

Firearms and Suicide in the Northeast

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Background: A central question in suicide research is whether firearm availability increases the overall number of suicides rather than the proportion of suicides from guns.

Methods: Seven state health departments supplied mortality and hospital discharge data for all suicides and nonfatal hospitalized suicide attempts between 1996 and 2000. Firearm prevalence measures

came from the Behavioral Risk Factor Survey Surveillance. Pearson correlation coefficients and associated χ^2 statistics were used to quantify the relation between firearm prevalence and rates of suicide; ordinary least squares regression was used to explore whether the relation could be explained by differences across states in attempt rates or method-specific case fatality rates.

Results: Firearm prevalence was

positively related to the suicide rate, even after controlling for rates of attempted suicide, and could not be accounted for by differences in method-specific case fatality rates.

Conclusion: When it comes to suicide, the availability of household firearms matters—a lot.

Key Words: Firearms, Guns, Suicide, Suicide attempts, Case fatality rate.

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In the United States, where approximately one third of households have firearms and almost 60% of all suicides are attributable to guns, firearms are the most lethal^{1–3} and the most commonly used method in completed suicides, not only for men but for women and children as well.⁴ Even in the northeastern United States, where rates of suicide⁴ and household firearm ownership are lower than in any other region of the United States,⁵ firearms account for more suicides than does any other method.⁴

A central question regarding the relationship between firearms and suicide is whether the availability of firearms increases the overall number of suicides rather than merely the proportion of suicides from guns. If seriousness of intent is all that matters, anyone serious enough to use a gun in a suicide attempt would, if guns were less available, either work harder to get a gun or make equally lethal attempts with other means. In contrast, if both seriousness of intent and lethality of means matter, some individuals might substitute less lethal means (or not attempt at all), and as a result the overall number of suicides might decrease.

Case-control and ecologic studies provide complementary lines of evidence suggesting that the availability of firearms increases the risk of suicide.^{6–8} Case control studies have consistently found that presence of a gun in the home is a risk factor for suicide in the home^{9–16} and that the purchase of a handgun from a licensed dealer is associated with becoming a suicide victim.^{17,18} To date, however, most case-control studies have included relatively small numbers of suicides (fewer than 100)^{9–14} and focused predominantly on

youth suicide;^{9–13} among studies large enough to look across several age groups,^{15–20} most have restricted analyses to suicides that occurred in the home^{15,16} or have used the purchase of a firearm rather than its presence in the home to measure exposure.^{17–19}

Ecologic studies have addressed some of the limitations of case-control studies, such as recall bias, but have been hampered because direct survey-based measures of household firearm ownership have previously been available for only the nation as a whole,⁵ the nine census regions,⁵ or for a nonrandom sample of 21 states.²¹ Consequently, most studies have tended to rely on indirect estimates of firearm prevalence (i.e., proxies), such as those derived from mortality data (e.g., the percentage of suicides from firearms) or from other indirect sources (e.g., subscription rates to particular firearm magazines), and have had to contend with uncertainty regarding the relative merits of the various proxies used. Nevertheless, most ecologic studies have found a link between various proxies of firearm prevalence and rates of suicide,^{22–25} although some have not,²⁶ and others have produced mixed findings depending on the age of the victim,^{27,28} the analytic model, or the firearm proxy used.²⁹

Four empiric studies have used direct survey measures of firearm ownership, either alone^{28,30,31} or in conjunction with proxy measures.²³ All found a positive association between household firearm ownership rates and rates of firearm suicide, and three found an association with suicide rates overall.^{23,28,30} These studies were, however, restricted to analyzing variation across (and ignoring variation within) the nine U.S. census regions^{23,30,31} or to a sample of states in the mid 1990s.²³

Despite the growing body of empiric evidence suggesting that the availability of firearms is associated with elevated rates of suicide, certain alternative explanations of the firearm-suicide connection remain largely unexplored. This article examines two: first, individuals who live in high-gun areas might be significantly more suicidal; and second, indi-

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viduals who live in high-gun areas might be significantly more adept at killing themselves with whatever method they choose or less likely to receive timely or adequate medical attention for a medically serious attempt.

The only cross-sectional study we could find that directly or indirectly addresses the first alternative explanation found that the association between household firearm prevalence and rates of suicide across the nine U.S. census regions could not be explained by cross-sectional differences in major depression or serious suicidal thoughts.³² Although the second hypothesis could be put to test by examining whether method-specific case fatality rates are higher in states where firearms are more prevalent, of the three studies reporting method-specific case fatality rates,¹⁻³ none provides data on method-specific variation across states.

The current study is the first of which we are aware that addresses these alternative hypotheses. We used recently available, state-level, survey-based estimates of the percentage of individuals living in households with firearms in conjunction with corresponding hospital discharge data on suicide attempts across several states to explore (1) whether rates of firearm prevalence are positively related to rates of suicide and (2), if so, whether the association can be explained by higher rates of attempted suicide or by higher fatality rates for a given method of attempt in states with more guns. We focus on the northeastern United States because we have been working with these state health departments and were able to obtain complete hospital discharge data for all suicide attempts in seven of the eight states in this region. Although few in number, these states vary considerably in rates of suicide and household firearm ownership,^{4,33} providing an opportunity to evaluate the relationship between firearm prevalence and suicide.

MATERIALS AND METHODS

Medically identified suicide acts were defined as those cases logged in medical hospital discharge records or in mortality files and E-coded as intentional self-inflicted injuries according to the *International Classification of Diseases, Ninth Revision, Clinical Modification* (codes E950.0–E959.9)³⁴ for the years 1996 through 1998, and for the years 1999 and 2000 from the *International Classification of Diseases, Tenth Revision, Clinical Modification* (X60–X84).³⁵ Suicide attempts that did not result in injury or in injury serious enough to require hospitalization were not included in our definition of suicide attempt.

Seven northeastern states provided complete electronic hospital discharge data for medical hospital admissions assigned an injury code (800–999). The pooled data comprised state hospital discharge data systems for Connecticut (1996–2000), Maine (1998–2000), Massachusetts (1996–2000), New Hampshire (1996–1999), New Jersey (1996–1999), Rhode Island (1996–2000), and Vermont (1996–1999).

The method used in a suicide act was identified according to E-codes and grouped into five categories: all suicides, firearm suicides, suicides by drug overdose/poisoning (in-

cluding poisoning by gases)/cutting/piercing, suicides by suffocation/hanging, and all suicides by all other methods (including jumping/lying before a moving object, fire/scalding, electrocution, motor vehicle crash, caustic substance, explosive device, drowning, jumping from a high place, and unspecified means). Some people who attempt suicide make more than one attempt.³⁶⁻³⁸ We estimated the number of attempts rather than the number of attempters.

Demographic data were used to compute rates. These data were derived from the Census Bureau Web site,³⁹ which provides annual state population estimates by age, sex, and race/ethnicity. For ages 4 and under, suicide is not classified as a cause of death by the National Center for Health Statistics; accordingly, this age group is omitted from analyses.

To examine rates of suicide attempts and the proportion of attempts that proved lethal, we examined cases of attempted suicide involving admission to a hospital and corresponding state mortality statistics. State counts of suicide, derived from E-coded U.S. Vital Statistics data,⁴⁰ were separately matched to the year of the discharge data for each state. The pooled data included 51,818 live injury discharges, 534 in-hospital deaths, and 7,797 lethal suicide attempts.

To avoid double counting, the 534 attempts that resulted in death within the hospital were excluded from calculations of case fatality and attempt rates because we assumed they were captured in the corresponding state mortality files. In addition, we excluded patients transferring from another hospital because this too could lead to double counting of the same attempt. Maine was unable to provide hospital transfer information. To obtain suicide attempt and case fatality rates for Maine, we assumed that the hospital transfer rate in Maine was the average of the transfer rates in the other states (4.5% of all suicide attempt admissions).

In calculating suicide attempt and case fatality rates, we used mortality data that corresponded to the years for which a state provided hospital discharge data. In calculating correlation coefficients for the association between rates of household firearm ownership and rates of suicide (total, firearm, and nonfirearm), we used the suicide rates for each state over the 5-year study period 1996 to 2000. The state-level suicide rates for the 5-year period 1996 to 2000 were virtually identical to the state-level suicide rates corresponding to the exact years for which we had hospital discharge data for each state (correlation coefficient = 0.99).

Estimates of the percentage of individuals living in households with firearms came from the only complete survey-based estimates available in the United States: the 2001 Behavioral Risk Factor Survey Surveillance (BRFSS).³³ For theoretical reasons, rather than using the percentage of households with firearms as our measure of exposure, we used the percentage of individuals who lived in households with firearms. In practice, however, there is little difference between these two measures because they are so highly correlated (e.g., for our seven states, these measures are almost identical [correlation coefficient = 0.997; $p < 0.0001$, not shown]).

The case fatality rate (CFR) was defined as the number of suicide deaths divided by the number of suicide attempts. Case fatality rates are calculated for each of our seven states for all attempts (overall CFR), for firearm attempts, and for three groups of nonfirearm methods (hanging/suffocation, poisoning/cutting/piercing, and all other methods combined).

Pearson correlation coefficients and associated χ^2 statistics were used to quantify the relation between firearm prevalence and rates of suicide; ordinary least squares regression was used to explore whether the relation could be explained by differences across states in suicide attempt rates or method-specific case fatality rates. Results were not materially affected when rates of household firearm ownership, suicide, or suicide attempts were standardized by age, gender, and race, regardless of whether the standard population chosen was the U.S. population in the year 2000, Vermont in the year 2000, New Jersey in the year 2000, or an entirely white population with the age and sex distribution of the United States in 2000. Results shown are not standardized.

RESULTS

Between 1996 and 2000, for every 100,000 individuals living in our seven states, 8.2 committed suicide, and 38% (3.1) used a firearm (Table 1). Across our states, rates of firearm prevalence varied considerably, as did rates of suicide. The strong and positive correlation between firearm prevalence and suicide was accounted for by substantially elevated firearm suicide rates in states with higher levels of firearm ownership (Table 2). This association held for the population as a whole and for every age group. By contrast, aggregate rates of nonfirearm suicides in states with higher firearm ownership did not differ across the seven states.

Methods commonly used in fatal suicide attempts differed from those commonly used in attempts overall. Among our seven states, fatal suicide attempts were predominantly attempts with firearms or by hanging/suffocation, accounting for 38% and 30%, respectively, of all fatalities (not shown). Most attempts, however, were not lethal and consisted of attempts by poisoning/cutting/piercing, accounting for 85% of all attempts (Table 3).

Overall, rates of firearm prevalence were highly correlated with rates of suicide attempts using firearms (correlation coefficient = 0.99; $p > 0.001$) but were not significantly associated with aggregate attempt rates using means other than firearms (Table 4). We added the rate of suicide attempts as an independent variable along with household firearm prevalence to a regression model with suicide rate as the dependent variable ($n = 7$). The association between firearm prevalence and suicide remained strong and significant ($p < 0.01$, not shown).

Attempts by methods previously reported to be highly lethal, such as by hanging/suffocation, were not significantly related to firearm prevalence (not shown). For female subjects, there was a nonsignificant trend ($p < 0.1$) relating firearm prevalence to rates of attempted suicide with means other than firearms (Table 4).

Thirteen percent of all suicide attempts across our seven states proved fatal, as did 91% of all attempts with firearms, 80% of all attempts by suffocation/hanging, and 3% of all attempts by poisoning/cutting or piercing (Table 5). Case fatality rates for firearms did not differ across states. Moreover, although method-specific case fatality rates were not significantly related to firearm prevalence, states with higher firearm ownership rates had significantly higher overall case fatality rates (Table 5) (correlation coefficient = 0.93; $p < 0.01$, not shown).

DISCUSSION

Our finding that firearm prevalence is associated with rates of suicide is consistent with most previous ecologic studies^{22–25,28,30,31} and, moreover, with the hypothesis that suicide rates are related to the availability of highly lethal means. The relationship we find between firearm prevalence and rates of suicide is driven entirely by the relationship between firearm prevalence and firearm suicide (i.e., firearm prevalence was not associated with rates of nonfirearm suicide) and holds for every age group. This finding, reported by other cross-sectional studies,^{22–24,28,30,32} is also consistent with results from case-control studies in which the presence of a gun in the home,^{9–18} or the purchase of a handgun from

Table 1 Rates of Household Firearm Ownership and Rates of Suicide, Firearm Suicide, and Nonfirearm Suicide across Seven Northeastern States, 1996–2000

	Households with Firearms (%)	Suicides per 100,000	Firearm Suicides per 100,000	Nonfirearm Suicides per 100,000
Vermont	42	12.3	8.0	4.3
Maine	41	13.3	7.8	5.5
New Hampshire	30	11.7	6.2	5.5
Connecticut	17	8.5	3.3	5.2
Rhode Island	13	8.3	3.0	5.3
Massachusetts	13	7.5	2.1	5.4
New Jersey	12	7.1	2.3	4.8
All seven states	17	8.2	3.1	5.1

Table 2 Correlation Coefficients for the Association between Rates of Household Firearm Ownership and Suicide, Firearm Suicide, and Nonfirearm Suicide across the Seven States, 1996–2000

	Suicides per 100,000	Firearm Suicides per 100,000	Nonfirearm Suicides per 100,000
All subjects	0.97***	0.99***	-0.23
Male subjects	0.98***	1.00***	-0.36
Female subjects	0.74~	0.91**	0.21
15–24 yr old	0.75*	0.88**	-0.48
25–44 yr old	0.94***	0.99***	0.07
45–64 yr old	0.96***	0.99***	-0.54
65 yr old and older	0.98***	0.99***	0.31

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; ~ $p < 0.1$.

Estimates are not reliable for the 5 to 14-yr age group over the study period because there are so few suicides among this age group.

a licensed dealer¹⁸ is a risk factor for suicide (by increasing the risk of firearm suicide), not only for the gun owner but for all other household members as well.

When we include the rate of suicide attempts as an independent variable along with household firearm prevalence in a regression model (with suicide rate as the dependent variable), the association between firearm prevalence and suicide remains strong and statistically significant, suggesting that, inasmuch as medically serious suicide attempts are a marker of suicidal tendency, the firearm-suicide connection is not accounted for by a greater suicidal tendency among inhabitants of areas with more guns. This result, not previously reported, is consistent with previous work showing that the association between household firearm prevalence and rates of suicide across the nine U.S. census regions could not be explained by cross-sectional differences in major depression or serious suicidal thoughts,³² as well as with case-control studies in which the presence of a gun in the home remained a strong risk factor for suicide even after controlling for established psychiatric risk factors for completed suicide.^{11,14,15}

We found no evidence to support the contention that complete substitution of highly lethal means will occur where

firearms are less readily available, not only in our mortality data (Tables 1–3) but in our attempt data as well (Tables 4 and 5). States with lower firearm prevalence did not have significantly higher suicide attempt rates using means previously reported to be commonly used and highly lethal,^{1–3} such as hanging/suffocation (Table 4). Nevertheless, incomplete substitution with lethal means may have occurred. Consistent with but only weakly supportive of this possibility, we found an inverse (but nonsignificant) correlation between attempted suicide by hanging/suffocation and firearm prevalence among our seven states (correlation coefficient = -0.6 ; $p < 0.2$, not shown). In addition, substantial nonlethal substitution may have occurred but gone unnoticed. Such would be the case when, in lieu of using a firearm, an attempt is made by poisoning, cutting, or piercing. Because attempt rates with these methods exceed attempt rates with firearms by an order of magnitude (accounting for 85% of all attempts vs. 5% for firearms), any substitution of poisoning or cutting or piercing would be lost in the denominator of our attempt data. Because the case fatality rates for these methods ($<5\%$) are so small relative to the case fatality rate for firearms ($>90\%$), such substitution would also not likely show up as significant differences in mortality data.

Whereas the method-specific case fatality rates we report are similar to those previously reported,^{1–3} our finding that the case fatality rate for a given method of attempted suicide is not related to firearm prevalence has not previously been reported. Moreover, this finding militates against the interpretation that individuals in our high gun states are either more adept at killing themselves with a given method or less likely to receive adequate medical attention for a particular life-threatening attempt.

Across our seven northeastern states, case fatality rates varied systematically (Table 5), correlating highly with household firearm prevalence and with the proportion of suicides that were firearm related (correlation coefficient = 0.93 and 0.89, respectively; $p < 0.001$, not shown). The variation we report in overall CFR across states could be attributable, in part, to the distribution of highly lethal methods used in suicide attempts. Because household firearm prevalence is also highly correlated with suicide attempt rates

Table 3 Rates of Suicide Attempts (per 100,000 Population) across Seven Northeastern States, Listed in Order of Firearm Prevalence, from Highest to Lowest^a

	All Methods	Firearm	Poisoning/Cutting/Piercing	Suffocation/Hanging	All Other Methods
Vermont	77	9	63	2	3
Maine	80	9	66	3	3
New Hampshire	78	7	65	3	3
Connecticut	67	4	57	3	2
Rhode Island	76	3	65	4	3
Massachusetts	64	2	55	4	3
New Jersey	55	3	48	3	2
Suicide attempts by method (%)		5	85	6	5

^a The percentage of suicide attempts by method in the last row sum to 101% because of rounding.

with firearms (correlation coefficient = 0.99; $p < 0.001$) (Table 4), but not with other highly lethal means such as hanging/suffocation, it may be that a state's overall case fatality rate, like its overall rate of suicide, is strongly influenced by the proportion of attempts that are firearm related, which, in turn, is strongly related to firearm prevalence.

Our study is subject to several caveats. First, the seven states we analyzed do not represent the United States either demographically or geographically. Consequently, our findings should not be used to extrapolate to national estimates of suicide acts.

Second, for several reasons, our counts of suicide attempts may be low. For example, suicide attempts treated only in clinics, physicians' offices, and emergency rooms were not included in our estimates. Previous work suggests that our method of counting may have underestimated the number of suicide acts by a substantial amount. For example, in the late 1960s in Allegheny County, Pennsylvania, 28% of suicide acts were not medically treated (or treatment was unknown);¹ in a study of college students in Nevada, of the 18 students who reported that they attempted suicide and received some form of medical attention, only 9 were admitted to a medical hospital;⁴¹ and in Belgium, 28% of suicide attempts reported by general practitioners did not involve a referral to a higher level of care.⁴² In addition, suicide acts may go unreported even if medical attention is sought in a hospital, because of diagnostic failure (e.g., misclassified as an unintentional injury or an injury of undetermined intent) or

because of reluctance to impose stigma or possible loss of insurance benefits.^{3,43} Nevertheless, there is no reason to expect underreporting bias to be correlated with firearm prevalence and therefore, on these grounds, no reason to expect that the relationships we report are biased.

Third, because attempts resulting in serious injury are more likely to result in hospitalization than attempts that do not result in injury or serious injury, our estimates of attempt and case fatality rates may be differentially biased depending on the method used. Our estimates of suicide attempt rates with firearms are, consequently, probably closer to the actual attempt rate than our attempt rate estimates for means other than firearms. This suggests that the difference between firearm case fatality rate and the case fatality rate for other methods may be even greater than reported.

Fourth, states may differ in the propensity with which individuals making similar attempts seek medical care (again, this is more likely to be a problem for attempts that do not cause serious injury). The extent to which differential rates of seeking medical attention may have contributed to the attempt (or case fatality) rates we observed is not known. Similarly, the variation we report in overall case fatality rates across states might be attributable to state level differences in thresholds for hospitalizing an attempted suicide, or to other unmeasured variables, such as the training and qualifications of coroners and medical examiners,⁴⁴ use of postmortem examinations in determining cause of death, and coding guidelines.

Table 4 Correlation Coefficients for the Association between Rates of Household Firearm Ownership and Suicide Attempts, Firearm Suicide Attempts, and Nonfirearm Suicide Attempts across the Seven States, 1996–2000

	Suicide Attempt Rate	Suicide Attempt Rate with Firearms	Suicide Attempt Rate with Means Other than Firearms
All ages	0.73~	0.99***	0.51
Male subjects	0.72~	1.0***	0.11
Female subjects	0.73~	0.93**	0.70~
15–24 yr old	0.66	0.90**	0.44
25–44 yr old	0.58	0.97***	0.33
45–64 yr old	0.45	0.98***	-0.04
65 yr old and older	0.79*	0.96***	-0.20

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; ~ $p < 0.1$.

Estimates are not reliable for the 5 to 14-yr age group over the study period because there are so few suicides among this age group.

Table 5 Case Fatality Rates by State and Method, Listed in Order of Firearm Prevalence from Highest to Lowest

	All Methods (%)	Firearm (%)	Poisoning/Cutting/Piercing (%)	Suffocation/Hanging (%)	All Other Methods (%)
Vermont	16	88	3	75	16
Maine	17	91	4	90	30
New Hampshire	15	91	4	80	16
Connecticut	13	91	4	77	30
Rhode Island	11	91	3	73	23
Massachusetts	12	90	3	77	29
New Jersey	13	93	3	87	39
All seven states	13	91	3	80	30

Fifth, our study does not include control variables because of the small number of observations. Suicide rates may be affected by many factors other than firearm prevalence, such as parenting, family violence, the media, a community's social capital, and social fragmentation. It is not clear whether trying to account for these or other area-wide characteristics would increase or reduce the magnitude of the association between rates of household firearm ownership and suicide. Addition of control variables would bring a potential cost of introducing several collinear measures at the state level, perhaps the most obvious example of which is a state's level of urbanization, which is highly colinear with household firearm ownership rates. Our finding that rates of household firearm ownership are strongly associated with rates of suicide, and that the association is driven by the correlation between household firearms and firearm (but not nonfirearm) suicide, is nevertheless consistent with similar findings in studies that used proxies of firearm ownership and simultaneously controlled for several state-level confounders, including urbanization, alcohol, poverty, divorce, unemployment, and education.^{22–24}

Sixth, although our estimates of firearm ownership have the advantage of being the first direct survey estimates of state level firearm ownership, these estimates may not be accurate. For example, telephone surveys typically underrepresent poor people (e.g., households without telephones), and it appears that women living in two-adult households with guns often do not have accurate information about whether there is a gun in the home.^{45,46} In addition, our measures do not provide direct information about the ease with which high-risk individuals can obtain firearms at flea markets, at gun shows, or on the streets, and those who have obtained firearms illegally may be less inclined to report them on surveys. Nevertheless, this is the first study of the firearm-suicide connection that does not rely on a proxy to estimate household firearm ownership rates at the state level and, given our findings, suggests that our measures of household firearm ownership are correlated with accessibility to firearms used in suicides.

A potentially more problematic issue with our estimates of firearm ownership rates is that our suicide attempt and mortality data pertain to attempts, fatal and nonfatal, that occurred between 1996 and 2000, whereas our estimates of firearm prevalence come from the 2001 BRFSS and measure exposure in 2001. Before the 2001 BRFSS, survey based state-level estimates of firearm prevalence were available for only a nonrandom 21 states (3 of which were in the northeast).²¹ Fortunately, at least for purposes of estimating firearm prevalence over a short period of time, changes in the stock of firearms at the state level are likely to be quite small from year to year (because the stock of firearms in the United States is so high and firearms have such a long useable life). Indeed, for the three northeast states for which data are available both in the mid 1990s and in 2001, measures of firearm prevalence in the 1990s correlated very highly with

measures in 2001. Specifically, household firearm ownership rates in Connecticut, Rhode Island, and New Jersey from the mid 1990s were 18%, 14%, and 12%, respectively, compared with 17%, 13%, and 12% in 2001.^{21,33} The relative stability over time of state-level household firearm ownership rates held not only in the northeast but also for all 21 states surveyed in the 1990s (correlation coefficient = 0.95). Thus, our estimates of household firearm ownership rates, although collected in 2001, are likely to be reliable reflections of ownership rates for the 5-year study period 1996 to 2000.

Lastly, our study has limitations resulting from the use of group-level rather than individual-level data. Of particular concern is the possibility that people who commit suicide with a firearm may not own firearms (or live in households with firearms) even if they live in states with disproportionately high firearm levels. However, because a firearm must be the instrument of death for individuals who commit suicide with a firearm, we know that individuals who actually commit suicide with a gun had access to a gun.

Despite these limitations, we find that among our seven northeastern states, where firearm ownership levels are higher, a disproportionately large number of people have died as a result of suicide. This association is driven by firearm (not nonfirearm) suicide, holds for every age group, and cannot be accounted for by differences across states in rates of medically serious suicide attempts or in the likelihood that an attempt with a given method will prove lethal. Considered together, these findings strongly suggest that when it comes to suicide, the availability of household firearms matters—a lot.

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