# Supplementary Materials for

## Firearms and accidental deaths: Evidence from the aftermath of the Sandy Hook school shooting

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Published 8 December 2017, *Science* **358**, 1324 (2017)
DOI: 10.1126/science.aan8179

**This PDF file includes:**

## Materials and Methods

### 1. Additional Information on Data

We use data from Google Trends in a preliminary analysis examining the impact of Sandy Hook on firearm exposure. Google Trends is a data source that enables one to track the frequency of search terms that users enter into Google. In our analysis, we consider the frequency of searches for the terms “clean gun” and “buy gun” in the United States. This index includes any searches that use those key words. For instance, the index for “clean gun” is not limited to searches for “clean gun”; it would also include searches such as “how to clean a gun” or “how often should I clean my gun?” For any particular search term, Google Trends provides an index over time of the relative frequency of that search. The periodicity of the results depends on the length of the period: one can track search data over weekly intervals across the span of up to five years. The index takes on the value of 100 in the period in which relative search frequency for that term was the highest over that interval. Index values for other periods represent the frequency of searches for that term relative to the peak period (i.e. a value of 50 indicates half the peak search frequency). In each period, search frequency for the terms of interest is indexed relative to overall search frequency. Thus, the index implicitly adjusts for overall trends in searching. These data are easily accessible at trends.google.com.

Much of our analysis relies on gun sales as a proxy for gun exposure and we use NICS background check data to proxy those sales. The Brady Handgun Violence Prevention Act, enacted in 1993, called for the system of background checks that are in place today. All sales of firearms completed through a licensed dealer require the buyer

to pass a background check, which examines the buyer's criminal record, history of mental illness, and residency status, among other characteristics. The act included the creation of an instant background check system (NICS), which was implemented in November of 1998. We use the publicly available data from this system to measure firearm sales, focusing on the period from 2008 through 2015. Use of these data as a proxy for gun sales is common in media reports and in the advocacy community. Background check counts are observed at the state and national level; we take advantage of both levels of aggregation.

These data possess certain limitations, which have been documented by other researchers (*11, 12, 13*). Briefly, background checks may understate gun sales because some sales are exempt from the background check requirement (e.g., gun show sales) and any individual background check may reference the sale of multiple firearms, among other reasons. One recent study estimates that that 22 percent of firearm sales occur without a background check (20). On the other hand, background checks may overstate firearm sales because an approved buyer may choose not to buy a weapon or because additional background checks are performed on concealed weapon permit holders who are not buying a new gun.

At a more basic level, data from some of the states possess idiosyncrasies that reflect simple flaws in the data. For instance, data from North Carolina exhibit ten-fold spikes in February and March of 2014 because the state required rechecks of all those who possessed concealed carry permits (*21*). Data from Kentucky, Utah, and the District of Columbia (DC) exhibit patterns that indicate similar flaws in the data. For our state-level analysis, we therefore drop these four states (including DC) from our analysis.

To be useful for our analysis, though, these data simply need to adequately capture the variation in firearm sales that takes place over time and, in some of our analysis, across locations. As long as the correlation between firearm sales and background checks is high, these data will meet our needs. As discussed in the text, these measures are highly correlated with other measures of firearm sales. Relative to other indicators of gun sales, background checks have the important advantage of being observed across states at monthly intervals.

In the text, we use population data to convert these sales levels to sales rates. Annual population data overall, by age group, and by state come from the Surveillance, Epidemiology, and End Results program at the National Cancer Institute. The data are available at https://seer.cancer.gov/popdata/. In all instances where population data is necessary to convert counts to rates, we use these data.

We use Vital Statistics mortality data between 2008 and 2015 for our analysis of the impact of gun exposure on the rate of deaths (per 100,000 population) by cause. These data represent every death that occurs in the United States along with the information contained on death certificates, including month of death, detailed cause of death, and demographic details of the deceased (age, sex, and race/ethnicity). We focus on firearms deaths that occurred as the result of accidents.

While there are other data sources, such as the Web-based Injury Statistics Query and Reporting System (WISQARS), that provide information on accidental firearm deaths, the Vital Statistics data have two particularly important features for our purposes. One is the ability to identify the month of death, rather than only the year of death. Since the five months of the post-Sandy Hook period spanned two calendar years, annual data does

not allow us to accurately separate this period from other time periods. In addition, use of annual data would add statistical noise from months in 2012 and 2013 during which there was no spike in sales.

Data on the deceased's state of residence is also important because it allows us to test whether the spikes in accidental deaths occurred in the same geographic areas where gun exposure spikes. Data on state of residence is restricted, but can be obtained by researchers under an agreement with the Centers for Disease Control (CDC). One limitation of the restricted-use data for our purposes is that the CDC does not allow publication of any subnational results with counts under 10. This restriction, by which we abide, is binding for rare events, like accidental firearm deaths, particularly for children, by state and month/year of death. At the time of our analysis, data are available only through the end of 2015, dictating the end date for our sample period.

For our state-level instrumental variables analysis, we use data on the share of each state's voters who voted for Barack Obama in the 2012 Presidential election. These data are available from the Federal Election Commission (*22*).

**2. Descriptive Data Analysis**

In Figure S1, we present the raw data, reflecting the total counts of gun sales reported in each month between January of 2008 and December of 2016. These data show a clear upward trend over this period. At the beginning of the period, monthly sales in the vicinity of 1 million were common, but by the end of the period no month is below 1.5 million and months with sales volume over 2 million are common. Sales peaked at 3.3 million in December of 2015. Beyond the upward trend, this figure shows that there is a very clear seasonal pattern in sales. The summer months are slow and then sales pick

up into the fall hunting season and peak each year in December. In the main text, we report patterns over time in firearms sales that remove those seasonal patterns and trends.

As we discussed in the text, there are also very clear patterns in the gun sales' spike associated with Sandy Hook across states. The magnitude of the spikes across states is strongly correlated with the political preferences of the states' residents. We capture these political preferences with the share of the state's electorate that voted for Barack Obama in the 2012 election (a little over a month before Sandy Hook). A similar approach has been used previously by others (*13*). Figure S2 presents a scatter plot of the size of the spike and the percentage of the state's electorate that voted for Barack Obama in the 2012 election. The results strongly indicate that states which more strongly supported Barack Obama experienced smaller increases in gun sales (correlation coefficient = -0.63).

Simple correlations over time and across places generate contradictory evidence regarding the relationship between gun exposure and accidental firearms deaths. For example, time series comparisons indicate a strong negative correlation (correlation coefficient = -0.84) between gun sales and accidental gun deaths over time. As we show in Figure S3, gun sales per capita have more than doubled between 1999 and 2016, increasing from 32 per 1,000 population in 1999 to 72 per 1,000 population in 2015. Accidental firearm deaths, on the other hand, have fallen approximately in half, starting at 0.3 per 100,000 in 1999 and reaching 0.15 per 100,000 in 2015. Cross-sectional variation in gun sales and accidental firearm deaths tells a different story. Figure S4 presents the relationship between gun sales and accidental firearm deaths between 2008

and 2015 across states. It shows that states with more guns sold per capita also have more accidental firearm deaths per 100,000 population. The correlation coefficient is 0.65. Others have pointed out the geographic correlation in gun ownership and accidental firearms deaths (*23, 24*). Our figure makes the modest extension of focusing on gun sales rather than gun ownership.

Of course, neither of these statistics necessarily reflects a causal relationship. The link between routine variation in gun sales and accidental deaths may not be causal because the timing of a household's decision to purchase a firearm may not be random. It may be correlated with other household changes that alter the risk of an accident. Changes in family structure, for instance, may alter a household's desire for greater security coincident with a reduction in the time available to oversee children. Our focus on the spike in gun sales following Sandy Hook overcomes this problem. The exact timing of this event – and therefore the resulting increases in gun sales – can be thought of as random, enabling us to plausibly identify a causal impact.

**3. Additional Information on Statistical Methods**

The statistical methods we use are designed to determine whether firearm-related deaths increased in the immediate aftermath of the Sandy Hook school shooting. As described in the text, we first implement this approach using monthly data at the national level. We also analyze monthly data at the state level, examining whether accidental deaths increased more in those locations where the spike in gun sales was larger. We provide additional details on this state-level analysis in this section.

We utilize this variation in post-Sandy Hook gun exposure spikes across states in an instrumental variables framework. We first create a state-specific predicted gun "sales rate," using the following regression equation:

$$Sales_{mys} = \phi_0 + \phi_1 SH_{my} + \phi_2 SH_{my} \cdot Obama_s + \eta_m + \eta_y + \eta_s + \eta_m \cdot \eta_s + \eta_y \cdot \eta_s + \omega_{mys}$$

where $SalesRate_{mys}$ refers to the sales rate in month $m$ of year $y$ in state $s$. As in the national-level regressions, our state-level regressions include month and year fixed effects ($\eta_m$ and $\eta_y$ ) to control for trends and seasonal patterns. In these specifications, we also include state fixed effects ($\eta_s$), which allow for fixed differences in sales rates across states. The interaction terms in these regressions ($\eta_m \cdot \eta_s$ and $\eta_y \cdot \eta_s$) allow the trends and seasonal patterns to be state-specific. Standard errors are clustered at the state level, and regressions are weighted by state population.

The regression includes two instruments: one is an indicator variable for the Sandy Hook period ($SH_{my}$). It is not indexed by state and captures the average increase in the rate of gun sales across states in the December 2012 through April 2013 sample window. The other instrument is the interaction between the Sandy Hook indicator and the share of the electorate in each state that voted for Barack Obama in 2012.

The F-statistic on these excluded instruments in this regression is 544, supporting the validity of our strategy. The estimated coefficients from this regression indicate that gun sales rose by around 9.5 per 1,000 population in states where Obama's vote share was 50 percent. That increase fell by 4.3 per 1,000 for every additional 10 percent of the electorate in a state that voted for Barack Obama in 2012.

We then use this predicted sales rate (indicated with a hat over "SalesRate") to estimate the following model:

$$DeathRate_{mys} = \alpha_0 + \alpha_1 \widehat{SalesRate}_{mys} + \lambda_m + \lambda_y + \lambda_s + \lambda_m \cdot \lambda_s + \lambda_y \cdot \lambda_s + \nu_{mys}$$

This equation provides an estimate of the relationship between the gun sales rate and the accidental firearms death rate. The key assumption of this model is that the share of Obama voters in a state should not impact the mortality rate during this five-month time period, except through its impact on gun exposure in that state during that time period. The results of this analysis are reported in the bottom panel of Table 1. Our results are not sensitive to our choice of a five-month window defining the post-Sandy Hook period; 3- or 6-month windows generate similar findings.

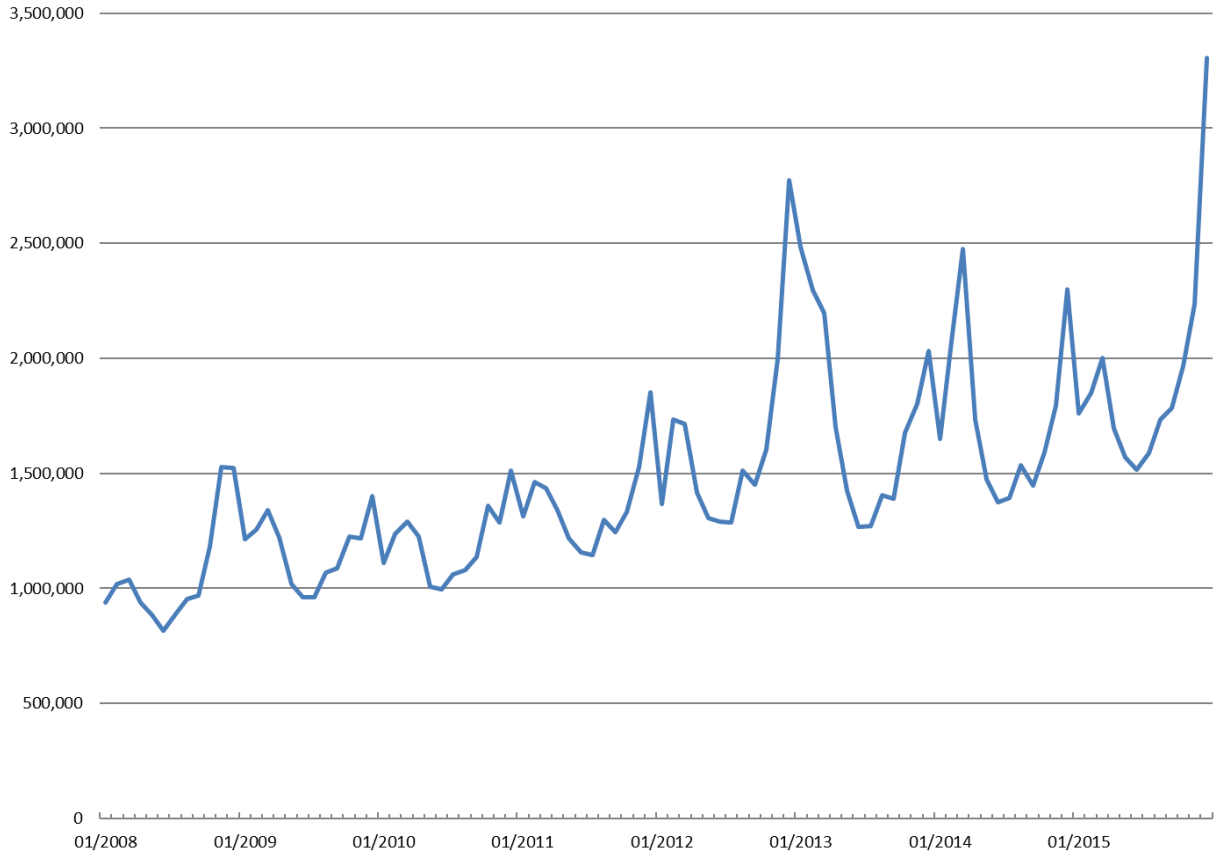


**Figure S1: Trend in Monthly Firearm Sales between 2008 and 2015.** Firearm sales are proxied by NICS data on background checks conducted when a firearm is purchased from a registered dealer. The figure shows monthly totals for the United States.

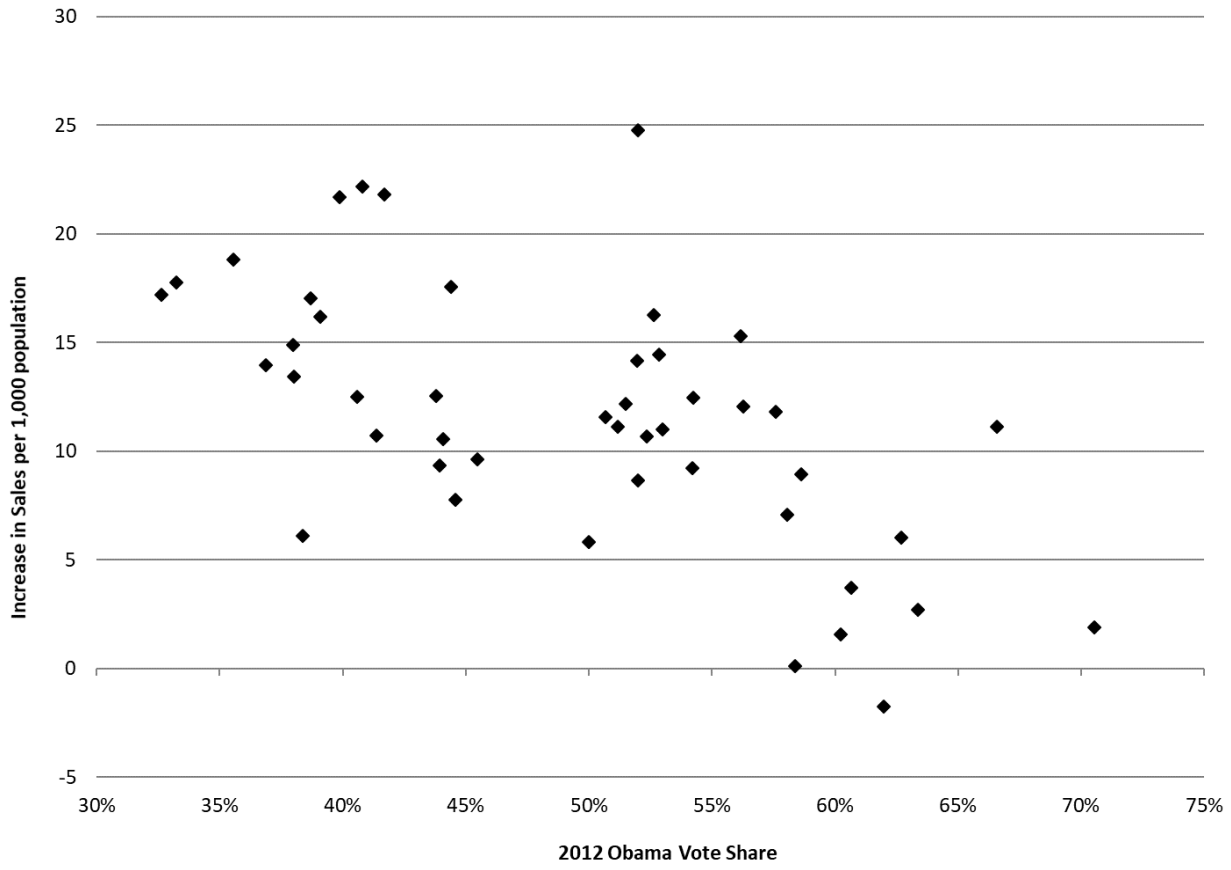


**Figure S2: Relationship between 2012 Obama Vote Share and Increase in Gun Sales Rates following Sandy Hook.** Each marker reflects an observation for a state. The 2012 Obama vote share indicates the fraction of voters in the state who voted for Obama (22). The increase in the sales rate indicates our estimate, based on models described in the text, of the additional firearm sales in a given state in the post-Sandy Hook period, relative to normal trends and seasonal patterns. See notes for Figure S2 for description of the sales rate data. Firearm sales are proxied by NICS data on background checks conducted when a firearm is purchased from a registered dealer. Population data is obtained from SEER.

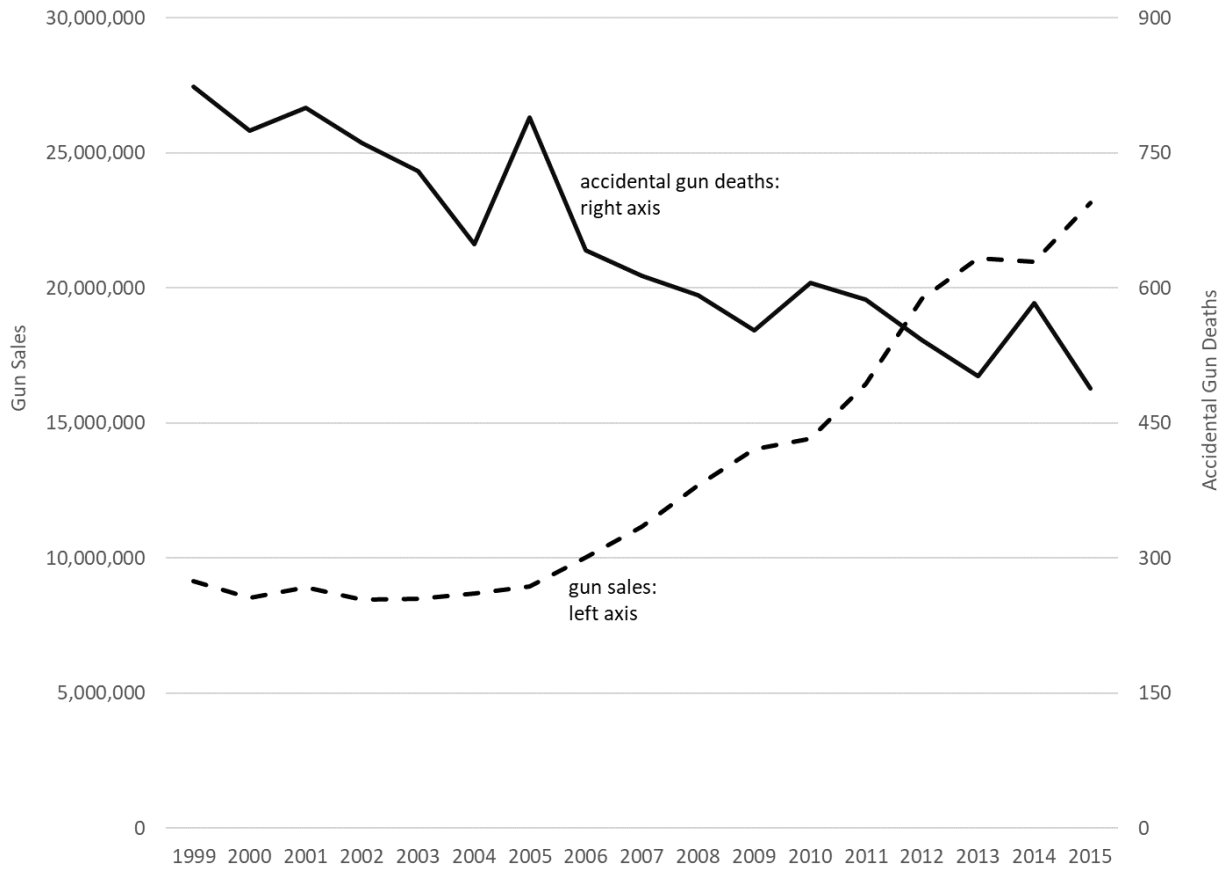


**Figure S3: The Correlation between Gun Sales and Accidental Firearm Deaths over Time.** Firearm sales are proxied by NICS data on background checks conducted when a firearm is purchased from a registered dealer. The accidental firearm death rate is calculated from Vital Statistics mortality data and SEER population data. The figure shows annual data.

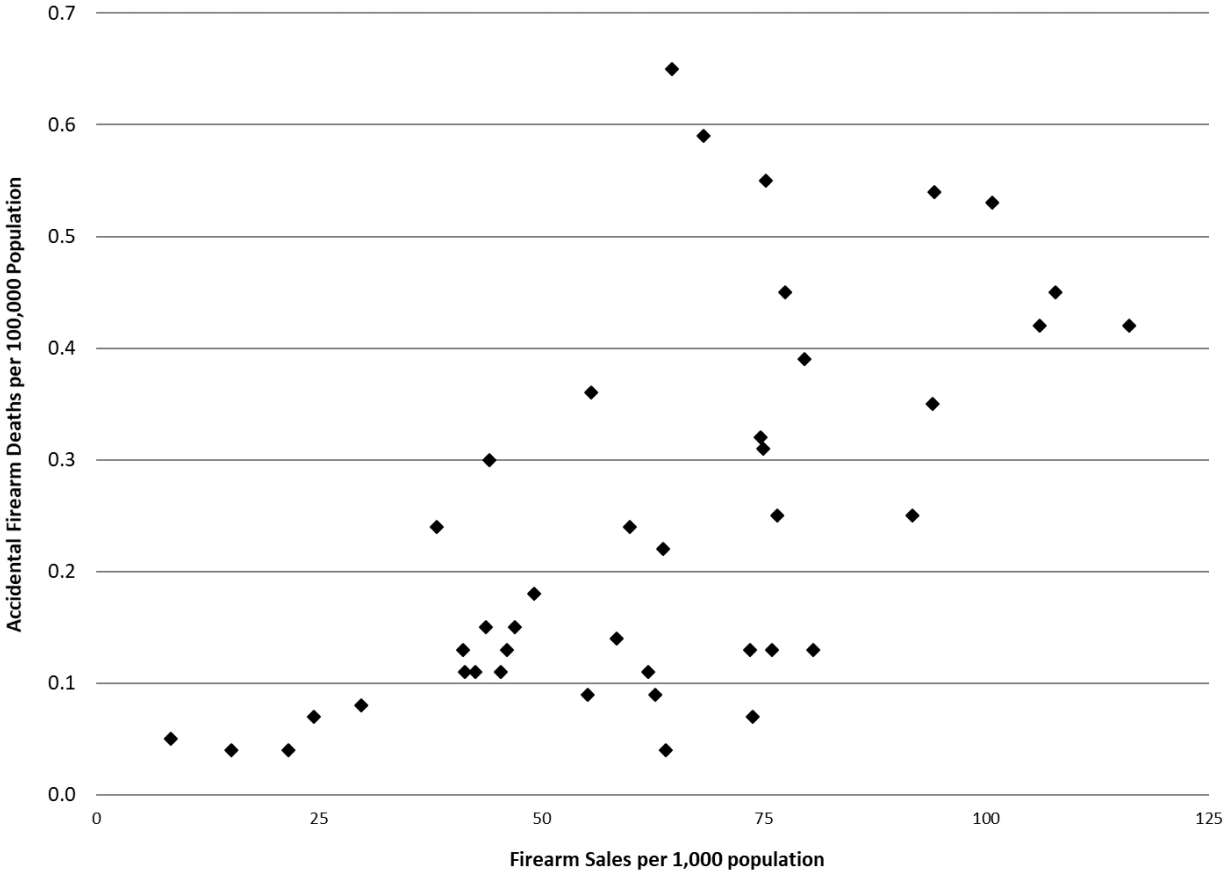


**Figure S4: The Correlation between Firearm Sales Rate and Accidental Firearm Death Rate at the State Level between 2008 and 2015**. See notes for Figure S3. Each marker reflects an annual average for a state. Only states with greater than 10 accidental deaths over this period are reported (omits five states). The District of Columbia, Kentucky, North Carolina, and Utah are also omitted because of data limitations, as described in the text.

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