suicide demonstrated no significant change. When analysing subgroups there was a significant drop in suicide by firearm with an equal switch to other methods, hanging in both cohorts, and poisoning in females. In people younger than 45 years old method change from firearm suicide to hanging occurred. Caron suggests that locking firearms may have prevented members of the household, spouses and younger males, from being able to obtain them, while the owner, generally a male older than 45, still has the keys and is able to access the firearms.

[Caron et al. \(2008\)](#), next looked at the Canadian province of Quebec using interrupted time series analysis and rates of suicide during the time periods 1987–1991 and 1992–2001 ([Caron et al., 2008](#)). No significant decreases in suicide by firearms, either immediate or trends were found associated with Bill C-17. An interesting shift in types of methods used during 1987–2001 was found where the proportion of suicides by hanging was increasing when the proportion by firearms was decreasing. Caron et al. also attempted to determine if there were associations between suicide rates and other variables such as divorce and unemployment rates but found no relationship.

[Gagne et al. \(2010\)](#), re-examined Quebec using suicide rates over the years 1981 to 2006 ([Gagne et al., 2010](#)). They noted several concerns with the study by [Caron et al. \(2008\)](#), such as regulations are implemented gradually and compliance is not immediate, therefore choosing specific dates of interventions during interrupted time series regression may produce false results. Additionally, they examined rates over a larger time period with Joinpoint regression analysis, a method that is used to examine a time series and find instances of statistically significant changes in trends ([Kim et al., 2000](#)). Joinpoint analysis found a decrease in the annual percent change in the rates of suicide by firearms in males aged 15 to 34 years and 35 to 64 years in 1996 and 1997, respectively corresponding temporally with the time of firearm legislation. However, there was also a similar decline in the annual percent change in suicide by hanging and total suicide rates in males in 1999. Using the dates of 1992 and 1995, interrupted time series regressions were also run on the dataset. An intervention timed in 1992 in their model demonstrated a significant annual percent change in the rate of suicide by firearm after 1992 and a significant immediate increase effect in the hanging rate. Overall suicide rates demonstrated a significant immediate increase in 1992 and no significant change in the annual percent change. This may represent a method shift to hanging.

The intervention timed in 1995 demonstrated significant immediate increase effects in the overall suicide rate, the hanging rate, and the suicide rate by firearms. As well there were significant decreases post 1995 in the annual percent change in the overall suicide rate, hanging rate, and in the rate of suicide by firearms. What can be concluded from these results is that there was a decrease in the trend of suicide by firearms in the time period of the implementation of Bill C-17 and Bill C-68 but there were also declines in the rates of hanging and overall suicide rates occurring at about the same time. It is difficult from this to conclude that the declines in firearm suicide trends is due to firearm controls or some other factor. Indeed, at around the same time as these decreases in suicide, Quebec had implemented a national suicide prevention strategy which specifically targeted young men, as well novel



medications such as SSRIs had come into practice (Gagne et al., 2010; Barbui et al., 2009).

Cheung and Dewa (2005), applied interrupted regression to suicide rates on Canadian youth 15–19 years of age between the years 1979 to 1999 using Bill C-17 in 1991 as the intervention (Cheung and Dewa, 2005). A reduction in suicide by firearm rates were found after 1991 with a corresponding increase in hanging rates. No change in overall suicide rates were found.

Langmann (2020), produced the most recent analysis of firearms legislation and the association with suicide in Canada (Langmann, 2020). Suicide rates over the year 1981 to 2016 were examined using a difference-in-differences time series regression method, designed to remove the potential effects of confounders that may contribute to suicide rate changes during the time frame. To examine the effects of different regulations, safe storage, 1992, psychological questionnaire, 1994, and licensing, 2001, these three time points were used as intervention points. Moreover, age cohorts in males were examined to search for any age specific associated effects that could possibly be hidden within overall trends. The only associations with reductions in suicide by firearms were found in males age 45–59 after the interventions in 1991 and 1994, males 60 years and over in the years 1991, 1994, and 2001, and females in the year 1991. However, these were accompanied by equal increases in hanging. Sensitivity analysis using difference-in-differences analysis of other non-firearm methods of suicide compared to hanging revealed there was no switch from these methods into hanging suggesting these methods did not cause the increase. Additional sensitivity analysis using difference-in-differences analysis of other methods of suicide than hanging compared to suicide by firearms revealed that it is possible that what was occurring during this time was simply an increase in suicide by hanging.

#### 4. Discussion

Thirteen studies that examined the association between Canadian legislation, regulation and suicide rates were reviewed in this study. Overall, a general theme emerged. While there may be an association between legislation and a reduction in suicide rate by firearms, overall suicide rates remained unaffected due to substitution into other methods.

Associated reductions in suicide by firearm were found to occur with Bill C-51, however, the strongest evidence for this is from one study, Leenaars et al. (2003), and there does appear to be a substitution effect into other methods of suicide (Leenaars et al., 2003). As C-51 was not designed to reduce suicide rates, it is possible that reductions in suicide rates occurred as an externality due to a decrease in firearms prevalence as background checks may serve as a barrier to purchasing firearms. There is evidence from Canada of a decline in firearm prevalence over the years 1970–1996 associated with a decrease in suicide by firearm, however there is no evidence that Bill C-51 is responsible for the decrease in firearm prevalence itself (Lester, 2000a; Lester, 2000b; Lester, 2001).

Unlike Bill C-51, Bills C-17 and C-68 contained some provisions to specifically address suicide such as a psychological questionnaire, safe storage regulations, mandatory waiting periods, and licensing, thus it would be expected that there might be an associated response on suicide rates. Indeed Bridges (2004), Caron (2004), and Cheung and Dewa (2005), demonstrated a reduction in suicide by firearms, however there were no overall change in suicide rates (Bridges, 2004; Caron, 2004; Cheung and Dewa, 2005). Caron et al. (2008), examining Quebec found no change in suicide rates by firearms associated with Bill C-17, while Gagne et al. (2010), found an immediate increase in suicide by firearms in Quebec associated with Bill C-68, with an annual percent decrease in both hanging and suicide by firearm (Caron et al., 2008; Gagne et al., 2010). Finally, Langmann (2020), found a possible and complete shift in Canadian females and males aged 45 and older to hanging, however this was lost after sensitivity tests and may represent an increase in hanging

alone (Langmann, 2020). Overall, the results of several studies suggest limited benefit, if any, in suicide prevention associated with Bill C-17 and C-68. Considering the lethality of firearms, and the fact that people who attempt suicide by firearms tend to have no prior history, one would expect a benefit from restriction of availability, however it may be that people who use firearms for suicide are choosing a significantly lethal method, have serious psychological motivations for suicide, and end up switching into another equivalently lethal method (Anestis, 2016; Daigle, 2005). It does appear in some of the Canadian studies that shifts to deadly methods such as leaping and hanging occurs and this may account for the limited results (Rich et al., 1990; Caron, 2004; Caron et al., 2008; Cheung and Dewa, 2005; Langmann, 2020).

It may also be that there is a simultaneous change in culture and beliefs such that there is a decrease in suicide by firearms due to diminished availability and social acceptability with a concurrent shift to suicide by hanging. Indeed, there is evidence of a trend in hanging increases postulated to have occurred as society views hanging less associated with criminal punishment and more associated with a peaceful and mutilation free death (Gunnell et al., 2005; Caron et al., 2008; Daigle, 2005; Leenaars et al., 2000). Sensitivity tests by Langmann (2020), do demonstrate an increase in hanging, but suggest no changes in suicide by firearm over the years 1981 to 2016 (Langmann, 2020). Unfortunately preventing hanging by reducing availability in the community is unlikely to be possible (Gunnell et al., 2005).

Some studies on firearm prevalence in other countries show associated lower suicide rates by firearm and overall rates in areas of lower firearms prevalence, however these studies tend to be cross-sectional designs, require proxies in place of actual firearms prevalence, and may suffer from errors due to confounding variables (Anglemyer et al., 2014; Kleck, 2019). Interestingly as Canadians are required to have a license to obtain and keep firearms, Langmann (2020), used licensing levels per Canadian province as a likely accurate indicator of firearms prevalence and found no association with suicide (Langmann, 2020). Drawing the link between interventions to control firearms availability and suicide is more complex. Studies of other countries on firearms control and suicide demonstrate mixed results, and many show a decline in firearms suicide associated with interventions that putatively decrease availability with no overall suicide rate reductions, or a substitution effect, and therefore the results from this review study are supported by previous findings in other countries (Siegel et al., 2019; Daigle, 2005; Kleck, 2019; Zalsman et al., 2016; Klieve et al., 2009; Gilmour et al., 2018; Chapman et al., 2016; Robinson et al., 2018; Kagawa et al., 2018; Castillo-Carniglia et al., 2019; Crifasi et al., 2015). For example, a recent review examining longitudinal studies from Australia and New Zealand demonstrated reductions in firearms suicides compensated by substitution with other methods resulting in no overall changes in suicide rates (Santaella-Tenorio et al., 2016).

There are several limitations to consider, the main being that due to the heterogeneous methods used in the reviewed studies it was not possible to produce a meta-regression analysis or tests for publication bias. As already discussed, many early studies used crude analytical methodology and very few studies included other independent variables in the analysis thus are subject to the possibility of confounding errors. The studies examine laws as a whole and do not focus on individual laws, though Langmann (2020), does attempt to break down the analysis into the time periods that certain laws were implemented, hence individual effects of each law are not reported. As well, there may be a complex interplay of aggregate, synergistic, or even antagonistic effects between laws that is not measured. Moreover, the studies only account for the presence or absence of laws and not implementation or enforcement, it may be that people ignore rules such as safe storage and thus limited benefit is found. All these studies are subject to the ecological fallacy of drawing conclusions about individual actions from aggregate data and apparent substitution effects may be the result of changes in social stigmatisms and behaviours, or responses to alternate events. Finally, studies finding limited association between legislation

and suicide may be the result of a lack of statistical power, Canada is a small country and firearms suicides make up a small percentage of overall suicides.

By no means does this review suggest that one should give up on education of risks, responsible storage, and control of firearms, for example, youth are at high risk of impulsive suicide attempts and those who commit suicide with a firearm often obtain it from their own home (Kivisto et al., 2020). What this review does suggest is that the current strategies may not have made an overall impact on suicide prevention in Canada.

This begs the question, what can be done? Evidence exists that interventions during the suicidal phase do have a beneficial effect, and those often occur in the Emergency Department, however, physicians in Canada do not inquire about access to firearms in half the cases seen (Katz et al., 2019). Regulations implemented under Bill C-68 allow the Chief Firearms Officer to store firearms until a patient is safe and the suicidal conditions have passed, hence physicians can establish a relationship with patients and work with them towards harm reduction. The Canadian government is considering expanding its red flag laws, or extreme risk protection orders, to allow physicians to sever patient-physician confidentiality and report firearms owners at risk, but arguments both for and against involve ethical issues regarding patient rights and physician-patient relationships (Canadian Broadcasting Corporation, 2020). Current evidence for risk-based firearms seizure laws and suicide prevention is limited and mixed, and Langmann (2020), may have found no benefit regarding suicide and the laws in practice in Canada, though it is not possible to assess how many physicians encourage harm reduction in this manner (Langmann, 2020; Kivisto and Phalen, 2018; Smucker, 2020). Future areas for public policy and research could involve physician education and implementation of the current strategies available for prevention of suicide by firearm, as well as evaluating the effectiveness of such. Finally, suicide amongst indigenous peoples in Canada, while declining, remains at levels much higher than the general population and there is a critical lack of research studies in this area (Bennett et al., 2015).

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