

FIREARM BACKGROUND CHECKS AND SUICIDE*

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A popular proxy for gun ownership is the fraction of suicides from firearms. This has made identifying the causal effect of guns on suicide difficult. In this article, firearm background checks are used as a proxy for changes in gun ownership rates, allowing the effect of guns on suicide to be identified. The results from panel data regressions show that increases in firearm background checks rates are associated with increases in firearm suicide rates. Overall suicide is positively, but insignificantly, related to background checks. To alleviate endogeneity that comes from suicidal individuals purchasing a gun to commit suicide, youth suicide is analysed and yields similar, but noisier results.

Over 50% of suicides in the US are firearm suicides. Guns appear to be so closely related to suicide in the US that the fraction of suicides that come from a firearm is typically believed to be the best cross-sectional measure of gun ownership at the state level (Azrael *et al.*, 2004; Kleck, 2004). Despite this strong association between guns and suicides, few papers have attempted to measure how changes in gun ownership influence the suicide rate. This article looks at the relationship between suicide and guns using the number of federal firearm background checks in a state between 1999 and 2007, data previously unused in the economics literature, to proxy for firearm purchases.

Using background checks to proxy for new firearms is an important contribution, as many papers analysing the potential effect of guns use the fraction of suicides from firearms (denoted FSS in the literature) to proxy for gun prevalence. Because suicide is the outcome of interest in this article, the FSS measure is inappropriate as it places the dependent variable on the right-hand side of the regression. The next Section discusses firearm background checks in detail and shows that it is a valid proxy for firearm prevalence in a state.

After showing the validity of background checks as a firearm proxy, the change in the suicide rate in a particular state and time period is regressed on the background check rate. The results show that increasing the number of firearms in a state is associated with an increase in the firearm suicide rate. Total suicide is positively related to background checks in all specifications but the results are noisier than firearm suicide regressions. Non-firearm suicide rates are insignificantly related to changes in the firearm stock. Using the change in youth suicide rates (10- to 17-year olds) as the dependent variable yields similar, but noisier, coefficients compared with the entire population. There is evidence that the firearm suicide rate for youth males increases when background checks increase. This is consistent with statistics showing that males

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account for a majority of suicides and are significantly more likely to use a firearm (CDC, 2010), although females are estimated to attempt suicide at twice the rate of men (Krug *et al.*, 2002).

This study is related to a number of studies showing that access to a particular method of suicide can increase the overall suicide rate. Switzerland has one of the highest suicide rates in Europe (Ajdacic-Gross *et al.*, 2010) along with a relatively high gun ownership rate, at around 50 per 100 citizens.¹ In contrast, the gun ownership rate in England and Wales is six per 100 citizens and the suicide rate is roughly a third of Switzerland's rate. Killias (1993) and Killias *et al.* (2001) look at a number of countries and show that high levels of gun ownership are associated with high homicide and suicide rates. Clarke and Mayhew (1988) observed a significant decline in overall suicide and suicide from toxic gases in England and Wales during the 1960s and 1970s. This decline coincided with a removal of carbon monoxide from the public gas supply. Although many papers find a positive correlation between suicide rates and access to a suicide method, the research relies primarily on cross-sectional data, limiting the strength of the conclusions.

Miller *et al.* (2007) examine US gun ownership using Behavioral Risk Factor Surveillance System (BRFSS) data in 2001 and find that states with more firearms also have higher suicide rates. Miller *et al.* (2002) draw similar conclusions using a panel of census divisions constructed from the General Social Survey (GSS). Hemenway and Miller (2002) merge data from the GSS and the National Comorbidity Survey (NCS) to show that firearm ownership is not related to major depression or suicidal thoughts, even though higher levels of handgun ownership are associated with higher suicide rates. Although past research suggests that access to a means to carry out a suicide can potentially influence the suicide decision, the BRFSS and GSS data sets do not have enough statistical power to analyse how the firearm stock changes over time within a state. Using state-level data on firearm background checks over time, this study suggests that the firearm suicide rate will increase significantly when firearms increase and provides moderate support for the hypothesis that access to a particular suicide method can increase the overall suicide rate.

The findings add to the economics literature exploring the role that firearms play in the economy and in economic and social outcomes. Most of the work in economics that focuses on guns attempts to identify the relationship between gun ownership and crime. Lott and Mustard (1997) and Lott (2000) found that more guns lead to less crime. Their work is supported by Bartley and Cohen (1998), Plassmann and Whitley (2003) and Helland and Tabarrok (2004). Papers by Ludwig (1998), Duggan (2001), Ayres and Donohue (2003) and Cook and Ludwig (2006) have all countered the 'more guns, less crime' theory' and show that guns and crime are positively related.

While the focus in the economics literature is primarily on firearms and crime, there are some notable papers by economists analysing the effect of gun accessibility on suicide. The most direct analysis of guns and suicide is by Duggan (2003), who finds that the correlation between gun ownership and suicidal tendencies is driving the

¹ The US with an estimated 270 million firearms and a population of 300 million has the highest gun ownership rate in the world. See the Small Arms Survey (2007) at: <http://www.smallarmssurvey.org/> for more information.

relationship between firearms and suicide. He also introduces a unique proxy of gun ownership, the number of magazine subscription to *Guns & Ammo*, and shows that the male–female suicide ratio is greater where there is more gun availability. Duggan *et al.* (2011) use geographic variation in gun shows to show that neither homicides or suicides respond to gun shows in nearby zip codes.

Despite the fact that suicide is the 11th leading cause-of-death in the country (3rd leading cause among the youth) and there are an estimated 11 suicide attempts for every completed suicide (CDC, 2010), research on suicide and guns has been largely unexplored in economics. This is likely due to the fact that the most popular firearm proxy, the fraction of suicides that are from firearms, presents obvious econometric issues. This article is able to overcome those issues with a new proxy for gun prevalence and provides valuable information for both economists and policy makers about the effect of guns on suicide.

1. The FBI's National Instant Check System

Gun ownership data on a local level are sparse. The GSS is the primary measure of gun ownership at the national level, but is not intended to measure gun ownership at areas that are smaller than census divisions. Using a wide variety of gun proxies, Kleck (2004) shows that the fraction of suicides from firearms (FSS) is the proxy most closely related to gun ownership in the GSS,² although he argues that the measurement is not appropriate in panel data models.³ Regardless of the validity of the FSS measure as a proxy for gun ownership, it is inappropriate to use in the current research as the dependent variable is the suicide rate and any independent variable that contains suicide will confound the estimation. To reduce the econometric issues from using FSS to proxy for guns, Duggan (2003) uses magazine subscriptions to *Guns & Ammo* as a proxy for firearms; however, the validity of this proxy remains in question (Cook and Ludwig, 2006).

This article uses a more direct proxy for firearm ownership than magazine subscriptions: the number of state background checks for firearm transactions. Since November, 1998, the FBI has required all firearm transactions that take place through a federal firearms licence (FFL) holder to have a background check. The FBI's National Instant Check System (NICS) contains information on criminals that the FBI has disqualified from receiving a firearm and typically takes less than two minutes to process (FBI, 2011).

Background checks at local levels are typically thought of as poor measures of gun prevalence as many states do not require registration or licensing of firearms (Jacobs, 2002). The federal NICS, on the other hand, requires each FFL holder to call a toll-free number and provide information on potential gun purchasers. The NICS has recorded

² Kleck (2004) also looks at the per cent of homicides, robberies and aggravated assaults with guns, fatal gun accidents, the value of stolen property from guns, *Guns & Ammo* subscriptions, NRA Membership, hunting licence holders and weapons arrests.

³ Cook and Ludwig (2006) use the FSS measure in a panel data model when analysing the effect of guns on crime.

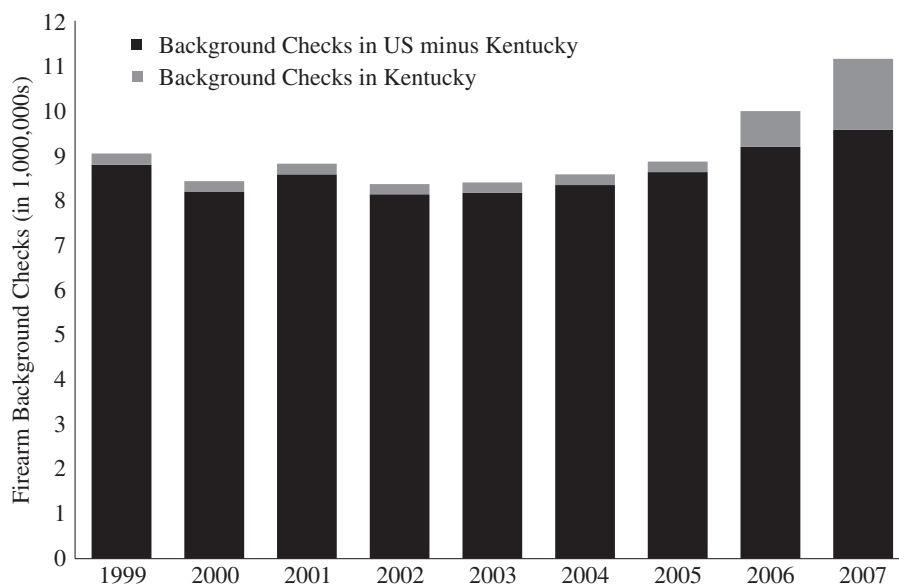


Fig. 1. *Number of Background Checks, 1999–2007*

the number of checks done each month, in each state since November, 1998. Over 120 million checks have been done, with just under 900,000 denials (FBI, 2011).

Figure 1 shows the number of background checks across the US and Kentucky between 1999 and 2007. The grey portion of shows the number of annual background checks in Kentucky. The aggregate number of background checks in the remaining states is shown in black. Between 1999 and 2005, the number of background checks in the nation ranged between 8 and 9 million. There is a significant increase in US background checks in 2006 and then again in 2007. The majority of this increase is driven by the state of Kentucky.

Kentucky started performing frequent background checks on concealed carry permit holders, beginning in July 2006.⁴ At the same time, individuals with concealed carry permits were exempt from having an NICS background check done when purchasing a firearm (ATF, 2006). The significant increase in Kentucky background checks presumably overestimates the number of firearm purchases, as not all permit holders purchase a firearm. However, because permit holders do not go through a background check when making a firearm purchase, these firearm purchases are not captured by the background check data making it unclear how much of the increase in the background checks in Kentucky represent actual firearm purchases.⁵

While the NICS background check data can provide a proxy for the number gun purchases at the state level, firearm background checks can capture more than firearm

⁴ Permit holders may have as much as one background check per month (Kelleher, 2012); however, the exact frequency of checks is unknown. Kentucky began issuing concealed carry permits in 1996 (Kentucky Legislature, 2012).

⁵ When the observations associated with the Kentucky permit background checks are controlled for in the regressions below, the implications of the results are unchanged.

purchases. There is the possibility of non-compliance by FFLs and that will be undetectable, as will transfers of guns across state lines. Private gun purchases are exempt from the background checks and will not be captured in the data. A substantial number of background checks represent handgun permits, which are not necessarily firearm purchases and the FBI (2011) notes that ‘a one-to-one correlation cannot be made between a firearm background check and a firearm sale’. Sales of firearms at gun shows do not go through appropriate checks as well (Duggan *et al.*, 2011).

Despite the fact that the number of background checks in a state may be subject to measurement error, background checks measure the intent to purchase guns from FFLs in a state and provide a proxy for the change in gun prevalence over time. While other gun measures such as magazine subscription rates capture interest in guns, an increase in gun-related activities does not necessarily mean that more guns will be added to the existing stock of guns.

1.1. Background Checks as a Proxy for Firearms

Before estimating the impact of background checks on suicide, it is necessary to establish a relationship between firearm background checks and existing firearm measurements. In order to show that background checks represent firearms in a region, GSS data are used. The GSS was administered annually from 1972 until 1994 (with the exception of the years 1979, 1981 and 1992) and has been administered bi-annually since 1994. The GSS is not intended for analyses finer than the census division but still remains the primary measure of gun ownership at the national level. Merging the data from the bi-annual GSS with background check data between 1999 and 2008 yields five years of data for the nine census divisions.⁶

The GSS (Smith *et al.*, 2011) contains information on the fraction of households in a census division that answered ‘yes’ to the question, ‘Do you happen to have in your home any guns or revolvers?’ The question can be used to approximate the number of guns per capita in a region by using the information provided by the respondent on the size of the household.⁷ After converting the guns per household measure to guns per capita, the relationship between background checks and the fraction of the population with a firearm can be explored by running the regression:

$$\Delta GP_{c,t,t-2} = \alpha + \beta \left(\frac{\sum BGC}{POP} \right)_{c,t,t-1} + \psi_c + \lambda_t + \varepsilon_{i,t}, \quad (1)$$

where $\Delta GP_{c,t,t-2}$ is the change in the estimated fraction of the population with a gun in census division c between the years t and $t - 2$. The term $(\sum BGC/POP)_{c,t,t-1}$ captures the total number of background checks performed in census division c in the years t and $t - 1$, divided by the average population in the census division over those years. Census division and year fixed effects are captured by the terms ψ_c and λ_t , respectively,

⁶ Because the GSS is bi-annual, the years 2000, 2002, 2004, 2006 and 2008 are used in the analysis.

⁷ The guns per capita variable is only able to assume that there is one gun per household, as the GSS does not provide information on the actual number of guns in a household. When using the guns per household measure provided by the GSS as the dependent variable, the results yield the same implications.

Table 1
The Change in the Fraction of the Population with a Firearm

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$(\Sigma BGC/POP)_{c,t,t-1}$	0.69*** (0.12)					0.69*** (0.12)	0.69*** (0.12)	0.78*** (0.12)
$(\Sigma BGC/POP)_{c,t-1,t-2}$		0.98*** (0.16)						
$\Delta FSS_{c,t,t-2}$			0.03 (0.24)			-0.018 (0.23)		
$FSS_{c,t-1}$				0.15 (0.24)			0.12 (0.22)	
<i>Firearm suicide Rate</i>					-0.003 (0.025)			-0.027 (0.016)
R ²	0.84	0.84	0.74	0.74	0.74	0.84	0.84	0.85
N	45	45	45	45	45	45	45	45

Notes. All regressions include census division and year fixed effects. Regressions are weighted by average census division population from 2000–8. Robust standard errors are reported in parentheses. *10% Significance; **5% Significance; ***1% Significance.

and robust standard errors are reported. The mean fraction of the population with a firearm in the data set is 0.08 with a standard deviation of 0.04.

Column (1) of Table 1 shows the results of estimating (1). The 2-year background check rate in a census division is positively related to the change in the fraction of the population with a firearm. A one standard deviation increase in the 2-year background check rate increases the fraction of the population with a firearm by approximately 2% points.⁸ When the 2-year background check rate is lagged by 1 year, column (2) shows that the positive relationship between background checks and firearms still exists.

When the change in the fraction of the population with a firearm is run on the change in the fraction of suicides from firearms, $\Delta FSS_{c,t,t-2}$, column (3) shows that the ΔFSS measure is positively, but insignificantly, related to the fraction of the population with a firearm. Column (4) reports that the fraction of suicides using firearms is positively related to changes in the fraction of the population with a firearm but is also insignificant. Although the FSS measures are commonly used as proxies for firearms, the variable is scaled differently than the dependent variable of guns per capita. Column (5) uses the firearm suicide rate as the independent variable and the firearm suicide rate is negatively and insignificantly related to the change the fraction of the population with a firearm.

The remaining columns of Table 1 explore whether the 2-year background check rate variable is altered by the inclusion of the other firearm measures in the regression. The point estimate for the background check rate variable is unchanged when the change in the fraction of suicides from firearms and fraction of firearm suicides is included, as seen in columns (6) and (7). The background check coefficient remains stable when the firearm suicide rate is included in column (8).

The results in Table 1 point to a deficiency in reliable data on firearms at fine geographic levels. While there is evidence that background checks are related to the

⁸ The population weighted mean of 2-year background check rate is 0.065, with a standard deviation of 0.030.

fraction of the population with a firearm, the regressions are at a census division level and because the GSS is only administered every two years, the number of years available in the analysis is currently limited. Despite the low number of observations, Table 1 provides evidence that background checks and firearm prevalence are positively correlated. By using the background checks as a proxy for guns in a state, the relationship between changes in state-level suicide rates and firearms can be explored.

2. Empirical Specification

The relationship between the suicide rate and the firearm stock is found by running the following regression:

$$SP_{i,t} = a + bGP_{i,t} + cX_{i,t} + \pi_i + \tau_t + s_i t + e_{i,t}. \quad (2)$$

The term $SP_{i,t}$ is the suicide rate per 100,000 in state i at time t and the variable of interest, $GP_{i,t}$, represents the guns per capita, where the guns per capita is the number of firearms in a state, divided by the population. Time-varying state controls, $X_{i,t}$ are included, along with state and year fixed effects, denoted as π_i and τ_t , respectively, and a state-specific time trend, $s_i t$. The coefficient b is the relationship between the firearm rate in a state and the suicide rate.

The firearm background checks variable discussed in the previous Section is not able to capture the stock of firearms as it represents the number of new firearm purchases in a state. By subtracting $SP_{i,t-1}$ from $SP_{i,t}$ in (2), the change in the guns per capita becomes the variable of interest:

$$\Delta SP_{i,t} = b\Delta GP_{i,t} + c\Delta X_{i,t} + \tau_t + s_i + \Delta e_{i,t}. \quad (3)$$

The variable of interest in (3) becomes the change in guns per capita, $\Delta GP_{i,t} = GP_{i,t} - GP_{i,t-1}$.

The change in guns per capita in state i between time periods t and $t - 1$ is equal to the rate of new gun purchases minus the number of gun retirements. The rate of new purchases can be proxied using the number of background checks in a state divided by the population, BGC/Pop , depicted in (1). If firearm retirements are assumed to be constant within a state, the retirements are captured by the state fixed effects parameter, s_i . Using the BGC/Pop variable in the current year assumes that the suicide rate will respond immediately to firearm purchases. However, if firearms are purchased in an area but suicidal individuals do not respond immediately to the increase in guns, a lagged value of the background check rate is more appropriate than the current value.⁹ Introducing the lagged value of BGC/Pop to (3) yields:

$$\Delta SP_{i,t} = b \left(\frac{BGC}{Pop} \right)_{i,t-1} + c\Delta X_{i,t} + \tau_t + s_i + \Delta e_{i,t}. \quad (4)$$

There may be additional concern that people have suicidal tendencies over a long period of time and, they purchase a gun as a result of their current feelings and then commit suicide in the future. This situation causes $E[\Delta e_{i,t}(BGC/Pop)_{i,t-1}] \neq 0$. A way to

⁹ Cook and Ludwig (2006) argue that using current estimates of guns will lead to biased estimates when individuals purchase guns with the intention to commit suicide.

Table 2
Descriptive Statistics

		All suicide			Youth suicide		
		Suicide rate	FA rate	NFA rate	Suicide rate	FA rate	NFA rate
All genders	Mean	10.97	5.84	5.12	2.93	1.27	1.65
	SD	(2.82)	(2.33)	(1.15)	(1.39)	(0.91)	(0.77)
	Min	4.72	0.52	2.31	0.00	0.00	0.00
	Max	23.44	16.90	11.05	17.91	12.31	9.47
Male only	Mean	17.78	10.39	7.39	4.41	2.11	2.29
	SD	(4.56)	(4.01)	(1.57)	(2.21)	(1.56)	(1.17)
	Min	8.28	1.10	3.08	0.00	0.0	0.00
	Max	40.53	29.96	16.83	26.04	20.90	12.05
Female only	Mean	4.38	1.45	2.93	1.37	0.39	0.98
	SD	(1.24)	(0.78)	(0.84)	(0.93)	(0.49)	(0.72)
	Min	1.32	0.00	0.99	0.00	0.00	0.00
	Max	10.97	6.77	7.52	11.62	7.11	8.68
Background checks			Levels			Per capita	
			Mean			0.03	
	SD		(236,723)			(0.02)	
	Min		7			0.00001	
	Max		1,587,850			0.37	

Notes. The suicide rates are the number of suicides per 100,000 of the population. Each cell contains 459 observations. Means are weighted by the average population of the state from 1999–2007.

eliminate this potential endogeneity is to analyse the youth suicide (10 to 17-year olds), as they are unable to legally purchase guns. Any remaining endogeneity from analysing youth suicide comes from the correlation between firearm background checks of adults in the previous period and changes in unobservable characteristics that correspond with youth suicide in the current period.

Finding a positive coefficient on b implies that suicidal individuals are more likely to commit suicide when there is a gun available, but those tendencies subside when a gun is not available. This is known as the ‘instrumentality effect’ (Culter *et al.*, 2001) and such a finding suggests that reductions in firearms will reduce the suicide rate.

If total suicide is unaffected by changes in gun prevalence, firearms can still play a significant role in the way that suicide is carried out. It is reasonable to assume that changes in the gun stock will non-negatively impact firearm suicide rates and non-positively impact non-firearm suicide rates. Results showing this substitution in the method of suicide may suggest that suicidal individuals will use a gun if it is available but seek out other methods of suicide if they cannot obtain a gun. To examine the effect of guns on the method of suicide, regressions are run using the firearm and non-firearm suicide rates as the dependent variable.

Regressions are also run on the subset of male and female suicide rates. Males commit suicide using a gun significantly more than females, as seen in the descriptive statistics in Table 2, and one may expect that changes in gun prevalence should affect male suicide more than female suicide. All regressions are weighted by the average state population from 1999 to 2007 and standard errors are clustered at the state level to control for autocorrelation (Bertrand *et al.*, 2004).

2.1. *Data*

As discussed above, the variable of interest is the number of background checks in a state and the dependent variable is the change in the suicide rate. The suicide rates per 100,000 are gathered from the Multiple Cause-of-Death Public-Use files, published annually by the National Center for Health Statistics (CDC, 2010). Suicide is defined using the International Classification of Diseases codebook (version 10) and is code 40 in the ICD '39 recode' classification. Firearm suicide is code 429 in the '358 recode' classification and non-firearm suicides are defined as any suicide that does not come from a firearm. The analysis covers the years 1999–2007.

Time-varying state characteristics included in the analysis are the unemployment rate, bankruptcies per capita and the percentage of individuals who are uninsured. The unemployment data measure unemployment rates for all ages and are published by the Bureau of Labor Statistics' Local Area Unemployment Statistics (2010).¹⁰ Bankruptcy data are published annually by the US Courts (2010) and report the number of all types of bankruptcy filings by state since 1990.¹¹ The percentage of the entire population that is uninsured is from the Current Population Survey (2008) (March Sample).¹² The age structure of a state is controlled for by including variables measuring the fraction of the population under 18 years old and the fraction of the population above 65 years old in the regressions. The population data are retrieved from the US Census (2010).¹³

2.2. *Descriptive Statistics*

Table 2 reports the population weighted means, standard deviations, and minimum and maximum suicide rates for each group of interest and covers the years 1999–2007. The overall suicide rate in the data is 10.97 suicides per 100,000 people and is found in the top left corner of the Table. The second and third columns of Table 2 report the firearm (FA) and non-firearm (NFA) suicide rates, respectively. Reading left to right, it is seen that firearms are used in over 50% of suicides. In the second row, the male suicide rates are reported and in the third row, female suicide rates are reported. Males make up over 75% of all suicides and nearly 90% of firearm suicides come from males. The discrepancy between male and female firearm suicide is what Duggan (2003) used to identify the relationship between guns and suicide, as he reasonably assumed that changes in gun prevalence should affect male suicide more than female suicide.

The last three columns of Table 2 report the mean suicide rates for the youth, where youths are defined as ages 10–17. The total youth suicide rate is 2.93 per 100,000 with approximately 43% of the youth suicides coming from firearms. Similar to the entire population, around 80% of the youth suicides are committed by males and over 85% of the firearm suicides are from males. Despite the fact that youth suicide is significantly less than the overall suicide rate, suicide is the third-largest cause-of-death for youth behind accidents and homicide, whereas suicide is the 11th leading cause-of-death in

¹⁰ The BLS LAUS can be accessed at www.bls.gov/lau/.

¹¹ The Bankruptcy Data can be accessed at www.uscourts.gov/Statistics/BankruptcyStatistics.aspx.

¹² Uninsured rates can be accessed at www.census.gov/hhes/www/hlthins/data/historical.

¹³ Population data can be accessed at www.census.gov/popest/data/historical.

the entire population. The bottom rows of Table 2 report that there are 326,461 annual background checks in a state on average and the average background check rate is 3%.

Table 2 shows the prevalence of suicides across groups and methods, but it does not give an indication of the relationship between changes in firearms and changes in suicide rates. Figures 2*a* and 2*b* show the relationship between background checks and suicide. Figure 2 shows the lagged background check rate and the change in suicide rates (Figure 2*a*) and the change in firearm suicide rates (Figure 2*b*) between 2000 and 2007 in North Carolina.¹⁴ The solid black line depicts how suicide and firearm suicide rates have changed over time, and the dotted black line shows the firearm background check rate of the previous year.

In Figure 2*a*, the lagged background check rate and the change in the suicide rate move in a similar manner between 2000 and 2002. After 2002, the two measurements diverge. In Figure 2*b*, the background checks and firearm suicide rates move together between 2000 and 2005, before diverging in 2006 and 2007. In North Carolina, the relationship between background checks and changes in firearm suicide rates is stronger than changes in the overall suicide rates. If other states react to background checks the same way as North Carolina, regression results in the next Section are expected to show that firearm suicide rates respond to background checks more than overall suicide rates.

3. Background Checks and the Change in Suicide Rates

Table 3 reports the results of regressing changes in suicide rates on the state firearm background check rate. The first row shows the regression results from using background checks in the current time period as the variable of interest, while the second row uses the background check rate in the previous time period as the variable of interest. Results using 2-year lagged background check rates are reported in the third row. All regressions are weighted by the average state population between 1999 and 2007 and include state and year fixed effects.

The first three columns of Table 3 show how the background check rate impacts changes in the overall, firearm and non-firearm suicide rates, excluding controls. An increase in the current background check rate is associated with an insignificant increase in the suicide rate. The second column shows that the firearm suicide rates increase significantly when background checks increase. The non-firearm suicide rate does not respond significantly to background checks, as seen in third column. Regressions using the lagged background check rate as the variable of interest yield the same result as the current rate, although the magnitude of the coefficient increases. The 2-year lagged background check rate is not significantly related to changes in the suicide rate.¹⁵

Controls for the change in the unemployment rate, the bankruptcy rate, the per cent uninsured, the fraction of the population younger than 18 and older than 65

¹⁴ The background check rate in North Carolina between 1999 and 2007 is within one standard deviation of the average background check rate in the entire sample.

¹⁵ Results for the lagged background check regressions are unchanged when a state-specific linear time trend is included in the regressions.

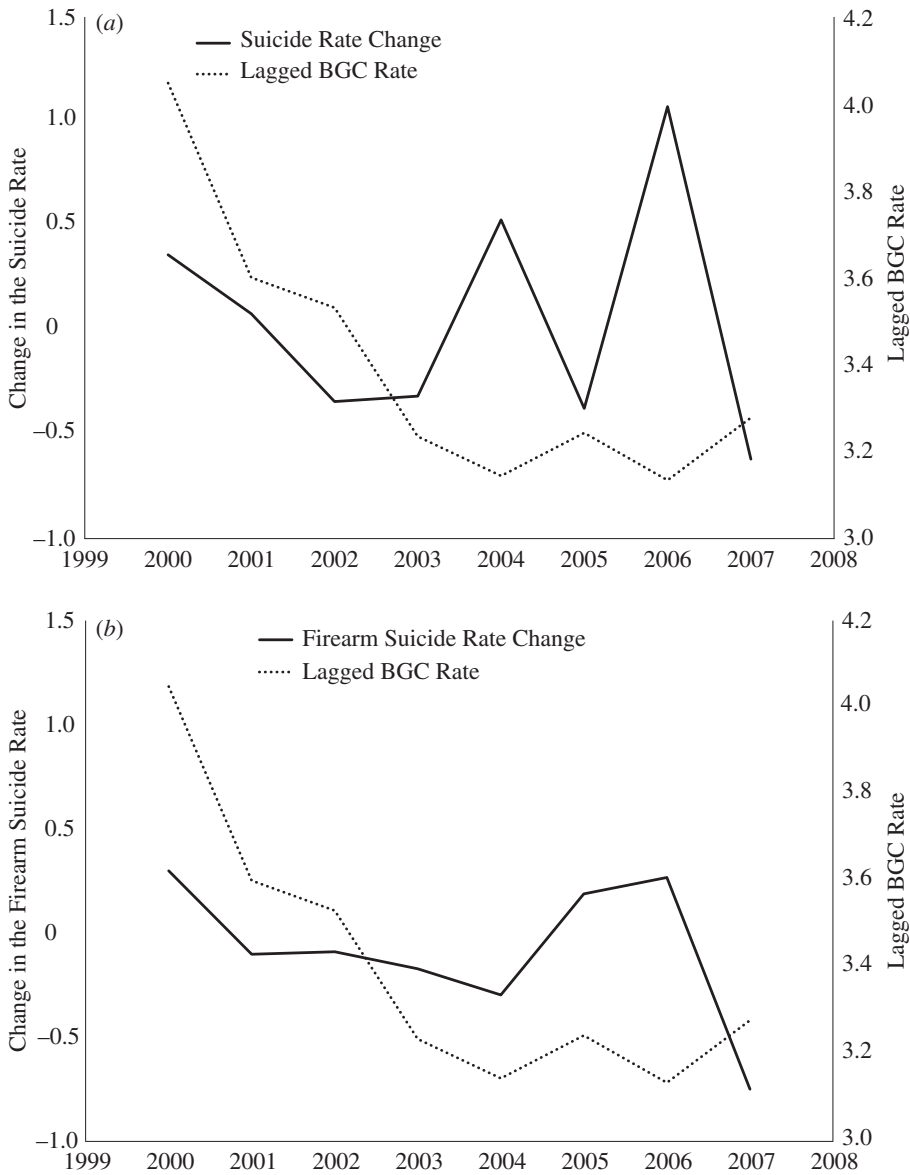


Fig. 2. (a) North Carolina Background Checks and Suicide (b) North Carolina Background Checks and Firearm Suicide

are added in the next set of results. The coefficients for current, lagged and 2-year lagged background check rates do not change significantly when controls are added.¹⁶

¹⁶ Regressions that run changes in suicide rates on the current, lagged and 2-year lagged background checks simultaneously show that lagged background check rate positively impacts firearm suicide rates and 2-year lagged background check rates negatively impact firearm suicide rates.

Table 3
The Change in Suicide Rates

	Suicide rate	FA rate	NFA rate	Suicide rate	FA rate	NFA rate
$(BGC/Pop)_{i,t}$	1.28 (1.14) [459]	1.68** (0.69) [459]	-0.39 (0.76) [459]	1.41 (1.11) [459]	1.75** (0.70) [459]	-0.34 (0.73) [459]
$(BGC/Pop)_{i,t-1}$	4.41 (3.35) [408]	4.00** (1.58) [408]	0.41 (2.78) [408]	4.53 (3.55) [408]	3.99** (1.59) [408]	0.53 (3.00) [408]
$(BGC/Pop)_{i,t-2}$	-0.17 (6.00) [357]	-3.80 (4.32) [357]	3.63 (4.51) [357]	0.20 (6.38) [357]	-4.01 (4.26) [357]	4.21 (4.92) [357]
Controls	No	No	No	Yes	Yes	Yes

Notes. The number of observations are reported in brackets. All regressions include state and year fixed effects and are weighted by the average state population from 1999–2007. Controls used in the regressions include changes in state unemployment rate, fraction uninsured, bankruptcy rate, the fraction of the population younger than 18 and older than 65. Standard errors in parentheses are clustered at the state level. * Significance at 10% level; ** Significance at 5% level; *** Significance at 1% level.

The findings in Table 3 show that an increase in the background check rate is positively and significantly related to the change in firearm suicide rates. Background checks insignificantly impact overall suicide rates but the point estimate is similar in magnitude as firearm suicide regressions. The similarity of the background check coefficients in overall and firearm suicide rate regressions in Table 3 provides support for the hypothesis that increases in firearms will lead to additional suicides.

Table 4 shows the results from regressions that use the lagged background check rate as the variable of interest and changes in youth suicide rates and gender-specific suicide rates as dependent variables. Each cell reports the lagged background check rate coefficient for the regression corresponding to the row and column titles. The first set of results show that changes in youth suicide, youth firearm suicide and youth non-firearm suicide are positively related to increases in lagged background check rates, although the relationship is insignificant.

When youth male suicide rates are analysed in the second set of regressions, results show that increases in lagged background checks are associated with increases in firearm suicide rates. Youth male suicide rates and non-firearm suicide rates do not respond significantly to background checks. This finding is consistent with the results from Table 3, as well as the fact that youth males use firearms to commit suicide more often than females. Regression results using male suicides have the same signs as youth males, but are insignificant.

The last set of regressions in Table 4 examines the impact of background checks on changes in female suicide rates. No consistent pattern emerges from the youth female results, which may be explained by the low suicide rate for youth females. Background check rates are positively related to changes in female suicide rates but background checks do not significantly impact firearm and non-firearm suicide rates for females. Similar to the youth females, females commit suicide significantly less than males.

Table 4
The Change in Youth and Gender-Specific Suicide Rates

	All			Males			Females		
	Suicide rate	FA rate	NFA rate	Suicide rate	FA rate	NFA rate	Suicide rate	FA rate	NFA rate
Youth	4.86 (4.20) [408]	3.10 (1.93) [408]	1.78 (4.44) [408]	5.89 (6.00) [408]	8.27** (3.47) [408]	-2.37 (5.66) [408]	3.75 (5.12) [408]	-2.36 (1.71) [408]	6.19 (5.54) [408]
All	4.53 (3.55) [408]	3.99** (1.59) [408]	0.53 (3.00) [408]	2.76 (6.70) [408]	3.20 (4.89) [408]	-0.44 (2.98) [408]	5.79*** (1.51) [408]	4.40 (3.21) [408]	1.39 (3.47) [408]

Notes. The number of observations are reported in brackets. The lagged background check rate coefficient is reported in each cell. All regressions include state and year fixed effects, are weighted by the average state population from 1999–2007 and include controls for changes in state unemployment rate, fraction uninsured, bankruptcy rate, the fraction of the population younger than 18 and older than 65. Standard errors in parentheses are clustered at the state level. * Significance at 10% level; ** Significance at 5% level; *** Significance at 1% level.

While it is possible for background checks to increase female suicide rates, the relatively low female firearm suicide rates reported in Table 2 suggests that more research is needed to confirm the validity of the relationship between guns and female suicide found in Table 4.

With the exception of the subset of regressions examining female suicide, the most consistent result that emerges from Tables 3 and 4 is that an increase in the background check rate is associated with a significant increase in the firearm suicide rate. At the same time, the overall suicide rate is positively, but insignificantly, related to background check rate increases. The findings support claims that the fraction of suicides using firearms (FSS) is a reasonable proxy for firearms in a state (Azrael *et al.*, 2004; Kleck, 2004; Cook and Ludwig, 2006) as any increase in total suicide from additional firearms purchases is driven by increases in the firearm suicide rate. Although the results do not show a significant relationship between background checks and overall suicide, the background check point estimates in the overall suicide regressions are consistent with the ‘instrumentality effect’ (Culter *et al.*, 2001), suggesting that reductions in firearms may potentially reduce overall suicide.

4. Conclusion

This article analyses the role that guns play in suicide using a panel of states over time and a valid proxy for the change in the stock of firearms. The results show that increases in firearm background checks increase the firearm suicide rate. The overall suicide rate increases insignificantly when background checks increase, suggesting that access to firearms may potentially affect the overall suicide rate. Regressions run on youth suicide exhibit a similar pattern as the total population, although the coefficients are not significant, except when analysing youth males.

In previous research on firearms and suicide, Duggan (2003) uses magazine subscriptions to *Guns & Ammo* as a proxy for firearms. Duggan (2003) does not find a

relationship between *Guns & Ammo* subscription rates and the firearm suicide rate. The discrepancy between the results in this article and Duggan (2003) is likely driven by the use of background checks as a proxy for firearms instead of magazine subscriptions. Because both papers find that firearms insignificantly impact the overall suicide rate, it is possible that movements in the suicide rate over time may be driven by unobservable factors, such as changes in suicide propensity.

The results are of interest to both gun and mental health policy makers; however, one cannot extrapolate the results to large-scale gun bans, as the coefficient estimates reported above are for small changes in background checks. Increases in the firearm stock may increase the overall suicide rate and any increase in the suicide rate will be driven by an increase in the firearm suicide rate. Before enacting policies aimed at reducing suicide, it is important to evaluate whether policies focused on influencing suicide ideation would be more effective than reducing firearms.

Overall, it is inconclusive how eliminating guns would impact the state suicide rate with the only insights being that small changes in gun prevalence within a state significantly affect firearm suicide. Before using these results in the gun policy debate, future work should look for natural experiments that lead to large-scale changes in gun access. As gun data becomes more accurate and accessible, the effect of guns on a variety of outcomes beyond suicide should be explored, including homicide, armed robbery and burglary. While these topics are beyond the scope of this article, the use of background checks as a gun proxy will likely lead to a better understanding of the role guns play in society.

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Additional Supporting Information may be found in the online version of this article:

Appendix A1. The Change in the Fraction of Households with a Firearm.

Appendix A2. The Change in Suicide Rates, Kentucky Outlier Dummy Included.

Appendix A3. The Change in Suicide Rates, Simultaneous Lags.

Appendix A4. The Change in Suicide Rates, State-Specific Time Trend.

Appendix A5. The Change in Youth Suicide Rates.

Appendix B. Data.

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