Handgun waiting periods reduce gun deaths

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Handgun waiting periods are laws that impose a delay between the initiation of a purchase and final acquisition of a firearm. We show that waiting periods, which create a "cooling off" period among buyers, significantly reduce the incidence of gun violence. We estimate the impact of waiting periods on gun deaths, exploiting all changes to state-level policies in the Unites States since 1970. We find that waiting periods reduce gun homicides by roughly 17%. We provide further support for the causal impact of waiting periods on homicides by exploiting a natural experiment resulting from a federal law in 1994 that imposed a temporary waiting period on a subset of states.

gun policy | gun violence | waiting period | injury prevention

More than 33,000 people die in gun-related incidents each year in the United States, accounting for as many deaths as motor vehicle accidents (1). This is concerning both in absolute terms and in comparison to other developed countries, all of which have lower rates of gun violence (2). For example, if the United States could lower its firearm death rate to that of Finland (the high-income country with the second highest rate), roughly 20,000 fewer people would die from guns every year. However, there has been no meaningful reduction in the US firearm-related death rate for more than a decade. Moreover, evidence about which policies would be effective at reducing violence remains limited (3), and the types of bills that are enacted depend on the political party in power (4).

One avenue for reducing gun deaths is to draw on insights from behavioral economics and psychology, which suggest that delaying gun purchases, even for a short time, might be an effective policy tool. Visceral factors, such as anger or suicidal impulses, can spur people to inflict harm on others or themselves, but tend to be transitory states (5, 6). For example, Card and Dahl (7) find that there is a 10% increase in domestic violence following an upset loss of the local National Football League team. Moreover, behaviors triggered by such visceral states can be contrary to longer term self-interest (5, 6).

Delaying a gun purchase could create a "cooling off" period that reduces violence by postponing firearm acquisitions until after a visceral state has passed. Increasing the time it takes to acquire a gun might also close the window of opportunity for would-be perpetrators of violence to use their weapons. Finally, a mandatory delay has the potential to deter purchases among people who have malevolent, but temporary, motivations for owning a firearm.

This article explores the impact of "waiting period" laws on firearm-related homicides and suicides using 45 y of data on law changes and mortality at the state level in the United States. A waiting period is a mandatory delay between the purchase and delivery of a gun; it requires purchasers to wait, typically between 2 and 7 d, before receiving their weapons. We exploit plausibly exogenous temporal and geographic variation in waiting period laws to implement a difference-in-differences approach that identifies the causal impact of waiting periods on homicides and suicides.

We find that waiting periods cause large and statistically significant reductions in homicides. Point estimates using our full 45-y sample and all waiting period changes imply a 17% reduction in gun homicides. We provide further evidence of a causal relationship between waiting periods and lower homicide rates based on a natural experiment in which federal law imposed waiting periods on a subset of states. Estimates from this analysis also suggest that waiting periods reduce gun homicides by 17%. The results of both analyses confirm a large and robust effect of waiting periods on homicides. We also find a negative effect of waiting periods on suicides, but the magnitude and statistical significance of the suicide effect vary across model specification.

Data and Research Design

We construct a panel of every change to waiting period laws in the United States between 1970 and 2014, which we obtained from state statutes and session laws. We combine these changes with annual data on firearm-related deaths from the Centers for Disease Control and Prevention. Fig. 1 shows the number of states with waiting periods over time. Overall, 44 states (including the District of Columbia) have had a waiting period for at least some time between 1970 and 2014. Exploiting the significant geographic and temporal variation in the adoption of waiting periods, we implement a difference-in-differences framework to estimate the causal impact of waiting periods on gun deaths. Essentially, we compare changes in firearm-related deaths within states that adopted waiting periods with changes in firearm-related deaths in other states. We control for changing economic and demographic factors that may be correlated with higher levels of gun violence or with the decision of lawmakers to adopt policies that delay gun purchases.

To support our causal interpretation, we then restrict the analysis to the period from 1990 to 1998, during which federal policy forced many states to implement waiting periods. The Brady Handgun Violence Prevention Act (hereinafter "Brady Act"), which went into effect in February 1994, required background checks on handgun purchases from licensed firearm dealers and created a 5-d waiting period to allow sufficient time for the check. Although it was a federal policy, the Brady Act only created new waiting periods for 19 states, since some states already required a background check and waiting period, and some implemented an "instant check" system that allowed for nearly immediate background checks (thereby obviating the need for a waiting period). We provide further details regarding the Brady Act and affected states in *Identifying Policy Changes* and *Materials and Methods*.

Significance

Waiting period laws that delay the purchase of firearms by a few days reduce gun homicides by roughly 17%. Our results imply that the 17 states (including the District of Columbia) with waiting periods avoid roughly 750 gun homicides per year as a result of this policy. Expanding the waiting period policy to all other US states would prevent an additional 910 gun homicides per year without imposing any restrictions on who can own a gun.

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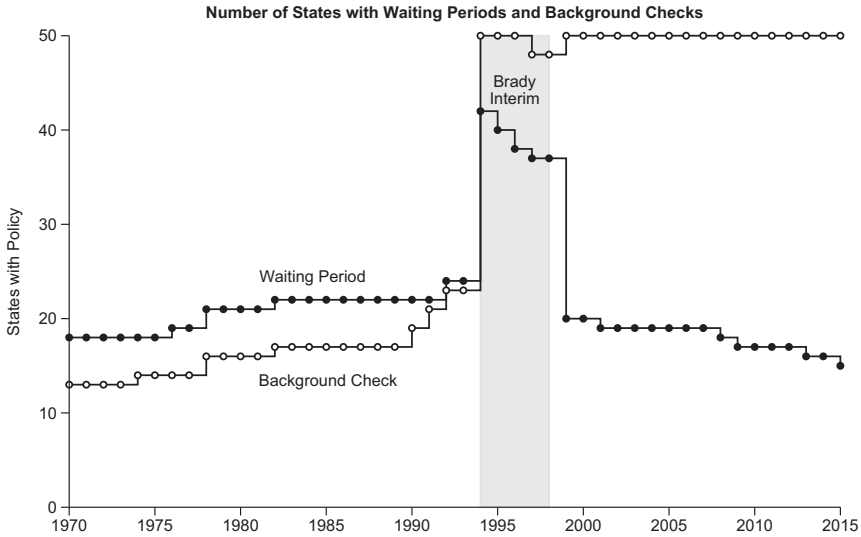

Fig. 1. States with handgun waiting periods and background checks on dealer sales from 1970 to 2015. Many states were required to implement these policies during the Brady interim period between February 1994 and November 1998 (shaded gray). Following prior research (8), Alabama and Ohio are coded as not requiring background checks after the Supreme Court's decision in *Printz v. United States*. Not all states had waiting periods during the Brady interim period because they implemented or already had an instant background check system that obviated the need for a waiting period to investigate gun buyers.

Results

We begin by examining the effect of waiting periods across the full sample period from 1970 to 2014. The results of Table 1 show that waiting periods are associated with a 17% reduction in gun homicides. This effect is equivalent to ∼36 fewer gun homicides per year for a state with an average number of gun deaths. Waiting periods also lead to a 7–11% reduction in gun suicides (depending on the control variables used in the specification), which is equivalent to 22–35 fewer gun suicides per year for the average state. The results in Table 1 use a log-linear specification; we

Table 1. Effects of handgun waiting periods and background checks on violence, 1970–2014

	1970–2014		1977–2014
Type of violence	(1)	(2)	(3)
All homicide			
Waiting period	−0.127 (0.059)**	−0.137 (0.059)**	−0.132 (0.050)**
Background check		0.049 (0.082)	0.025 (0.081)
Gun homicide			
Waiting period	−0.188 (0.077)**	−0.187 (0.086)**	−0.186 (0.071)**
Background check		−0.004 (0.103)	0.022 (0.107)
Non-gun homicide			
Waiting period	−0.016 (0.051)	−0.048 (0.060)	−0.035 (0.037)
Background check		0.153 (0.076)**	0.036 (0.057)
All suicide			
Waiting period	−0.047 (0.021)**	−0.070 (0.023)***	−0.024 (0.011)**
Background check		0.113 (0.061)*	0.023 (0.020)
Gun suicide			
Waiting period	−0.097 (0.034)***	−0.120 (0.031)***	−0.074 (0.017)***
Background check		0.111 (0.073)	0.029 (0.028)
Non-gun suicide			
Waiting period	−0.017 (0.038)	−0.058 (0.059)	−0.006 (0.033)
Background check		0.199 (0.072)***	0.084 (0.031)**

Coefficients represent the effects of waiting periods and background checks on the natural logarithm of deaths per 100,000 adult residents. All models include state and year fixed effects. Models 1–2 include only the policy variables shown. Model 3 follows the specification of Ludwig and Cook (8) and includes alcohol consumption, poverty, income, urbanization, black population, and seven age groups. Model 3 uses fewer years of data due to missing control variables in earlier years. Summary statistics for all variables are included in Table S1. The 1970–2014 period includes 2,295 state-year observations; the model for gun homicides omits three state-years, and the model for non-gun homicides omits two state years because the death count was zero and the model is specified with a logged dependent variable. Similarly, the 1977–2014 period includes 1,938 state-years, but omits two state-years for gun homicides and one state-year for non-gun homicides. SEs, shown in parentheses, are clustered by state. Alternative model specifications presented in Tables S7 and S8 are not logged and include all state-years. *$P < 0.10$; **$P < 0.05$; ***$P < 0.01$.

present models with state-specific trends, models linear in the rate of violence, and Poisson models as part of Tables S3 and S5. The conclusion that waiting periods reduce gun homicides is robust across all specifications. The conclusion regarding suicides is robust to all specifications except those that include state-specific, linear trends (Table S3). Both conclusions are robust across models with and without controls for state-level economic and demographic changes. We also investigate the robustness of the results to the exclusion of individual states in Fig. S1.

To further support the hypothesis that waiting periods lead to a reduction in gun homicides, we then focus on a natural experiment created by the Brady Act, a federal law that forced some states to adopt new waiting period and background check policies between 1994 and 1998. Ludwig and Cook (8) also use the Brady Act to study whether background checks and waiting periods affect violence. They compare "Brady states" that were subject to the Brady Act with "Brady-exempt states" that were not. However, some states that were classified as Brady states already had waiting periods and background checks before the Brady Act, and other states chose to implement an "instant" background check system instead of requiring a waiting period. As a result, the coding of Brady states in the study by Ludwig and Cook (8) fails to capture all states that had preexisting waiting periods. In contrast, we precisely code which states had waiting periods (before 1994) and which implemented waiting periods only because of the Brady Act. In total, our coding differs from theirs for 16 states. This additional accuracy allows us to assess the causal impact of waiting periods resulting from the Brady Act. The full list of differences between our coding and prior research, along with supporting citations, can be found in Table S4.

We find that waiting periods led to large and statistically significant reductions in gun violence (Table 2) during the Brady interim period. Specifically, the results of column 3 of Table 2 show that waiting periods implemented during the Brady interim years resulted in a 17% reduction in gun homicides. This is equivalent to roughly 39 fewer homicides per year for the average state. There was also a 6% reduction in gun suicides (i.e., 17 fewer suicides per year for the average state). Both results are robust across models with and without controls for state-level economic and demographic changes. Notably, exploiting the Brady Act as a natural experiment produces similar estimates as the longer sample period from 1970 to 2014.

Tables 1 and 2 also show that waiting periods have no significant effect on non-gun homicides, suggesting that people subject to waiting period laws do not substitute other means of committing homicide. This is consistent with other research (9) finding no increase in non-gun homicides in response to policies restricting access to firearms. Results for non-gun suicides, however, are less clear; some specifications suggest partial substitution toward non-gun methods of suicide in response to handgun waiting periods.

Discussion

Our results show that waiting periods reduce gun homicides. Waiting periods for gun purchases are supported not only by the American Medical Association but also by a majority of Americans and a majority of gun owners (10, 11). Our point estimates, based on 45 y of data, suggest that the 17 states (including the District of Columbia) with waiting periods as of 2014 avoid ∼750 gun homicides. Expanding the waiting period policy to states that do not currently have it would prevent an additional 910 gun homicides per year. Waiting periods would therefore reduce gun violence without imposing any restrictions on who can own a gun.

Materials and Methods

Our main specifications are of the form:

$$r_{it} = \alpha_i + \lambda_t + \beta W_{it} + \gamma B_{it} + \delta' X_{it} + \epsilon_{it},$$

where r_{it} is the natural logarithm of the rate of violence (homicides or suicides) per 100,000 adult residents, W_{it} is an indicator for handgun waiting periods and B_{it} is an indicator for whether background checks are required for dealer handgun sales. We include an indicator variable for background checks on handgun purchases from licensed firearm dealers because a major source of policy variation in our dataset (the Brady Act) also affected

Table 2. Effects of handgun waiting periods and background checks on violence, 1990–1998

	Brady period, 1990–1998		
Type of violence	(1)	(2)	(3)
All homicide			
Waiting period	−0.073 (0.084)	−0.130 (0.077)*	−0.145 (0.060)**
Background check		0.091 (0.064)	0.010 (0.053)
Gun homicide			
Waiting period	−0.103 (0.093)	−0.179 (0.087)**	−0.181 (0.068)**
Background check		0.120 (0.080)	0.033 (0.065)
Non-gun homicide			
Waiting period	−0.019 (0.068)	−0.035 (0.064)	−0.072 (0.050)
Background check		0.025 (0.044)	−0.043 (0.039)
All suicide			
Waiting period	−0.016 (0.021)	−0.022 (0.023)	−0.036 (0.020)*
Background check		0.009 (0.022)	−0.007 (0.019)
Gun suicide			
Waiting period	−0.039 (0.024)	−0.053 (0.028)*	−0.066 (0.021)***
Background check		0.023 (0.028)	−0.003 (0.024)
Non-gun suicide			
Waiting period	0.050 (0.021)**	0.035 (0.022)	0.018 (0.022)
Background check		0.024 (0.023)	0.009 (0.018)

Coefficients represent the effects of waiting periods and background checks on the natural logarithm of deaths per 100,000 adult residents. All models include state and year fixed effects. Models 1–2 include only the policy variables shown. Model 3 follows the specification of Ludwig and Cook (8) and includes alcohol consumption, poverty, income, urbanization, black population, and seven age groups. Summary statistics for all variables are included in Table S2. The sample includes 459 state-year observations for all models. SEs, shown in parentheses, are clustered by state. *$P < 0.10$; **$P < 0.05$; ***$P < 0.01$.

background check policies. As seen in Tables 1 and 2, the estimated impact of background checks depends on model specification. We also incorporate time-varying state-level control variables that may influence rates of gun violence (8), X_{it}, including alcohol consumption, poverty, income, urbanization, black population, and seven age groups. Summary statistics for these variables are included in Tables S1 and S2. The α_i and λ_t parameters represent state and year fixed effects. These fixed effects control for stable, state-specific factors affecting violence and time-varying factors that affect all states identically. It is impossible to control for all time-varying, state-specific factors that affect gun violence. For example, policing tactics, drug use, and environmental factors such as lead exposure might not have changed uniformly across states over time and may also affect violence. However, the consistency between our estimates during the short (Brady interim) period and the longer period (including all waiting period changes since 1970) supports our interpretation of the results. The model parameters are estimated via least squares weighted by state population. We then calculate the percentage effect of waiting periods on violence using the estimator described by Kennedy (12).

We code a state as having a waiting period if it imposes any mandatory delay on the purchase of a handgun or has a permitting system for dealer and private sales. (In Table S5, we estimate models with a separate control variable for handgun permit systems and show that the effect of waiting periods is not limited to states with permitting systems.) Currently, 10 states and the District of Columbia impose an explicit waiting period on handgun sales, and an additional five states have permitting systems for private and dealer sales that result in a delay of firearm purchases. Forty-four states have had a handgun waiting period at some point since 1970, although 19 implemented the policy only due to the Brady Act's interim provisions, in effect from February 1994 to November 1998. These provisions required local law enforcement agencies to conduct background checks on handgun purchases from licensed firearm dealers and required a 5-d waiting period to conduct the check. Some states already required background checks and/or waiting periods before the Brady Act, and were therefore not affected by the new law, but other states were forced to adopt a new waiting period due to the federal policy change. When the permanent provisions of the Brady Act took effect on November 30, 1998, the federal waiting period requirement was replaced with an instant background check system [the National Instant Criminal Background Check System (NICS)]. As a result, many states discarded their waiting periods after 1998 because the NICS eliminated the need for a waiting period to investigate purchasers' backgrounds. We use the subset of waiting period changes that resulted from the Brady Act as a natural experiment to provide further support for our analysis of the full sample period from 1970 to 2014.

Although nine states have also had a waiting period on long-guns (i.e., rifles and shotguns) sometime since 1970, we focus on handgun waiting periods because handguns account for 70–80% of firearm homicides (13) and because a major source of variation in our data, the Brady Act's interim period, only affected handgun sales.

1. National Center for Health Statistics, Centers for Disease Control and Prevention (2015) About Compressed Mortality, 1999-2014. CDC WONDER Online Database. Available at wonder.cdc.gov/cmf-icd10.html. Accessed August 5, 2016.
2. Grinshteyn E, Hemenway D (2016) Violent death rates: The US compared with other high-income OECD countries, 2010. *Am J Med* 129:266–273.
3. Sacks CA (2015) In memory of Daniel–Reviving research to prevent gun violence. *N Engl J Med* 372:800–801.
4. Luca M, Malhotra D, Poliquin C (2017) The impact of mass shootings on gun policy. Harvard Business School NOM Unit Working Paper No. 16-126. Available at dx.doi.org/10.2139/ssrn.2776657. Accessed October 1, 2016.
5. Loewenstein G (1996) Out of control: Visceral influences on behavior. *Organ Behav Hum Decis Process* 65:272–292.
6. Loewenstein G, Lerner JS (2002) The role of affect in decision making. *Handbook of Affective Sciences*, eds Davidson RJ, Scherer KR, Goldsmith HH (Oxford Univ Press, Oxford), pp 619–642.
7. Card D, Dahl GB (2011) Family violence and football: The effect of unexpected emotional cues on violent behavior. *Q J Econ* 126:103–143.
8. Ludwig J, Cook PJ (2000) Homicide and suicide rates associated with implementation of the Brady Handgun Violence Prevention Act. *JAMA* 284:585–591.
9. Raissian KM (2016) Hold your fire: Did the 1996 Federal Gun Control Act expansion reduce domestic homicides? *J Policy Anal Manage* 35:67–93.
10. American Medical Association (2016) AMA Expands Policy on Background Checks, Waiting Periods for Gun Buyers. Available at https://perma.cc/CNE4-FEQ9. Accessed October 28, 2016.
11. Sides J (December 23, 2012) Gun owners vs. the NRA: What the polling shows. Washington Post, Wonkblog. Available at https://perma.cc/HCC9-4DY5. Accessed October 28, 2016.
12. Kennedy P (1981) Estimation with correctly interpreted dummy variables in semi-logarithmic equations. *Am Econ Rev* 71:801.
13. Planty M, Truman J (2013) Firearm Violence, 1993-2011 (US Department of Justice, Washington, DC), NCJ 241730. Available at https://www.bjs.gov/index.cfm?iid=4616&ty=pbdetail. Accessed October 18, 2016.
14. Wolfers J (2006) Did unilateral divorce laws raise divorce rates? A reconciliation and new results. *Am Econ Rev* 96:1802–1820.
15. Webster D, Crifasi CK, Vernick JS (2014) Effects of the repeal of Missouri's handgun purchaser licensing law on homicides. *J Urban Health* 91:293–302.
16. Rudolph KE, Stuart EA, Vernick JS, Webster DW (2015) Association between Connecticut's permit-to-purchase handgun law and homicides. *Am J Public Health* 105: e49–e54.
17. Lott JR, Jr, Mustard DB (1997) Crime, deterrence, and right-to-carry concealed handguns. *J Legal Stud* 26:1–68.
18. Ludwig J (1998) Concealed-gun-carrying laws and violent crime: Evidence from state panel data. *Int Rev Law Econ* 18:239–254.
19. Ayres I, Donohue JJ, III (2002) Shooting down the 'more guns, less crime' hypothesis. *Stanford Law Rev* 55:1193–1312.
20. Manski CF, Pepper JV (2017) How do right-to-carry laws affect crime rates? Coping with ambiguity using bounded-variation assumptions. *Rev Econ Stat*, 10.1162/REST_a_00689.
21. Solon G, Haider SJ, Wooldridge JM (2015) What are we weighting for? *J Hum Resour* 50:301–316.
22. Federal Register 59 (1994). Available at https://www.gpo.gov/fdsys/pkg/FR-1994-07-22/html/94-17819.htm. Accessed June 29, 2016.
23. Manson DA, Gilliard DK, Lauver G (1999) Presale Handgun Checks, the Brady Interim Period, 1994-98 (US Department of Justice Bureau of Justice Statistics Bulletin, Washington, DC), NCJ 175034. Available at https://www.bjs.gov/content/pub/pdf/phc98.pdf. Accessed June 29, 2016.
24. Vernick J, Hepburn L (2003) State and federal gun laws. *Evaluating Gun Policy: Effects on Crime and Violence*, eds Ludwig J, Cook PJ (The Brookings Institution, Washington, DC), pp 345–402.
25. U.S. Department of Justice Bureau of Justice Statistics (1996) Survey of State Procedures Related to Firearm Sales (US Department of Justice Bureau of Justice Statistics Bulletin, Washington, DC), NCJ 160763. Available at https://www.bjs.gov/index.cfm?ty=pbdetail&iid=1067. Accessed August 2, 2014.
26. Carroll CA, Jr (January 27, 1994) South Carolina Executive order no. 94-03. Available at hdl.handle.net/10827/1350. Accessed June 14, 2017.