

Household Gun Ownership and Youth Suicide Rates at the State Level, 2005–2015



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Introduction: Determining whether the prevalence of gun ownership is associated with youth suicide is critical to inform policy to address this problem. The objective of this study is to investigate the relationship between the prevalence of household gun ownership in a state and that state's rate of youth suicide.

Methods: This study, conducted in 2018, involved a secondary analysis of state-level data for the U.S. using multivariable linear regression. The relationship between the prevalence of household gun ownership and youth (aged 10–19 years) suicide rates was examined in a time-lagged analysis of state-level household gun ownership in 2004 and youth suicide rates in the subsequent decade (2005–2015), while controlling for the prevalence of youth suicide attempts and other risk factors.

Results: Household gun ownership was positively associated with the overall youth suicide rate. For each 10 percentage-point increase in household gun ownership, the youth suicide rate increased by 26.9% (95% CI=14.0%, 39.8%).

Conclusions: Because states with high levels of household gun ownership are likely to experience higher youth suicide rates, these states should be especially concerned about implementing programs and policies to ameliorate this risk.

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INTRODUCTION

The predominant cause of firearm-related death in the U.S. is suicide.¹ Of the 38,658 firearm-related deaths in 2016, a total of 59% ($n=22,938$) were suicides, and they accounted for approximately 800,000 years of potential life lost.¹ The problem of firearm suicide among youth is particularly alarming: every day, an average of three youth between ages 10 and 19 years die by firearm-related suicide.¹ In 2016, there were 1,102 youth (aged 10–19 years) firearm suicides.¹ Data from the National Violent Injury Statistic System demonstrated that 82% of firearm-related suicides among youth (aged 17 years and younger) involved a firearm owned by a household member.² Therefore, understanding the association between the prevalence of gun ownership and rates of youth suicide is critical to inform policy that aims to prevent youth suicide.

The conceptual basis for hypothesizing a relationship between access to firearms and suicide rates has been

well established.^{3–11} In a 2017 review article, Houtsma et al.³ concluded that an important factor that contributes to the risk of suicide is the lethality of the method accessible to the at-risk population. Firearms are 2.6 times more lethal than any other means of suicide⁶; thus, access to firearms might be expected to contribute to a higher incidence of suicide.

A number of previous studies have assessed the relationship between household gun ownership and

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overall rates of suicide at the state or regional level.^{12–38} These studies have generally reported a significant positive relationship between gun ownership and overall suicide rates.^{12–32} Most recently, Anestis and Houtsma³² found that states with higher rates of household gun ownership have significantly higher overall suicide rates, even after controlling for psychopathologic variables, such as serious mental illness, serious suicidal thoughts, and episodes of depression.

Although the link between gun ownership and overall suicide rates is well established, less is known about the relationship between household gun ownership and youth suicide rates. Of the 27 studies cited above, just seven specifically examined youth suicides.^{12–18} These studies found a significant relationship between higher levels of household gun ownership and increased rates of youth suicide.^{12–18} However, there is an important limitation to all seven of these studies: they did not control for differences between states in the rate of suicide attempts, which may be correlated with levels of household gun ownership. As Miller and colleagues¹⁹ have noted: “the idea that the availability of firearms plays an important role in determining a person’s suicide risk and a population’s suicide rate continues to meet with skepticism, the most decisive objection being that empirical studies to date have not adequately controlled for the possibility that members of households with firearms are inherently more suicidal than members of households without firearms.” Miller et al.¹⁹ have addressed this issue by modeling adult suicide rates while controlling for suicide attempt rates. Anestis and Housma³² addressed the same issue by modeling overall population suicide rates after controlling for serious suicidal thoughts. However, no previous study has examined the relationship between household gun ownership and youth suicide rates, while controlling for differences in the rate of youth suicide attempts across states.

This study takes advantage of the availability of state-level data from the Youth Risk Behavior Surveillance System (YRBSS)³⁹ on risk behaviors that may influence suicide, including rates of severe negative affect, suicidal planning, and suicide attempts. This study models the relationship at the state level between household gun ownership and suicide rates among youth aged 10 through 19 years during the period 2005–2015. Using the YRBSS data, the authors examine the hypothesis that any observed association between gun ownership and youth suicide rates can be explained by a higher prevalence of suicidal behavior in states with higher levels of gun ownership.

METHODS

Study Population

This study, conducted in 2018, modeled the youth (aged 10–19 years) overall suicide rate between 2005 and 2015 at the state level as a function of household gun ownership measured by the survey in 2004, while controlling for state-specific socioeconomic factors and youth behavioral risk factors known to be associated with suicide.^{32,40–43} Because this research involved secondary analysis of existing data sets without personal identifiers, the Boston University Medical Center IRB deemed it to be exempt from human subjects review.

Measures

The outcome variable was the age-adjusted youth (aged 10–19 years) overall suicide rate in each state, aggregated over the period 2005–2015. Suicide rates were calculated by dividing the number of deaths due to suicide among youths aged 10–19 years in a state by the population of youth (aged 10–19 years) in that state. These data were obtained from the Centers for Disease Control and Prevention’s Web-Based Injury Statistics Query and Reporting System.¹ These data are derived from death certificates and collected as part of the National Vital Statistics program. Centers for Disease Control and Prevention does not report suicide rates based on <10 deaths. Therefore, to generate stable estimates of suicide rates for all 50 states, data were aggregated across the 11-year study period. For two states—Hawaii and Rhode Island—data were aggregated from 2003 to 2015 because of the low numbers of annual suicide deaths.

The outcome variable, youth suicide rates, was highly skewed (skewness=1.6) with high kurtosis (5.4). Therefore, the rates were log-transformed to produce the final dependent variable, which had an acceptable level of skewness (0.5) and kurtosis (3.1).

The main exposure variable was the proportion of households with a gun in each state, obtained from the 2004 Behavioral Risk Factor Surveillance System surveys, in which a representative sample of adults in each state were interviewed by telephone.⁴⁴ The total national sample size was 303,822.⁴⁴ The prevalence of gun ownership at the state level has not been assessed by the Behavioral Risk Factor Surveillance System since 2004, so there are no contemporaneous state-level data available on household gun ownership. The use of 2004 data has the advantage of ruling out reverse causation (i.e., the possibility that gun ownership levels are responding to changes in youth suicide rates rather than the reverse).

A set of control variables were chosen based on prior literature that establishes a connection between these variables and suicide risk, especially among youth. These variables, outlined by Anestis and Houtsma (for suicide in general)³² and Cash and Bridge (for youth suicide),⁴³ included psychopathologic factors (depression and suicidal thoughts and behaviors),^{32,43} race,^{32,43} alcohol and drug use,^{32,43} family constellation (single-parent households and people per household),^{32,43} and sociodemographic variables (poverty, divorce, education, unemployment, and urbanicity).³² With respect to race, Native American youth have significantly higher suicide rates than white youth, black youth have significantly lower rates, and Hispanic youth have similar rates. Therefore, the authors decided to control for the proportion of youths who are Native American and the proportion of youths who are black in each state. With respect to drug use, both marijuana use⁴⁵ and

heroin use⁴⁶ have been shown to be associated with increased suicide risk, so both of these variables were controlled for. With respect to alcohol use, binge drinking is most closely associated with adolescent suicide attempts,⁴³ so self-reported binge drinking was also controlled for.

Data for the control variables were obtained from several sources. The YRBSS is a biennial national in-school survey administered every odd year to a representative sample of youth in ninth through 12th grades in each state.³⁹ The YRBSS uses a three-stage cluster sample design with the sampling frame consisting of all public and private high schools.⁴⁷ The primary control variables obtained from the YRBSS were the state-level prevalence of severe negative affect (in the past 12 months, having felt so sad or hopeless almost every day for 2 weeks or more that you stopped doing some usual activities), suicidal planning (having made a plan for a suicide attempt in the past 12 months), and suicide attempts (having made an attempt in the past 12 months) among youth in each state, averaged across the study period (2005–2015). The prevalence of self-reported severe negative affect, suicidal planning, and suicide attempts was estimated using survey weights that accounted for survey nonresponse and for oversampling of black and Hispanic students and were post-stratified to match the grade-specific population in each state in each survey year.⁴⁷ Because three states (Minnesota, Oregon, and Washington) did not participate in the YRBSS, the sample size for multivariable analyses was 47 states. All 50 states were included in bivariate analyses comparing youth suicide rates with gun ownership levels.

The YRBSS was also used to collect data on the following youth-specific variables, also obtained by averaging estimates from the 2005–2015 surveys in each state: proportion of students who are black, proportion of students who are Native American, and the prevalence of lifetime heroin use, past 30-day marijuana use, and past 30-day binge drinking.

The second data source was the Behavioral Risk Factor Surveillance System, from which data were obtained on the proportion of gun-containing households in which guns are stored loaded and unlocked.

The third data source was the U.S. Census Bureau, American Community Survey, which was used to obtain data on the following household-related variables that have been shown to be associated with youth suicide rates: (1) the proportion of households with children, (2) the average number of people per household, and (3) the proportion of children living in single-parent households. For each variable, single-year estimates from 2005 to 2015 were averaged.

Data were obtained from the U.S. Census⁴⁸ on the following state-level socioeconomic factors that have been shown to be associated with youth suicide rates: poverty rate, divorce rate, the proportion of adults with a college degree, unemployment rate, and the percentage of the population living in an urban area. Annual data were averaged across the period 2005–2015. Finally, data for per capita alcohol consumption were obtained from annual estimates provided by the National Institute on Alcohol Abuse and Alcoholism, averaged over the study period.⁴⁹

Statistical Analysis

Using linear regression analyses, the log-transformed suicide rates in each state were regressed on 2004 household gun ownership rates, while controlling for severe negative affect, suicidal

planning, suicide attempts, race and ethnicity covariates, substance abuse covariates, and socioeconomic covariates. All analyses were conducted using Stata, version 14.0.

To ease the interpretation of the regression coefficients for household gun ownership, this paper reports the estimated percentage change in the youth suicide rate associated with each 10 percentage-point increase in gun ownership. Because the outcome was the log of the suicide rate, multiplying the regression coefficient by 100 yields the percentage change in this rate associated with a unit change in the independent variable (in this case a 10 percentage-point increase in gun ownership).

Finally, as a falsification test, the authors separately modeled the relationship between household gun ownership and the firearm-related and non-firearm-related youth suicide rates. Higher levels of household gun ownership would be expected to increase the firearm suicide rate only, not the non-firearm suicide rate. This analysis also allowed the assessment of the possibility of a “substitution effect,” whereby lower availability of firearms might lead to an increase in suicide attempted by other means. All of the covariates were included in each of these analyses.

RESULTS

During the 2005–2015 study period, the overall youth suicide rate ranged from a high of 15.2 per 100,000 youth in Alaska to a low of 2.6 per 100,000 youth in New Jersey (Table 1). The estimated household gun ownership in 2004 ranged from a high of 65.5% in Wyoming to a low of 10.2% in Hawaii. In the ten states with the highest youth suicide rates, the average household gun ownership was 52.5%, compared with a household gun ownership rate of 20.0% in the ten states with the lowest youth suicide rates. The household gun ownership level in 2004 was highly correlated with the overall youth suicide rate, explaining 55% of the variance across the 50 states (based on a bivariate analysis; Figure 1).

Controlling for the prevalence of youth severe negative affect, suicidal planning, and suicide attempts, as well as a range of youth-specific behavioral risk factors and state-level socioeconomic factors, household gun ownership in 2004 was positively associated with the overall youth suicide rate during the period 2005–2015 (Table 2). For each 10 percentage-point increase in the prevalence of household gun ownership, the youth suicide rate increased by 26.9% (95% CI=14.0%, 39.8%, $f^2=0.68$).

The only other factors that were associated with overall youth suicide rates were the suicide attempt rate (positively associated) and the percentage of youth who were Native American (positively associated; Table 2). Together, the model explained 92% of the variation in overall youth suicide rates across the 47 states.

In the falsification test, although household gun ownership was strongly related to the youth firearm-related

Table 1. Average Youth Suicide Rates, Gun Ownership Rates, and Suicidal Behavior Rates

State	Suicide rate (per 100,000)	Household gun ownership prevalence (%)	Severe negative affect prevalence (%)	Suicide plan prevalence (%)	Suicide attempt prevalence (%)
Alaska	15.2	59.8	27.7	13.8	9.4
South Dakota	14.9	59.9	24.3	13.5	8.7
Wyoming	11.9	65.5	27.5	15.9	9.9
Montana	11.1	62.6	26.6	13.8	8.2
New Mexico	10.9	39.7	30.4	14.5	11.1
North Dakota	10.6	56.2	22.7	11.6	8.8
Idaho	9.4	55.7	28.7	14.0	7.9
Colorado	8.4	34.6	25.2	10.8	7.2
Utah	8.2	44.8	26.5	12.5	7.9
Oklahoma	7.1	46.5	27.8	11.9	6.9
Arizona	6.8	32.3	34.4	15.1	9.8
Iowa	6.6	45.7	23.4	11.4	6.6
Nebraska	6.4	45.4	22.6	12.2	8.0
Arkansas	6.3	58.8	30.0	14.9	11.1
Kansas	6.2	42.8	22.7	10.2	6.7
Minnesota	6.2	41.2	—	—	—
Nevada	6.0	34.0	29.7	15.1	9.9
Washington	6.0	34.0	—	—	—
Oregon	5.9	39.8	—	—	—
Hawaii	5.9	10.2	30.5	16.0	11.3
Wisconsin	5.8	43.0	23.7	12.1	7.0
Vermont	5.8	43.8	21.9	10.3	5.3
West Virginia	5.7	58.5	29.2	12.8	8.6
Missouri	5.6	44.2	26.2	11.6	7.6
Kentucky	5.5	47.7	28.1	12.7	8.9
Maine	5.3	40.3	23.1	11.3	7.4
Michigan	5.3	40.8	27.4	13.5	9.0
Indiana	5.2	38.5	28.3	14.1	9.4
Louisiana	5.2	45.0	30.8	12.7	10.9
Ohio	5.1	34.0	26.4	12.7	8.5
Delaware	4.8	26.3	25.8	10.2	7.3
Tennessee	4.8	46.6	27.9	12.4	8.1
Texas	4.8	37.1	29.4	12.6	9.2
Alabama	4.7	52.2	27.9	14.0	9.8
South Carolina	4.7	43.3	28.0	12.9	10.0
Virginia	4.5	37.5	26.1	13.4	8.9
Mississippi	4.5	54.6	28.0	12.3	9.8
North Carolina	4.4	39.4	27.5	12.3	12.0
Pennsylvania	4.2	35.1	25.7	11.5	6.6
New Hampshire	4.2	31.0	25.4	10.5	6.1
Florida	4.0	25.2	26.2	10.0	7.2
Illinois	3.9	20.7	27.9	13.0	9.1
Georgia	3.7	40.3	29.3	13.1	8.7
Maryland	3.5	21.7	26.2	12.0	9.5
Connecticut	3.3	18.1	25.1	11.7	8.7
California	3.1	20.1	29.7	15.2	8.2
Rhode Island	3.1	12.4	25.1	11.1	9.8
Massachusetts	3.0	11.5	24.8	11.4	6.7
New York	2.7	18.5	25.5	10.2	7.7
New Jersey	2.6	11.4	27.4	11.2	8.0

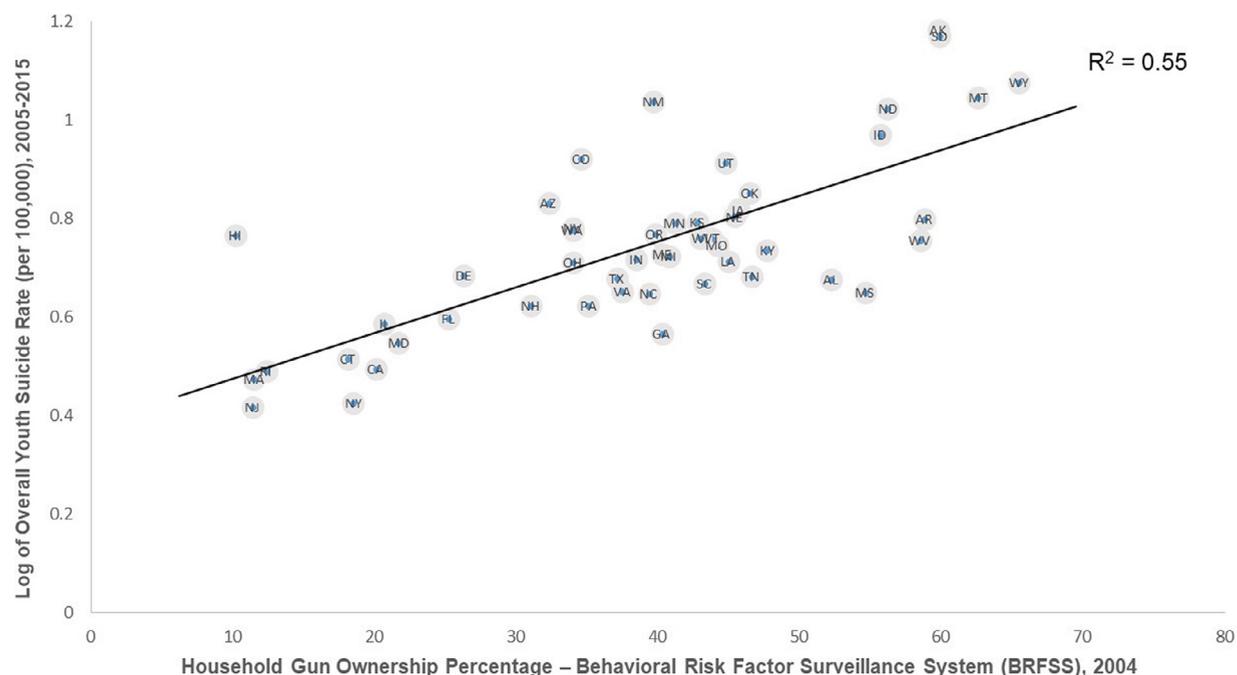


Figure 1. Relationship between household gun ownership in 2004 and log of youth suicide rate, 2005–2015.

suicide rate (regression coefficient=0.531, 95% CI=0.319, 0.742), it was not significantly related to the youth non–firearm-related suicide rate (regression coefficient=0.150, 95% CI=−0.023, 0.322).

Because the data on youth suicides pertains to youth aged 10–19 years, but the YRBSS data are based on responses of youths aged 14–19 years, a sensitivity analysis was conducted to make sure that omitting suicides among youth aged 10–13 years did not affect the results. In that analysis, the results were unchanged. Each 10 percentage-point increase in household gun ownership was associated with a 27.4% increase in suicide rates (95% CI=14.3%, 40.5%) among youth aged 14–19 years.

In a final sensitivity analysis, the data were analyzed while omitting Rhode Island and Hawaii, the two states for which the period of evaluation was extended for suicide deaths back to 2003. The results were unchanged. Each 10 percentage-point increase in household gun ownership was associated with a 34.4% increase in youth suicide rates (95% CI=20.7%, 48.2%).

DISCUSSION

This is the first paper to examine the relationship between household gun ownership and youth suicide rates at the state level, while controlling for differences between the states in the prevalence of youth suicide attempts. The prevalence of household gun ownership in a state in 2004 was strongly associated with the youth

suicide rate over the next decade, even after controlling for the number of youth who reported being depressed, having made a plan to attempt suicide, and having made a suicide attempt.

Importantly, higher levels of household gun ownership were associated with higher rates of overall youth suicide. This is noteworthy because it argues against the presence of a substitution effect. In other words, a higher prevalence of gun ownership is not associated with merely a shift from non-firearm to firearm suicide, but instead it is actually associated with an increase in the overall youth suicide rate. There is abundant evidence that the proportion of suicide attempts resulting in a fatality is substantially higher when using a firearm than using any other means.^{3–10} Therefore, the observed findings are consistent with the hypothesis that access to a means of attempting suicide with a higher case fatality rate is associated with an overall increase in the rate of youth suicide.

This explanation for the observed relationship between household gun ownership and youth suicide rates is empirically supported by the finding that differences across states in the rates of completed youth suicide are largely explained by variations in household gun ownership, despite substantial differences in self-reported suicide attempt rates. For example, Illinois had a low youth suicide rate (3.9 suicides per 100,000 youth) despite having a relatively high suicide attempt rate (9.1%). Meanwhile, Iowa had a higher suicide rate (6.6 suicides per 100,000

Table 2. Results of Multivariable Linear Regression Analyses Modeling Overall Youth Suicide Rates,^a 2005–2015

Variable	Regression coefficient (95% CI)	f ²
Gun ownership	0.269 (0.140, 0.398)	0.68
Severe negative affect	−0.023 (−0.088, 0.043)	—
Suicidal planning	−0.013 (−0.090, 0.065)	—
Suicide attempts	0.070 (0.007, 0.133)	—
Percent black	−0.011 (−0.023, 0.000)	—
Percent Native American	0.021 (0.002, 0.039)	—
Heroin use	−0.001 (−0.104, 0.103)	—
Marijuana use	−0.008 (−0.016, 0.000)	—
Binge drinking	0.008 (−0.014, 0.031)	—
Poverty rate	−0.014 (−0.062, 0.035)	—
Divorce rate	0.008 (−0.080, 0.095)	—
Alcohol consumption	0.088 (−0.064, 0.241)	—
Educational attainment	0.004 (−0.018, 0.026)	—
Unemployment	−0.013 (−0.081, 0.054)	—
Percent urban	0.006 (−0.001, 0.014)	—
Percent of households with children	−0.032 (−0.084, 0.020)	—
Average household size	0.860 (−0.341, 2.061)	—
Percent of children in single-family households	0.011 (−0.043, 0.065)	—
Gun households with loaded and unlocked guns	0.002 (−0.022, 0.026)	—
R ²	0.92	—

Note: Boldface indicates statistical significance ($p < 0.05$).

^aThe outcome variable is the logged youth suicide rate.

youth) than Illinois, despite having the third lowest suicide attempt rate (6.6%). The most significant difference between these two states across the indicators tested is that Illinois had a household gun ownership rate of 20.7%, whereas Iowa had a household gun ownership rate of 45.7%.

Limitations

This study has several limitations. First, there could be omitted variables that are related to both household gun ownership and youth suicide rates. However, the likelihood that omitted variables explain the observed findings is low because the inclusion of the youth suicide attempt rate in the model should capture any omitted variable that influences the propensity of a youth to attempt suicide. Another finding that further supports the validity of these findings was the failure to detect any significant relationship between household gun ownership and the non-firearm-related youth suicide rate. If an omitted variable were leading to a spurious finding of an association between gun ownership and suicide, then one would not expect that variable to confound only the relationship for firearm suicides.

Second, the analysis suggests that differences in gun ownership levels explain variation in youth suicide rates across states. Because this is a cross-sectional study, this does not necessarily imply that changes in gun ownership over time within a state translate into changes in

youth suicide rates. A panel study with multi-year data would be necessary to explore the within-state effects of gun ownership.

Third, the suicide rate data pertain to youth aged 10–19 years, whereas the YRBSS measures of suicide attempts pertain to youth aged 14–18 years. Unfortunately, there are few available data on suicide attempts among the group aged 10–13 years. Nevertheless, the authors do not expect that this limitation substantially affected the findings because the group aged 10–13 years accounted for only 7.8% of the suicides in the data set. Fourth, it is important to emphasize that the suicide attempt data are based on self-reports. It is not clear how accurately youth report attempted suicide.

Finally, a significant association was not found between the proportion of gun households with unlocked and loaded firearms and the rate of youth suicide. Previous research conducted at the level of the individual household has demonstrated such a relationship.⁵⁰ Further study is necessary to understand why this relationship is not evident at the population level.

CONCLUSIONS

This paper finds a strong association between the prevalence of household gun ownership and the rate of youth suicides at the state level. This suggests that lowering the

overall prevalence of household gun ownership could be an effective strategy to prevent youth suicide. Further research is needed to determine whether there are public policies that might be effective in limiting youth access to firearms and result in subsequent reductions in youth deaths by suicide.

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