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Firearm Availability and Suicide, Homicide, and Unintentional Firearm Deaths Among Women

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ABSTRACT

Context. *In the United States, more than 45,000 women died from gun violence over the last decade.*

Objective. *To determine whether measures of firearm availability are related to rates of suicide, homicide, and unintentional firearm deaths among women in the United States.*

Design. *Pooled cross-sectional time series data on suicide, homicide, and unintentional firearm deaths (1988–1997) were used to estimate the association between the rate of violent death among women and four proxies of firearm availability. Two proxies came from survey reports of household firearm ownership rates; two were derived from mortality statistics.*

Setting. *United States, 1988–1997.*

Results. *The increased rate of suicide and homicide in states with high gun levels was accounted for primarily by significantly elevated firearm suicide and firearm homicide rates. Unintentional firearm death rates were also increased in states with more guns. At the regional level, qualitatively similar results were obtained.*

Conclusion. *Between 1988 and 1997, the suicide, homicide, and unintentional firearm death rates among women were disproportionately higher in states where guns were more prevalent. The elevated rates of violent death in states with more guns was not entirely explained by a state's poverty or urbanization and was driven primarily by lethal firearm violence, not by lethal nonfirearm violence.*

KEYWORDS *Accidents, Firearms, Guns, Homicide, Suicide, Unintentional Death, Violence, Women.*

INTRODUCTION

In the United States, over 45,000 women died from gun violence between 1988 and 1997.[1] Among women 20 years of age and older, 22,614 took their own lives with guns, 21,587 were shot and killed by others, and 1,114 were killed unintentionally

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with firearms. An additional 34,049 died from nonfirearm suicides and 20,438 from nonfirearm homicides.

Case-control studies suggest that the presence of a gun in the home substantially increases the risk of suicide and homicide among women[2] and among adults.[3,4] These findings are consistent with those of others, suggesting that the purchase of a handgun[5] is associated with an increased risk of suicide and homicide among adults and an increased risk of suicide among adolescents.[2,6–10] Cross-sectional and interrupted time series studies suggest a link between the availability of guns and rates of suicide and homicide among adults[11–17] and with the rate of unintentional firearm deaths among children and adults.[18,19]

Case-control studies of household gun ownership and violent deaths provide useful, individual-level information about context; interrupted time series studies help control for many unobserved time-invariant confounders. These studies, however, have been geographically limited. In addition, case-control studies have not accounted for the risk associated with gun availability in the larger community. For example, case-control studies have been unable to take into account how having gun-owning neighbors might deter would-be murderers from preying on members of a community or, alternatively, how an armed neighbor might turn an otherwise nonlethal argument into a fatal one. Although nationally representative cross-sectional studies of firearm availability and mortality net out (or sum) individual- and area-level risk, these studies have been hampered by the lack of direct measures of gun availability at levels smaller than the nine census regions. In addition, none have specifically focused on risk factors for women—which case-control studies suggest may differ from those for men (e.g., homicide by intimates is a far greater problem when the victim is a woman than when the victim is a man).[2,20] Furthermore, because of the much higher rate of violent death among men compared to women, previous analyses are dominated by the relationships between violent death and risk factors among men.

Our study extended previous findings by focusing on women and by further exploring the relationship between firearm levels and violent death at the state level. We took advantage of the greater variability in dependent and independent variables that exist when states rather than regions are compared by using three state-level proxies for gun availability (one survey-based measure available for a nonrandom 21/50 states and two nonsurvey measures derived for all 50 states). These results were then compared to those obtained at the regional level, for which another survey-based measure of firearm ownership was available. In addition, we adjusted for poverty and urbanization levels, factors previously linked to the rate of violent death.[21–27]

METHODS

We used pooled cross-sectional time series data from the 50 US states over a 10-year period (1988–1997) to examine the association between four different measures of the availability of firearms and the corresponding rates of suicide, homicide, and unintentional firearm deaths among adult women 20 years of age and older. Women were divided into six groups by years of age (20–24, 25–34, 35–44, 45–54, 55–64, and 65 and older).

State- and year-specific population figures and data for the number of suicides (International Classification of Diseases, 9th revision [ICD-9], codes E950.0–E959), homicides (E960.0–E969), suicides by firearm (E955.0–E955.4), homicides

by firearm (E965.0–E965.4), unintentional deaths caused by firearm (E922.0–E922.9) came from the National Center for Health Statistics (NCHS) Mortality Files. Deaths from firearms of undetermined intention (ICD-9 E985) constituted less than 2% (606/45,315) of all firearm deaths among women and were excluded from analyses. Region-specific population and mortality figures were derived by aggregating the corresponding state-based figures.

Two of our measures of firearm availability came from published survey-based estimates of household firearm ownership, one at the state level and the other at the regional level. At the state level, published data on reported household gun ownership rates are available for 21 states from the 1990s Behavioral Risk Factor Surveillance System (BRFSS).[28] The 21 states for which the BRFSS obtained data on household gun ownership are a nonrandom sample; they were not, however, selected on the basis of the rates of violent death or the purported relationship between gun levels and violent death rates. The second survey-based measure of firearm availability, collected at the level of the nine census regions, comes from the average of reported household gun ownership rates between 1988 and 1998, as reported in the General Social Surveys (GSS).[29]

Direct measures of exposure to guns are not available at the state level for all 50 US states. To allow all 50 states to contribute to the analyses, we used two measures derived from mortality statistics as proxies for firearm availability: (1) Cook's Index, developed and previously validated at the city level,[14] and (2) the fraction of all suicides that involved a gun. Both of these measures have been used in cross-sectional studies within the United States,[30–32] and Cook's Index has also been independently correlated with household gun ownership levels across 14 industrialized nations.[33]

Cook's Index for a given state in a given year is calculated by averaging (among adults of both genders 20 years old and older) the percentage of all suicides committed with a firearm and the percentage of all homicides committed with a firearm. That is,

$$\text{Cook's Index} = (\text{Fraction of suicides with guns} + \text{Fraction of homicides with guns})/2$$

The second mortality-derived estimate of firearm availability is closely related to Cook's Index: the fraction of suicides that are gun related. This proxy is referred to as FS/S in the text to indicate that it is the number of firearm suicides in a given state-year (among adults) divided by the total number of suicides in that state-year (among adults).

A state's FS/S and Cook's Index reflect the distribution of firearm versus nonfirearm means of suicide (in the case of FS/S) and the distribution of firearm versus nonfirearm means of suicide and homicide (in the case of Cook's Index). Neither FS/S nor Cook's Index inherently reflects the number or rate of suicides or homicides in a state. For example, FS/S is based on the assumption that firearms are likely to be more readily available in states where guns make up a larger fraction of all suicides than in states where guns make up a smaller fraction of all suicides—independent of the number or rate of suicides in a state. If 90 of every 100 suicides in state A are firearm suicides and in state B 10 of every 100 suicides are firearm suicides, FS/S assumes that guns are more readily available in state A than in state B. FS/S assumes nothing about the relative number or rate of suicides in state A and state B. The null hypothesis (which we set out to test) states that gun availability does not influence the overall suicide rate—that is, if people really want to commit suicide, they will find the means. FS/S merely reflects the distribution of

these means. Therefore, FS/S and, by similar reasoning, Cook's Index do not per se bias our testing of the null hypothesis.

Qualitatively and statistically similar results were obtained whether Cook's Index (or FS/S) assumed the average Cook's Index (average FS/S) for each state over the 10-year study period, a 5-year rolling average, or a specific value for each state-year. We present results using 10-year averaged values for all our proxies since the gun stock in the United States is so high (over 200 million guns) that changes in a state's stock are likely to be quite small from year to year and because using a 5-year rolling average would require us to drop data from 2 of our 10 years of data (i.e., 1996 and 1997). The 10-year averaged measures yielded regressions that were qualitatively similar to regressions using 5-year rolling averages and also to regressions in which we used the specific Cook's Index (FS/S) for each state-year.

To make the comparisons among our four proxies more intuitive, all were standardized so that each proxy had a mean of 0 and a standard deviation of 1. The raw average values (1988–1997) for Cook's Index, FS/S, and the BRFSS survey-based gun ownership levels are presented to two decimal points in Table 1, ranked according to Cook's Index. The dependent variable used in our analyses is the number of deaths per population per state/year. Distributions of death rates were skewed, and variances were greater than the means. Consequently, negative binomial models were used (rather than Poisson).

A state's suicide, homicide, and unintentional firearm death rates in a given year were not independent from rates in that state in other years. To account for this nonindependence, standard errors in regressions were corrected by clustering observations (by state in the regressions presented in Table 2, by region in Table 3).

Primary analyses use incidence rate ratios (IRRs), obtained by exponentiating β coefficients in the negative binomial regressions, to express the magnitude of the association among suicide, homicide, and unintentional firearm death rates and gun availability. Since the standard deviation of each of the standardized proxies is, by construction, equal to 1, the reported IRRs represent the percentage change in the dependent variable (e.g., the suicide rate) for a unit change in the independent variable (i.e., for a change of one standard deviation of the proxy under consideration). Because the proxies differ somewhat from each other in their ranges (and a given proxy will have a different range when considered at the state vs. the regional level), comparisons of IRRs must take into account the range of the particular proxy under the conditions specified. The relevant ranges are specified in the legends for each table.

State-based analyses adjust for the percentage of the population living in poverty and the percentage of the population living in urban areas, factors that have been linked to homicide and suicide rates.[22–27] When data for these control variables were not available for all years, values for missing observations were interpolated from surrounding years. Whether interpolations were linear interpolations from the surrounding years or averages of the 4 years closest to the missing year did not materially affect results. Linear interpolations were used in the data presented. Data for control variables came from the Statistical Abstracts of the United States (poverty and urbanicity). In the region-based analyses, we did not control for other variables because of the small number of observations.

RESULTS

Overall, bivariate and multivariate results showed positive and statistically significant associations between gun availability and state-level rates of suicide, homicide,

TABLE 1. State-level proxies of firearm availability, nonstandardized average values ranked by Cook's Index, 1988–1997

State	BRFSS	FS/S	Cook's Index
Hawaii		0.29	0.37
Massachusetts		0.31	0.40
New Jersey	0.12	0.35	0.43
Rhode Island	0.14	0.36	0.45
Delaware	0.28	0.48	0.48
South Dakota		0.63	0.48
Minnesota		0.51	0.52
New York	0.14	0.37	0.53
Iowa		0.55	0.54
New Hampshire		0.57	0.54
Connecticut	0.18	0.44	0.56
Illinois		0.47	0.56
North Dakota		0.59	0.56
Colorado	0.38	0.57	0.57
Maine		0.61	0.57
Washington		0.57	0.58
Wisconsin	0.49	0.54	0.58
Utah		0.59	0.58
New Mexico	0.43	0.63	0.59
Pennsylvania	0.41	0.55	0.60
Oregon	0.49	0.61	0.60
Nebraska		0.58	0.61
California	0.30	0.53	0.61
Ohio		0.60	0.62
Alaska		0.70	0.63
Michigan	0.46	0.57	0.63
Montana		0.69	0.63
Maryland		0.56	0.63
Florida		0.60	0.64
Nevada		0.67	0.65
Kansas	0.41	0.64	0.65
Vermont		0.67	0.65
Oklahoma	0.54	0.69	0.65
Indiana	0.40	0.63	0.66
Arizona	0.33	0.67	0.67
Idaho	0.57	0.71	0.67
Missouri		0.65	0.68
South Carolina		0.72	0.69
Texas		0.68	0.69
Virginia		0.68	0.69
Wyoming		0.74	0.70
North Carolina		0.72	0.70
Georgia		0.74	0.72
Tennessee		0.74	0.72
Kentucky	0.49	0.74	0.72
West Virginia	0.51	0.75	0.73
Arkansas		0.75	0.73
Mississippi	0.55	0.80	0.74
Alabama		0.78	0.75
Louisiana	0.53	0.76	0.75

BRFSS, Behavioral Risk Factor Surveillance System; FS/S, firearm suicides in a state-year (among adults) divided by the total number of suicides in that state-year (among adults).

TABLE 2. Crude and multivariate adjusted incidence rate ratios (IRRs) of state-level suicide, homicide, and unintentional firearm deaths among women 20 years of age and older in the United States by state-level measures of household firearm availability, 1988–1997

	Suicide	Firearm suicide	Nonfirearm suicide
Bivariate			
Cook	1.09 (1.02, 1.15)*	1.61 (1.46, 1.78)†	0.86 (0.79, 0.93)†
FS/S	1.12 (1.06, 1.19)†	1.70 (1.50, 1.84)†	0.88 (0.81, 0.95)*
BRFSS	1.16 (1.05, 1.27)**	1.64 (1.38, 1.95)†	0.95 (0.84, 1.08)
Multivariate			
Cook	1.13 (1.02, 1.24)‡	1.64 (1.39, 1.94)†	0.93 (0.85, 1.02)
FS/S	1.25 (1.15, 1.36)†	2.01 (1.83, 2.22)†	0.99 (0.91, 1.08)
BRFSS	1.37 (1.22, 1.53)†	1.88 (1.44, 2.44)†	1.22 (1.09, 1.37)*
	Homicide	Firearm homicide	Nonfirearm homicide
Bivariate			
Cook	1.34 (1.23, 1.46)†	1.58 (1.46, 1.71)†	1.17 (1.08, 1.27)†
FS/S	1.26 (1.16, 1.38)†	1.46 (1.32, 1.61)†	1.11 (1.02, 1.21)‡
BRFSS	1.17 (1.01, 1.35)‡	1.32 (1.12, 1.56)*	1.04 (0.90, 1.20)
Multivariate			
Cook	1.37 (1.26, 1.48)†	1.60 (1.48, 1.73)†	1.20 (1.11, 1.31)†
FS/S	1.33 (1.20, 1.47)†	1.53 (1.36, 1.72)†	1.17 (1.06, 1.30)*
BRFSS	1.09 (0.97, 1.22)	1.22 (1.08, 1.37)*	1.01 (0.88, 1.15)
	Unintentional firearm deaths		
Bivariate			
Cook	2.29 (1.82, 2.88)†		
FS/S	2.20 (1.75, 2.75)†		
BRFSS	1.65 (1.33, 2.06)†		
Multivariate			
Cook	2.11 (1.62, 2.73)†		
FS/S	2.30 (1.54, 3.43)†		
BRFSS	1.28 (0.94, 1.74)		

In the multivariate analyses, IRRs are adjusted for the percentage of a state's population living in poverty and the percentage of the state's population living in urban areas.

IRRs represent the percentage change in the dependent variable (e.g., the suicide rate) for a unit change in the independent variable (i.e., for a change of one standard deviation of the proxy under consideration).

Gun availability is measured using three different state-level proxies: (1) Cook's Index (Cook), which is defined as the average of the fraction of suicides with guns and the fraction of homicides among adults with guns (among adults); (2) the percentage of suicides among adults that are firearm suicides (FS/S); and (3) the percentage of households that reported owning a firearm in the Behavior Risk Factor Surveillance System (BRFSS) survey of a nonrandom 21 states. These three proxies were standardized so that their mean equals 0 and their standard deviation equals 1.

IRRs correspond to the standardized proxies, which range from 4.2 standard deviations for Cook's Index to 4.1 standard deviations for FS/S to 3.2 standard deviations for BRFSS Household Gun levels.

*$P < .01$; †$P < .001$; ‡$P < .05$.

TABLE 3. Crude incidence rate ratios (IRRs) of regional suicide, homicide, and unintentional firearm deaths among women 20 years of age and older in the United States by region-level measures of household firearm availability, 1988–1997

	Suicide	Firearm suicide	Nonfirearm suicide
Cook	1.11 (1.02, 1.22)*	1.56 (1.37, 1.78)†	0.89 (0.76, 1.03)
FS/S	1.13 (1.01, 1.27)*	1.61 (1.40, 1.86)†	0.90 (0.76, 1.06)
GSS Hand Guns	1.14 (1.00, 1.31)‡	1.63 (1.33, 2.00)†	0.90 (0.76, 1.05)
GSS All Guns	1.09 (0.96, 1.25)	1.53 (1.23, 1.89)†	0.87 (0.75, 1.02)‡
	Homicide	Firearm homicide	Nonfirearm homicide
Cook	1.33 (1.22, 1.46)‡	1.52 (1.37, 1.67)‡	1.18 (1.07, 1.30)‡
FS/S	1.29 (1.13, 1.46)‡	1.45 (1.25, 1.68)‡	1.14 (1.01, 1.29)*
GSS Hand Guns	1.29 (1.11, 1.49)§	1.45 (1.22, 1.72)‡	1.14 (1.00, 1.30)*
GSS All Guns	1.23 (1.07, 1.42)§	1.38 (1.15, 1.65)‡	1.10 (0.98, 1.24)
	Unintentional firearm deaths		
Cook	2.11 (1.68, 2.65)‡		
FS/S	2.01 (1.61, 2.52)‡		
GSS Hand Guns	1.98 (1.68, 2.33)‡		
GSS All Guns	1.98 (1.66, 2.66)‡		

Gun availability is measured using four different regional-level estimates, two derived from mortality statistics, and two regionally gathered survey estimates of household gun ownership. The two derived proxies are (1) Cook's Index (Cook), which is defined as the average of the fraction of suicides among adults with guns and the fraction of homicides among adults with guns, and (2) the percentage of suicides among adults that are firearm suicides (FS/S). The survey-based measures are the regional household ownership rates of any firearms and of handguns in particular, as reported in the GSS.

All proxies in this table were standardized at the regional level so that their mean equals 0 and their standard deviation equals 1.

IRRs correspond to the standardized proxies. At the regional level, the range for all standardized measures of household gun ownership is approximately equal: 3.4, 3.1, 3.3, and 3.4 for Cook's Index, FS/S, GSS Hand Guns, and GSS All Guns, respectively.

*$P < .05$.

‡$P < .1$.

§$P < .01$.

†$P < .001$.

and unintentional firearm death among adult women (Table 2). The increased rate of suicide in states with high gun levels was accounted for by elevated firearm suicide rates, which more than offset the decrease in nonfirearm suicide rates in high-gun states. The increased rate of homicide in states with high gun levels was accounted for primarily by significantly elevated firearm homicide rates, although the rate of nonfirearm homicide was also elevated to a lesser extent.

The 21 states for which household firearm ownership rates are available (the BRFSS sample) do not include 2 of the 5 states with the highest gun levels and 2

of the 5 states with the lowest gun levels (as ranked by Cook's Index). Nevertheless, analyses showed an association between household firearm ownership rates and overall rates of both suicide and homicide (Table 2). For suicide, both bivariate and multivariate analyses are significant at the $P < .05$ level; for homicide, bivariate analyses are significant at the $P < .05$ level, but multivariate analyses do not quite reach statistical significance. Among the 21 states for which household gun ownership rates are published, for each standard deviation increase in the percentage of households reporting at least one firearm in the home (range = 3.2 standard deviations), the bivariate rate for overall suicide rate increased by 16% (driven by a 64% increase in firearm suicide rates); the overall homicide rate increased by 17% (driven by a 32% increase in firearm homicide).

When all 50 US states contribute to analyses (Table 2), for each standard deviation increase in Cook's Index (range = 4.2 standard deviations), the multivariate-adjusted rate for suicide increased by 13% (driven by an increase in firearm suicide rates of 64%); the homicide rate increased by 37% (driven by a 60% increase in the rate of firearm homicide). The corresponding unintentional firearm death rate increased by 111%. Similarly, when FS/S was used as the proxy for all 50 states, for each standard deviation increase in FS/S (range = 4.1 standard deviations), the multivariate-adjusted rates for suicide, homicide, and unintentional firearm deaths increased by 25%, 33%, and 130%, respectively.

At the regional level (Table 3), despite the contraction of variability in going from 50 states to 9 regions, we generally observe a positive association between gun availability and the rates of suicide, homicide, and unintentional firearm death. Results using household firearm ownership rates reported in the nationally representative GSS survey (the GSS proxy) are similar to those obtained with the other proxies. For each standard deviation in a given proxy, the suicide rate increased approximately 10%–15%, the homicide rate increased approximately 25%–30%, and the unintentional firearm death rate increased approximately 100%.

Differences in incidence rate ratios (i.e., point estimates) reported for proxies based on surveys and proxies derived from mortality statistics (Tables 2 and) appear less to do with the gun availability proxies themselves and more to do with the sample of states in an analysis. For example, differences between point estimates reported for BRFSS and FS/S (Table 2) are largely due to the fact that results for BRFSS are based on analyses using only 21 of the 50 states used in the analyses for which we report incidence rate ratios for FS/S (and Cook's Index). When we restricted analyses to only the 21 states for which BRFSS firearm ownership measures are available, point estimates associated with BRFSS, Cook's Index, and FS/S are not statistically different and, overall, are within ±10% of one another (not shown). At the regional level, for which the samples are all equal (i.e., the nine census regions), survey-based measures (BRFSS and GSS) and the derived measures (Cook's Index and FS/S) have similar point estimates and a similar range of values (range 3.1 to 3.4; Table 3).

Table 4 compares the actual number of women who were victims of homicide, suicide, or unintentional firearm death (1988–1997) in the five states with the highest Cook's values to the corresponding rates in the five states with the lowest Cook's values. These states were chosen on the basis of their extreme firearm levels, not on the basis of their extreme violent death rates among women. Compared to women living in the low-gun states (Hawaii, Massachusetts, Rhode Island, New Jersey, and Delaware), women living in the high-gun states (Louisiana, Alabama,

TABLE 4. Homicide, suicide, and unintentional gun deaths among women 20 years of age and older in the five US states with the highest versus the lowest average Cook's Index of gun availability, 1988–1997

	High gun States	Low gun States	Mortality rate ratio (high gun : low gun)
Total population (1988–1997)	57 million	65 million	
Suicides			
Gun suicides	2,294	401	6.5
Nongun suicides	1,197	2,262	0.6
Total	3,491	2,663	1.5
Homicides			
Gun homicides	2,309	536	4.9
Nongun homicides	1,626	1,114	1.7
Total	3,935	1,650	2.7
Unintentional firearm deaths	196	20	11.2

The five states with the highest average gun levels (1988–1997) were Louisiana, Alabama, Mississippi, Arkansas, and West Virginia. The five states with the lowest average gun levels were Hawaii, Massachusetts, Rhode Island, New Jersey, and Delaware.

Mississippi, Arkansas, and West Virginia) were 1.5 times as likely to die from suicide, 2.7 times as likely to die from homicide, and 11.2 times as likely to die from an unintentional firearm injury.

Our firearm proxies gave similar results since they are highly correlated (Table 1). Not only are Cook's Index and (the derivative) FS/S highly correlated, but these proxies are also highly correlated with survey-based measures. At the state level, the correlation coefficient for the BRFSS survey-based estimates of household firearm ownership (among the 21 states for which data are available) is 0.81 with Cook's Index and 0.88 with FS/S. Among the subgroup of 21 states for which BRFSS provides household ownership levels, the 5 states with the highest reported household ownership levels constituted 4 of the 5 states with the highest FS/S and 3 of the 5 states with the highest Cook's Index. Similarly, the 5 states with the lowest reported household gun levels corresponded to the same 5 states with the lowest FS/S and Cook's Index. At the regional level, our modified Cook's Index and FS/S were also highly correlated with household firearm ownership levels reported in the GSS (correlation coefficient = 0.86 and 0.89, respectively). The two survey-based estimates of household gun ownership rates were also similar: When the BRFSS estimates of household firearm ownership were collapsed to the regional level, the correlation with GSS estimates was 0.88. Because of the high correlations among all proxies, we believe that analyses using Cook's Index and FS/S (which use information from all 50 US states) better represent the relationship between gun availability and violent death among women in the United States than do analyses using only the nonrandom 21 states that provide gun ownership data from the BRFSS.

DISCUSSION

The present study is the first nationwide cross-sectional study to examine the relationship between firearm availability and violent death among women within the United States. We found that each of our proxies led to the same conclusion:

Women were more likely to die from suicide, homicide, and unintentional firearm injuries if they lived in states (or regions) with more, rather than fewer, guns. Overall, the relationship between guns and violent death among women persisted at both the state and the regional level, in virtually every age group (not shown), and even after controlling for state-level poverty and urbanization.

If, as has been suggested for adolescents and adults generally,[34–36] suicides and homicides among women are commonly impulsive acts, the easier it is to find lethal means, such as firearms, the more suicides and homicides there might be. On the other hand, if the choice of firearm has less to do with the availability of the weapon than with the strength of the intent, persons determined to kill others or themselves will work harder to get a gun where guns are less available or will substitute other lethal means. Consistent with some,[11–17,22,37] but not all,[38] previous studies among US adults, we found that not only firearm-related suicide rates, but also overall suicide rates, were significantly associated with state and regional gun levels. The increase in overall suicide rates associated with greater firearm availability, together with our finding of a small but significant inverse relationship between nonfirearm suicide rates and relative gun availability, suggests that substitution of equally lethal means for guns appears to occur, but does so incompletely.

The increased rate of homicide in states with high gun levels was accounted for primarily by significantly elevated firearm homicide rates (Table 2), although the rate of nonfirearm homicide was also elevated to a lesser extent. The disproportionately high level of firearm related (compared to nonfirearm-related) homicide in states (and regions) where guns are more available suggests that where there are more guns, regardless of the baseline level of nongun homicide, violence is more likely to turn lethal.

Over the 10-year study interval, 1,114 women died from unintentional firearm deaths. The 11-fold higher unintentional firearm death rate among women from the five states with the highest gun levels compared to that for women from the five states with the lowest gun levels (Table 4) is not readily accounted for by any identifiable variable other than guns. Because of the relatively small number of unintentional firearm deaths (606/45,315), the statistical significance of our findings is reduced when multivariate analyses are conducted and when cell size is limited by parsing deaths at the state level.

Using measures that rely on different estimating mechanisms may capture different (perhaps complementary) aspects of the relevant exposure variable. The extent to which Cook's Index or FS/S captures some of these factors better (or less well) than do survey-based estimates of household gun ownership rates is unknown. In any event, household gun ownership levels (BRFSS and GSS measures) and our mortality-derived estimates (Cook's Index and FS/S) are highly correlated, suggesting that they provide information about similar constructs.

Our findings are robust. The proxy chosen did not drive the regression results. Regressions also were not driven by either the largest states or the states most extreme in gun levels. Statistically significant and qualitatively consistent results were produced regardless of whether the data analyzed were for the 50 US states or the 40 largest or the 40 smallest states or when analyses excluded the 5 states with the highest (or lowest) Cook's Index (or FS/S). We obtained similar results even when we used the survey-based estimates of household firearm ownership rates among the non-random 21 states for which this measure was available. Analyses using only the 9 census regions likewise produced qualitatively similar findings. Including the 606 (1.3%) firearm deaths coded as firearm deaths of undetermined

origin (ICD-9 E985) did not alter our findings, regardless of whether these deaths were included as firearm suicides, firearm homicides, or unintentional firearm deaths.

Consistent with others, we found that overall unintentional firearm death rates were positively associated with poverty[23] and inversely related to urbanization.[23,24] In addition, we found that higher homicide rates were associated with higher rates of poverty[27] and urbanization[25,26] (not shown).

Drawing causal inferences from group data to individual behaviors is generally referred to as the "ecological fallacy."[39–42] For example, although the poverty rate in a given state with a high unintentional gun death rate may be disproportionately high, that does not prove that the actual individuals in this state who are dying from guns are disproportionately poor. On the other hand, if a person dies from gunfire, that particular individual did come in contact with a bullet. The ecological fallacy is thus not likely to be a major issue with our analyses.

A potentially more problematic issue is that of reverse causation—although only in the case of homicide (i.e., reverse causation is not a problem for suicide or for unintentional firearm deaths). It might be that, where homicide rates are higher, individuals are more likely to obtain guns in the belief that they are protecting themselves and their families. Our finding that the nonfirearm homicide rate was slightly higher in areas with more guns is consistent with this supposition. In this case, the direction of any causal relationship between high gun levels and high homicide rates cannot be determined. Nevertheless, our finding that all of our proxies of gun availability are much more strongly related (i.e., associated with disproportionately greater incidence rate ratios) to the rates of gun homicide (and overall homicide) than to the rate of nongun homicide is consistent with firearm availability playing some causal role in homicide rates among women.

Another limitation of our study is that our analyses may not have accounted for some reasons that states with higher gun levels have higher violent death rates. Although we included some potential state-level confounders (poverty and urbanization), these represent only a small number of the characteristics likely to affect suicides, homicides, or unintentional firearm deaths. It is not clear, however, whether accounting for these unobserved characteristics would revise the magnitude of observed association upward or downward.

Most geographically limited US studies have found a positive relationship between gun density measures and overall homicide[43] and suicide[44] rates. Consistent with these studies, we find that of the women in the United States who were killed with firearms between 1988 and 1997, a disproportionately large number, per population, died in states where guns were more prevalent. Moreover, the elevated rates of suicide and homicide among women living in states with more guns appear to be driven largely by lethal firearm violence, not by nonfirearm violence. Our findings suggest that, although guns may confer a theoretical or actual benefit to some women, overall, where there are more guns women are at higher risk of becoming victims of lethal violence.

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