Abstract

Introduction: Firearm injury is a leading cause of death among Americans. As the right to bear arms is protected by the Second Amendment, policy-makers must consider the impact of legislation on both firearm ownership and firearm harms. Current state of knowledge in firearm research majorly examines the impact of firearm legislation on firearm injuries and fatalities alone, and it relies on correlational analyses. The few studies that consider causal effects employ counterfactual-based inference. This study introduces information-theoretic tools to explore the role of firearm laws in mitigating firearm harms while maintaining citizens' right to bear arms.

Methods: We study monthly time series from January 2000 to October 2019 for the implementation of firearm laws from RAND's State Firearm Law Database, firearm deaths by intent from the Centers for Disease Control and Prevention databases, and firearm ownership from an econometric model. We employ transfer entropy, an information-theoretic method that relies on Granger causality, to infer relationships from time series. Specifically, we examine transfer entropy from firearm restrictiveness to deaths per firearm owner, firearm ownership, and firearm deaths, independently.

Results: On a national level, we uncover a negative association from firearm restrictiveness to deaths per firearm owner and a positive association from firearm restrictiveness to firearm ownership. On a regional level, we identify a negative association from firearm restrictiveness to deaths per firearm owner in the Northeast, a negative association from firearm restrictiveness to firearm ownership in the Midwest, and a negative association from firearm restrictiveness to firearm suicides in the South.

Conclusions: We present an information-theoretic approach to study relationships in firearm research. Our method provides preliminary evidence for the role of restrictive legislation in promoting safe firearm ownership. We find that firearm acquisition considerably increases following the implementation of restrictive firearm laws and, simultaneously, firearm deaths decrease. These effects vary with respect to death by intent and the geographical region laws were implemented in.

Keywords: Causal inference, Firearm laws, Firearm violence, Information theory, Transfer entropy.

Introduction

Firearm violence is a major public health issue in the United States (US), where rates of firearm injury are among the highest in the world and steadily increasing.[1] In 2020, more than 45,000 Americans died by firearms, averaging 123 deaths per day and surmounting the number of deaths due to motor vehicle crashes.[2] Although official data on mortality in 2022 are yet to be released, provisional estimates suggest that this figure climbed to 48,000 and an average of 132 fatalities per day.[3] These grim statistics are tightly connected to firearm ubiquity, whereby literature consistently correlated firearms accessibility with firearm harms.[4, 5, 6, 7, 8] Government authorities often act to regulate harmful agents, yet, there is no consistent approach to firearm regulation among US states. This may stem from the fact that firearms play a defining role in American culture and identity,[9] so that many Americans continue to bear arms.[10] Thus, in order to reconcile citizens' desire to bear arms with the eminent need to mitigate risks of firearm injury, policymakers must identify legislative interventions that minimize harms without limiting firearm acquisition.

While numerous studies provide insights into the potential of firearm legislation in reducing firearm harms, they largely rely on correlational analyses and only a few employ counterfactual-based causal inference methods,[11, 12, 13, 14, 15, 16, 17, 18, 19, 20] likely due to lack of federal funding and unavailability of data on firearm ownership and harms.[21, 22, 23] Causal inference with counterfactuals is limited in the study of state firearm legislation and presently cannot provide definitive evidence for the effectiveness of firearm laws.[24, 25, 26] In particular, counterfactual approaches require the identification or design of appropriate untreated units to compare against. In many instances, control units would encompass vastly different characteristics in terms of demographics, culture, and political ideology such that a comparison may not be appropriate, even with covariate adjustment.[24] Furthermore, since all US states have implemented a firearm law of some kind, the extent to which some states should be consider "treated" against others is difficult to assess. In this context, information theory emerges as a powerful means to complement counterfactual-based methods in the inference of associations from time series. At the heart of information theory lies the notion of entropy, which quantifies uncertainty with respect to a measurement.[27, 28] Transfer entropy quantifies temporal associations in a Granger sense as reduction in the uncertainty of predicting the future state of a process from its present, given additional knowledge about the present or past of another process.[29] Although model-free inference of temporal associations based on transfer entropy has some limitations (including sensitivity to unmeasured variables),[30] it does not require the identification of untreated units and therefore overcomes some shortcomings of counterfactual-based inference in firearm research.

In the present study, we employ transfer entropy to explore the effects of permissive and restrictive firearm legislation on firearm ownership and firearm harms, simultaneously. In a country with inhabitants who revere the right to bear arms, effective and widely adopted firearm legislation must consider its influence on both outcomes. To this end, we combine the measures of firearm deaths and firearm ownership into a quantity called “deaths per firearm owner” to capture the safety of owning a firearm. We test three hypotheses in three independent analyses, considering all firearm law classes. First, we test the hypothesis that deaths per firearm owner will improve upon the implementation of restrictive laws and compromised upon the implementation of permissive laws. This analysis is motivated by a multitude of studies that hint at such effects.[31, 32, 33, 34, 35, 36, 37] The second hypothesis addresses the intent of injury (accidents versus homicides versus suicides). Laws often target aspects of regulation that are relevant for one intent of injury and not another.[20, 35, 38, 39] Therefore, we hypothesize that restrictive (permissive) firearm laws will influence firearm accidents, homicides, and suicides differently. Our third hypothesis examines the two elements that define “deaths per firearm owner”: firearm violence and firearm ownership. In agreement with the first hypothesis, we expect that restrictive (permissive) legislation will reduce (increase) firearm violence. At the same time, based on findings that media coverage of firearm legislation leads to surges in firearm acquisition,[40, 41, 42] we anticipate that firearm ownership will not be negatively affected by legislation.

Data on firearm deaths and firearm ownership are available on a state level. However, state firearm laws are not implemented with sufficient frequency that would support statistically robust transfer entropy analysis. Therefore, we study the three aforementioned hypotheses on a national level, as well as in each US region. We hypothesize that results would vary among regions due to differences in culture, demographics, and political orientation.

Methods

Study Sample

To test the hypotheses put forth, we collected data on three variables: firearm laws, firearm deaths, and firearm ownership. Data were collected for each month between January 2000 and October 2019. Since data on firearm ownership were missing for Alaska, Hawaii, and District of Columbia, these states were excluded from the study.

Data on firearm laws were obtained from RAND's State Firearm Law Database.[43, 44] This database contains information about firearm-related laws, including the US states they were passed in, the dates they became effective, and a summary of their content. Importantly, the database systematically categorizes each law into one of 20 different law classes and denotes its overall effect (permissive or restrictive), based on the legal regime they impart relative to the one prior to their implementation.[44] A law that eases access to and use of firearms is considered permissive, whereas a law that curtails access to and use of firearms is categorized as restrictive. Within the time period under consideration, the database contains law changes from all 20 law classes, including 30 actions related to stand-your-ground laws (all of which are considered permissive), five actions related to child access (all of which are restrictive), and 43 actions related to background checks (38 restrictive new implementations or modifications, four permissive repeals, and one permissive modification).

Data on firearm deaths were collected from the Centers for Disease Control and Prevention (CDC) WONDER database.[2] WONDER reports death rates of US residents based on their death certificates. In particular, the database allows to subset death rates based on injury intent ("Homicide", "Suicide", or "Unintentional") and mechanism ("Firearm" or otherwise). For each intent, we grouped the results by state, year, and month and obtained a monthly time series. In addition, we created a time series of firearm deaths by summing the three injury intents.

Data on firearm ownership were based on measurements from a spatio-temporal econometric model.[42] This model estimates the monthly fraction of firearm owners out of the population by integrating two cogent proxies, background checks per capita and fraction of suicides committed with a firearm, and calibrating on yearly survey data that assess the fraction of the population that can access a firearm in their home or property. Unlike other proxies, this model accounts for geographic spillover effects whereby firearms move across state borders and incorporates temporal autoregression. We also estimated number of firearm owners in a given US state and month by multiplying the model's output by the state's population size in the same year (taken from the US Census Bureau[45]). Such an estimate is not exact as it maps one owner to one firearm.

For all three variables, we generated time series on state level. State level time series were then aggregated following the US Census Bureau designations[46] to obtain time series for each variable in each region (Supporting Information S1).

Measures

From the data we collected, we generated two additional time series: firearm restrictiveness and deaths per firearm owner. For firearm restrictiveness, we created a continuous monthly time series that contained the cumulative number of permissive legislative actions that were implemented since January 1, 2000, subtracted from the cumulative number of restrictive legislative actions in the same period. Since each implemented law impacts a fraction of the nation, we scaled each by the fraction of the population affected by the law out of the entire US population.

For deaths per firearm owner, we divided firearm deaths by firearm ownership. In order to evaluate the influence of firearm restrictiveness on firearm death by intent, we also generated time series for each injury intent: accidents per firearm owner, homicides per firearm owner, and suicides per firearm owner. Deaths caused by legal interventions or undetermined causes were not included in those counts.

Finally, to study interactions on a regional level, we generated time series of firearm restrictiveness, firearm deaths, firearm ownership, and deaths per firearm owner, for each of the four US regions: Northeast, Midwest, South, and West (Supporting Information S1).

Transfer entropy analysis

We performed three analyses with transfer entropy on a national level (Supporting Information S2). To test our first hypothesis, we computed transfer entropy from firearm restrictiveness to deaths per firearm owner. In Supporting Information S3, we tested alternative measures of deaths per firearm owner where popular measures of firearm prevalence are used. To test our second hypothesis, we computed transfer entropy from firearm restrictiveness to accidents per firearm owner, homicides per firearm owner, and suicides per firearm owner. To test our third hypothesis, we computed transfer entropy independently from firearm restrictiveness to firearm ownership, firearm deaths, firearm accidents, firearm homicides, and firearm suicides. In total, transfer entropy was computed for nine relationships on a national level. All relationships were evaluated with delays ranging from zero to eleven months. To account for multiple comparisons in the delay analysis, levels of significance were corrected via false discovery rate.[47] The Results herein summarize transfer entropy values that remained statistically significant after this correction, although we highlight that the absence of a statistically significant effect does not imply that an association does not exist. To explore the possibility of reverse causal effects from outcomes to firearm restrictiveness, in Supplementary Information S5, we performed an equivalent transfer entropy analysis where firearm restrictiveness is the target variable and deaths per firearm owner, firearm ownership, and firearm deaths are the source variables.

To pinpoint trends on a regional level, we selected the delay associated with the largest amount of transfer entropy on a national level and performed transfer entropy analysis in each of the four regions. We computed transfer entropy from firearm restrictiveness to deaths per firearm owner, firearm ownership, and firearm suicides.

Data analysis was performed between May 2023 and February 2024. All analyses were performed in MATLAB (MATLAB R2022b, The MathWorks, Inc., Natick, Massachusetts, United States) with a significance level $\alpha = 0.05$ ($\alpha = 0.10$ was used for assessing trends).

Results

Study sample and measures

On a national level, a total of 318 “non-redundant” laws were recorded, 222 restrictive and 96 permissive (Figure 1a). The time series of firearm deaths was majorly composed of firearm homicides and suicides, rather than firearm accidents (Figure 1b). In the specified time period, 11,844 accidents, 239,753 homicides, and 385,651 suicides were recorded, totalling 637,248 deaths by firearms. The time series of firearm ownership showed that the number of firearm owners in the US ranged from 54.7 million to 209 million (Figure 1c). Processed time series (firearm restrictiveness and deaths per firearm owner) were constructed. Firearm restrictiveness consisted of 127 changes and generally increased over time (Figure 1d). Deaths per firearm owner were predominantly driven by suicides, followed by homicides and accidents (Figure 1e). Regional time series are presented in Supporting Information S1.

Influence of firearm restrictiveness on deaths per firearm

Transfer entropy from firearm restrictiveness to deaths per firearm owner revealed negative associations for delays of zero, one, two, and three months (TE=0.031, 0.022, 0.033, and 0.038 bits and ρ=−0.239, −0.271, −0.371, and −0.271, respectively;

Figure 2a). Transfer entropy was significantly different from zero for delays of zero, two, and three months (p=0.007, 0.005, and 0.003, respectively), and marginally different from zero for delay of one month (p=0.030). The values of transfer entropy, p-values of permutation tests, and partial correlation coefficients for the remaining delays are reported in Supporting Information S3.

Influence of firearm restrictiveness on accidents, homicides, and suicides per firearm owner

Results for transfer entropy from firearm restrictiveness to the disaggregated forms of deaths per firearm owner are reported in Figures 2b-d and Table S3. Transfer entropy to accidents per firearm owner revealed a negative association with a delay of zero months that is significantly different from zero (TE=0.034 bits, p=0.004, and ρ=−0.211). When considering homicides per firearm owner, three negative associations emerged for delays of one, two, and three months (TE=0.026, 0.029, and 0.039 bits, and ρ=−0.268, −0.358, and −0.249, respectively). Transfer entropy was significantly different from zero for a delay of three months (p=0.002) and marginally different from zero for delays of one and two months (p=0.015 and 0.010, respectively). Transfer entropy to suicides per firearm owner also yielded three negative associations, for delays of zero, two, and three months (TE=0.027, 0.039, and 0.032 bits and ρ=−0.222, −0.352, and −0.265, respectively). It was marginally different from zero for a delay of one month (p=0.013), and significantly different from zero for delays of two and three months (p=0.002 and 0.006, respectively).

Influence of firearm restrictiveness on firearm ownership and firearm deaths

Results for transfer entropy from firearm restrictiveness to individual components of deaths per firearm owner are reported in Figure 2e-i and Table S4. Transfer entropy to firearm ownership unveiled three positive associations for delays of zero, one, and three months, all significantly different from zero (TE=0.040, 0.031, and 0.028 bits, p=0.001, 0.006, and 0.011, and ρ=0.198, 0.244, and 0.229, respectively). Transfer entropy to firearm deaths, firearm accidents, and firearm homicides did not reveal any associations, positive or negative. Instead, transfer entropy to firearm suicides yielded negative associations marginally different from zero for delays of two, four, and five months (TE=0.024, 0.029, and 0.036 bits, p=0.022, 0.012, and 0.004, and ρ=−0.004, −0.047 and −0.099, respectively).

Influence of firearm restrictiveness on a regional level

Results for regional analyses are reported in Figure 3. Transfer entropy from firearm restrictiveness to deaths per firearm owner was computed with a delay of three months. It uncovered a negative association in the Northeast that is marginally different from zero (TE=0.015 bits, p=0.085, and ρ=−0.084). Transfer entropy from firearm restrictiveness to firearm ownership was computed with a delay of zero months and revealed a negative association in the Midwest that is significantly different from zero (TE=0.020 bits, p=0.038, and ρ=−0.128). Lastly, since no associations were detected for transfer entropy from firearm restrictiveness to firearm deaths but three were found to firearm suicides, we computed the latter in each region for a delay of five months. A negative association that is significantly different from zero was uncovered in the South (TE=0.023 bits, p=0.028, and ρ=−0.052).

Discussion

Herein, we introduce an information-theoretic approach to study the influence of firearm legislation on firearm ownership and firearm harms, simultaneously. We sought to elucidate whether a restrictive (permissive) legal landscape would reduce (increase) the safety of owning a firearm, quantified as the number of deaths per firearm owner. In agreement with our prediction, we found that restrictive firearm laws lead to a safer environment with lower deaths per firearm owner. The effect was observed immediately and lasted for three additional months. This finding supports the conclusions of several studies in literature[31, 34, 38, 39, 48, 49] and is the first to demonstrate the role of restrictive legislation in reducing firearm harms systematically, across law classes and US states. Notwithstanding, our result was further digested to draw additional conclusions.

In contrast to our expectations, we found that accidents, homicides, and suicides per firearm owner all decreased in an increasingly restrictive firearm environment, albeit to different extents. While the effect on firearm homicides and suicides lasted for four months, the effect on accidents lasted for one month only. It is tenable that certain classes of firearm laws address firearm deaths by intent differently.[20, 38, 35, 39] For example, Crifasi et al.[38] stipulated that the effects of comprehensive background checks, permit-to-purchase, right-to-carry, and stand-your-ground laws impact firearm homicide, but not suicides and accidents. It can be argued that certain law classes impact firearm accidents in the shorter term only,[39] however, research on the circumstances that lead to such disparate effects is required.

In subsequent assessment of the influence of firearm restrictiveness on firearm ownership, we found a positive association where restrictive laws lead to greater rates of firearm ownership. The effect was observed immediately and lasted for the three succeeding months. This finding is consistent with existing literature related to “Panic-Buying”, a well-documented phenomenon where crowds anticipate future scarcity of a product and buy unusually large amounts of it. It has been previously proposed that firearm regulation prompts firearm and ammunition sales among newly ineligible persons.[40, 41] In fact, panic-buying of firearms was recorded in 2008 following the election of President Barack Obama, whose political agenda advocated for stricter firearm laws.[50] Similar surges were observed in 2013 in New Jersey following Governor Christie’s proposal to expand background checks, and in Maryland following the ban of semiautomatic rifles.[50] Thus, there is mounting evidence for panic-buying of firearms.

Upon examination of the influence of firearm restrictiveness on firearm deaths, we discovered that firearm laws impact death rates differentially. We expected an effect parallel to the one observed in firearm ownership, yet restrictive firearm laws did drive down firearm deaths. When disaggregated by intent, only firearm suicides were impacted by the legal environment. This result suggests that the observed influence of firearm laws on firearm safety is largely driven by increasing the prevalence of firearms, and to a lesser extent by decreasing firearm suicides. We also explored the possibility of reverse causal effects where firearm restrictiveness is influenced by the outcomes. We discovered a negative association between deaths per firearm owner and firearm restrictiveness. When we disaggregated the measure of deaths per firearm owner into its components, we found that this relationship is driven by a positive association between firearm ownership and firearm restrictiveness. This finding further supports the notion of panic-buying preceding the implementation of restrictive firearm laws.

In addition to analyses on a national level, we investigated the effects of regional legal environments on firearm safety, firearm ownership, and firearm deaths. Only in the Northeast did legislation impact deaths per firearm owner, following the national pattern. This finding could be explained by regional legal landscapes. In the Northeast, 65 firearm-related laws were passed with only six of them being permissive, corresponding to 9.23% of the laws. When comparing this figure with 20.69% in the West, 38.46% in the South, and 49.33% in the Midwest, a pattern emerges where the more restrictive laws are passed, the safer citizens are. Further, only in the Midwest did the implementation of restrictive laws reduce firearm ownership, contrary to the trend found on a national level. It is plausible that citizens in the Midwest were unaware of the restrictive laws passed[51] or that they did not perceive them as strict.[52] Research on citizens' interpretation of individual firearm laws and their perception of threat on their ability to bear arms could shed light on this finding. Finally, upon examination of the influence of firearm restrictiveness on firearm suicides, only the South exhibited a negative response. Since no influence was observed on a national level, it is possible that the large proportion of deaths in this region (twice as in the Midwest and West and three times as in the Northeast) dominated the analysis on a national level.

Limitations

This study is among the first to examine the role of firearm legislation on firearm harms in conjunction with firearm ownership. In a country where the right to bear arms is enshrined in its constitution, it is crucial to understand the influence of firearm legislation on both outcomes toward the formulation of agreeable policies. Nonetheless, our study is not free of limitations. First, the international collaboration within this study prevents the use of the National Center for Health Statistics' restricted data such that mortality counts below ten are suppressed. Moreover, we consider only firearm deaths as a measure of firearm harms, although rates of firearm injuries are substantially greater than those of firearm fatalities.[53, 54] Firearm injuries also pose non-negligible costs to the American economy, estimated at 557 billion dollars annually.[3, 54, 55, 56] For complete assessment of firearm harms, one could analyze data on firearm injuries, made available through the CDC WISQARS database.[57] However, WISQARS does not return results on state and month resolutions, thereby limiting data-driven methodologies. Moreover, firearm injuries are usually under-reported[58, 59] and the intent of injury is difficult to determine due to the illicit nature of firearm violence.[60, 61] Thus, inclusion of firearm injuries in quantitative analyses remains a challenge.

Another limitation relates to the granularity of our analyses and their implication for state legislation. We conducted tests on national and regional levels, which do not inform on the effects of firearm laws in individual state, nor could they elucidate the intricate roles of state demographics and culture. Geographical disparities likely stem from differences in laws, urban, demographics, economics, and culture in the US regions and states.[6, 56, 62, 63] However, approaches that infer causality based on information theory or dynamical systems require rich time series with variation and the majority of states have implemented only a few firearm-related laws.[44] Consequently, these methods are become non-viable on a state level. Ultimately, firearm research presents a need for methodological advances in causal inference methods that can address single point interventions while systematically accounting for multiple treatments with potentially identical outcomes that may be taking place (nearly) simultaneously.

Conclusions

We present evidence for the role of restrictive legislation in promoting safe firearm ownership. Within an information-theoretic framework, we demonstrate that following the implementation of restrictive firearm laws, firearm acquisition rates considerably increase and at the same time firearm deaths nominally reduce. The effects vary with respect to death by intent and geographical locality. The results provide a first understanding of how firearm laws might impact firearm harms and ownership simultaneously. This study should be expanded upon with granular analyses to provide insights into the roles of demographics, socioeconomics, and culture to inform effective legislation that minimizes firearm harms while allowing law-abiding citizens bear arms.

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Author Contributions

Conceptualization— Conceptualization— RBV, JM, MP; methodology— RBV, MRM, MP; software— RBV, MRM, MP; validation— RBV, MRM, MP; formal analysis— RBV, MRM, MP; investigation— RBV, MRM, MP; resources— MP; data curation— RBV; writing— original draft preparation— RBV; writing—review and editing— RBV, JM, MRM, MP; visualization— RBV; supervision— MP; project administration— RBV, MP; funding acquisition— RBV, JM, MRM, MP.

Data sharing statement

All data and codes needed to evaluate the conclusions in the paper are available on Github.

Financial conflicts statement

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Figures and captions

Figure 1. Analysis of national times series in this study.

(a) Stacked number of restrictive (red) and permissive (blue) firearm laws. (b) Number of firearm deaths (solid), disaggregated by intent into accidents (dashed), homicides (dotted), and suicides (dash-dotted). (c) Firearm ownership, reflecting the number of firearms in the entire country. (d) Firearm restrictiveness. (e) Deaths per firearm (solid), divided by intent into accidents (dashed), homicides (dotted), and suicides (dash-dotted). (f) Illustration of transfer entropy from Y to X. Should Y help predict X continuously throughout the time series, the relationship between the two variables will be deemed causal.

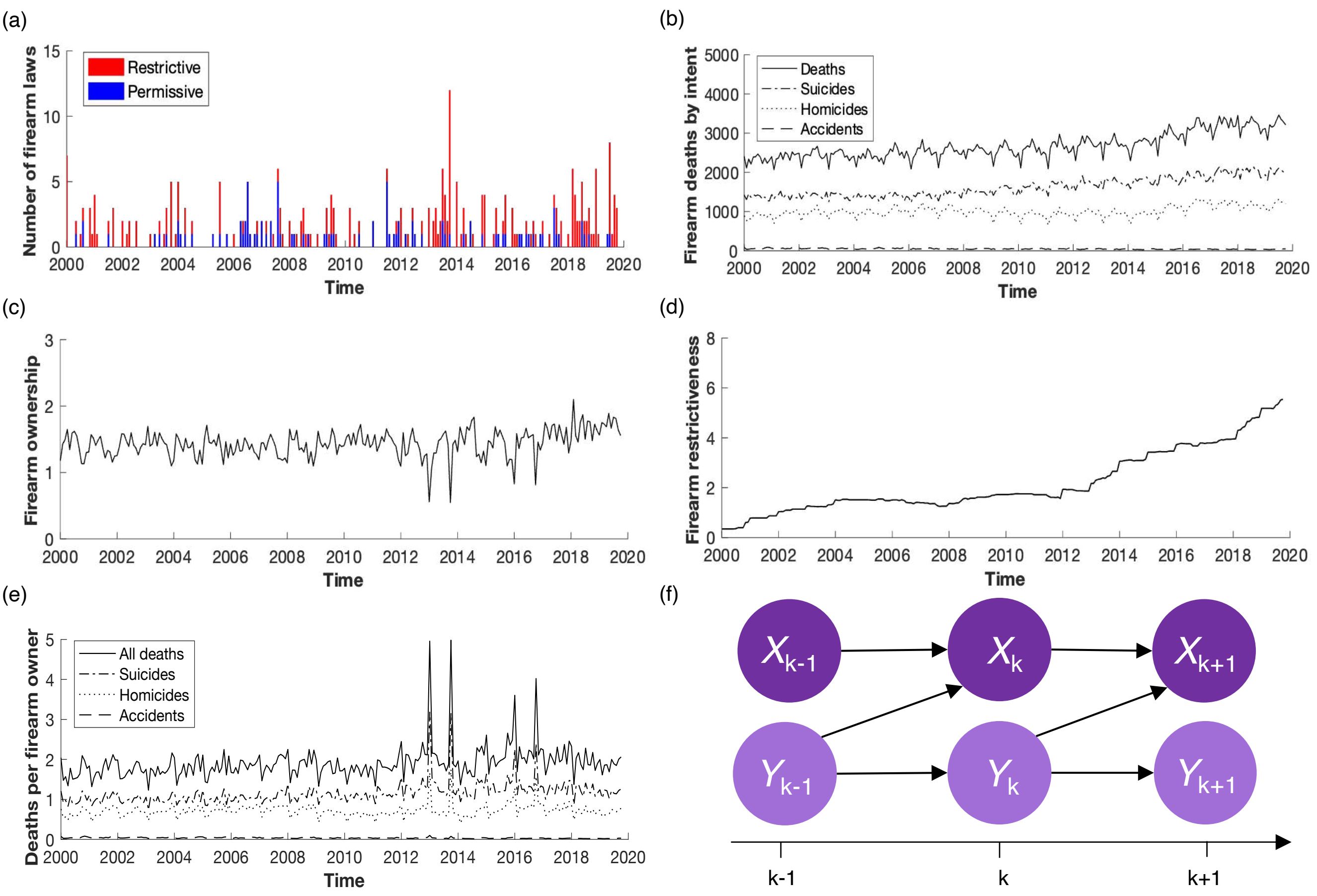
Figure 2. Addressing the three hypotheses on a national level.

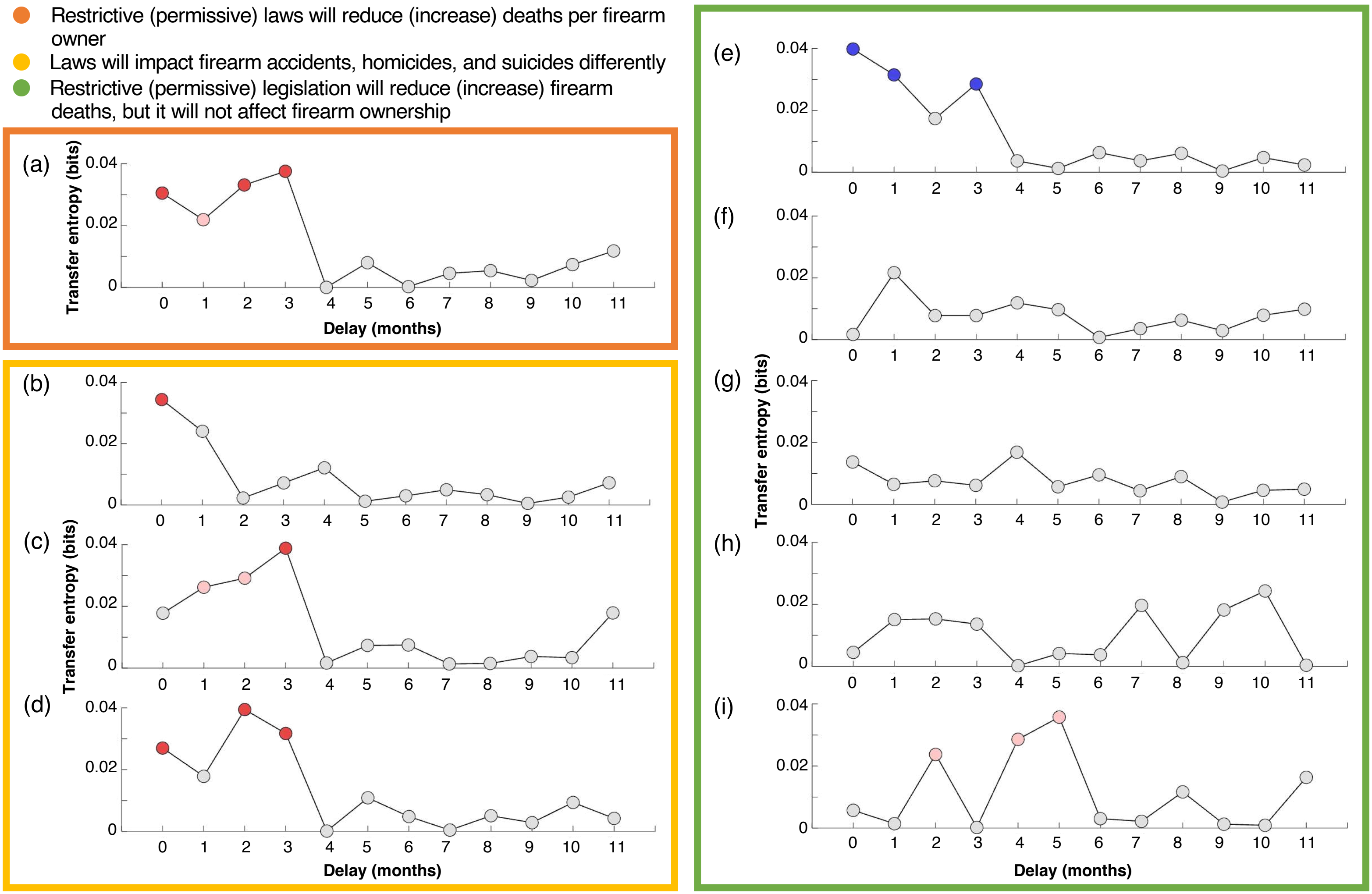
In the orange frame, the first hypothesis is tested by computing transfer entropy from firearm restrictiveness to deaths per firearm (a). In the yellow frame, the second hypothesis is tested by computing transfer entropy from firearm restrictiveness to accidents per firearm (b), homicides per firearm (c), and suicides per firearm (d). In the green frame, the third hypothesis is tested by computing transfer entropy from firearm restrictiveness to firearm ownership (e), firearm deaths (f), firearm accidents (g), firearm homicides (h), and firearm suicides (i). Grey circles indicate that transfer entropy was not significantly different from zero in permutation tests. Red and pink circles indicate a negative association that is different from zero with a significance level of $\alpha = 0.05$ and $\alpha = 0.1$, respectively. Blue circles indicate a positive association that is different from zero with a significance level of $\alpha = 0.05$

Figure 3. Results for analyses on a regional level.

Each row reports the amount of transfer entropy computed for the analysis list on the left. Transfer entropy from firearm restrictiveness to deaths per firearm (top row) was evaluated with a delay of three months, transfer entropy to firearm ownership (middle row) was evaluated with a delay of zero months, and transfer entropy to firearm suicides (bottom row) was evaluated with a delay of two months. Red and pink cells indicate a negative causal association that is different from zero with a significance level of $\alpha = 0.05$ and $\alpha = 0.1$, respectively.

Supporting information contents


(a)
Restrictive
Permissive
Number of firearm laws
15
10
5
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Time
(b)
Deaths
Suicides
Homicides
Accidents
Firearm deaths by intent
5000
4000
3000
2000
1000
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Time
(c)
Firearm ownership
3
2
1
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Time
(d)
Firearm restrictiveness
8
6
4
2
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Time
(e)
All deaths
Suicides
Homicides
Accidents
Deaths per firearm owner
5
4
3
2
1
0
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Time
(f)
X k-1
X k
X k+1
Y k-1
Y k
Y k+1
k-1
k
k+1



Restrictive (permissive) laws will reduce (increase) deaths per firearm owner
Laws will impact firearm accidents, homicides, and suicides differently
Restrictive (permissive) legislation will reduce (increase) firearm deaths, but it will not affect firearm ownership
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
Transfer entropy (bits)
Delay (months)
0.04
0.02
0
0 1 2 3 4 5 6 7 8 9 10 11

	Midwest	Northeast	South	West
Firearm restrictiveness → deaths per firearm owner	0.008	0.015	0.003	0.014
Firearm restrictiveness → firearm ownership	0.020	<0.001	0.005	0.009
Firearm restrictiveness → firearm suicides	<0.001	0.011	0.023	0.004