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State and Local Prevalence of Firearms Ownership Measurement, Structure, and Trends

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Of the readily computed proxies for the prevalence of gun ownership, one, the percentage of suicides committed with a gun, is most highly correlated with survey-based estimates. It is the best choice for use in cross-section analysis of the effect of gun prevalence on crime patterns across states and larger counties.

Analysis of this proxy measure for the period 1979–1997 demonstrates that the geographic structure of gun ownership has been highly stable. That structure is closely linked to rural tradition. There is, however, some tendency toward homogenization over this period, with high-prevalence states trending down and low-prevalence states trending up.

KEY WORDS: gun prevalence; proxy variables; measurement; suicide; violence.

1. INTRODUCTION

About 40% of America's households own at least one firearm. The prevalence of ownership differs geographically, ranging from 25% in the Northeast and 35% in the Pacific states, to 60% in the East South Central Census division.[4] Just where a particular state or city falls along this wide spectrum may have a variety of consequences for crime and public health. The probability that a gun is available for immediate use for a suicide attempt, escalating an episode of family violence, or self-defense against an intruder is greater in areas where gun ownership is common than areas where it is less usual. But while firearms prevalence influences availability for these and other crime-related uses, there is no scientific consensus on the consequences of gun prevalence for crime rates.

For example, some commentators have claimed that a greater prevalence of gun ownership deters residential burglary, and especially

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burglaries of occupied homes. An alternative view is that burglary is more profitable in localities with high gun prevalence, because guns are especially valuable loot. A sound empirical strategy for exploring this issue requires a comparison of burglary rates with gun prevalence over a large number of jurisdictions (Cook and Ludwig, 2003). The prevalence of gun ownership may also be an important influence on violent crime patterns, since given what we know about how delinquent youths and criminals obtain guns, the availability of guns for use in crime is closely linked to population prevalence (Cook and Braga, 2001; Cook and Leitzel, 1996). Previous analysis has found that the prevalence of gun ownership is positively correlated with the likelihood of a gun being used in robbery and serious assault (Cook, 1979). There is evidence that, as a result, gun prevalence has a positive effect on homicide rates (Cook and Ludwig, 2002; Duggan, 2001; Miller *et al.*, 2002a, b; Zimring and Hawkins, 1997).

A systematic analysis of the effects of gun prevalence requires a valid measure of gun prevalence. Prevalence cannot be accurately measured from administrative records, since most states do not require registration or licensing, and compliance is poor in those that do (Jacobs, 2002; Vernick *et al.*, 2003). When available, surveys are a more promising source of data on gun prevalence. A number of national surveys have provided such estimates, but national surveys are not designed to support reliable estimates at the state or local level. While there are occasional state or local surveys with gun-ownership items, they provide only spotty coverage and are in any event not entirely comparable due to differences in survey method, response rate, and wording of items.

The remaining possibility for analyzing the effects of gun prevalence is use of a good proxy that is consistently available at the desired level of aggregation. Finding a valid and reliable proxy is an old problem (Cook, 1979), and a number of alternatives have been proposed and utilized, typically without any direct test of validity.

In this paper we analyze several plausible proxies for gun prevalence for which the data are readily available at the state and county level over a number of years. We find that among these proxies is a simple measure that performs as well or better than the rest; namely, the percentage of suicides committed with a firearm. After validating this measure, we use it to describe the geographic structure of gun prevalence, documenting the wide differences among states and the remarkable stability of these differences over recent decades. We further demonstrate that this stable structure is becoming "flatter" over time, with a trend toward greater geographic homogeneity.

That this proxy performs well in the cross section is no guarantee that it also performs well in a time-series analysis. We find that it does correlate

with intertemporal variation in regional gun prevalence over the period 1980 to 1998.

2. SURVEY ESTIMATES OF FIREARMS PREVALENCE

Surveys provide the only useful direct estimates of the prevalence of gun ownership. Most states lack any sort of registration or licensing requirement for gun owners. Even in the handful of states that do have such a requirement in place, the resulting administrative records provide little useful information on the number of gun owners; such records are typically incomplete (due to lack of compliance), out of date, and difficult to access (Jacobs, 2002). Survey data fill this gap, but only to a limited extent.

The "gold standard" for national surveys of gun ownership is the General Social Survey, conducted by the National Opinion Research Center most years from 1972 to 1993 and biennially since 1994 (Davis and Smith, 1998). In its current form the GSS is conducted in person with a national area-probability sample of 3000 non-institutionalized adults. The response rate has been quite high (e.g., 78% in 1994, 76% in 1996, 76% in 1998). Its sample is chosen to be representative of the nation and of each of the nine Census divisions, but not of individual states.

Two other readily available survey sources provide some information on the prevalence of gun ownership at the state level. First, between 1992 and 1995 the Behavioral Risk Factor Surveillance System (BRFSS) included gun-ownership items in surveys conducted in 21 states (Powell *et al.*, 1998). These surveys were conducted under the auspices of state health departments using the random-digit-dial telephone technique. The median sample size of adults ages 18 and over was 2061, and the median response rate was 67%.[5]

Second, two national surveys conducted on behalf of the Harvard Injury Control Research Center (HICRC) provide the basis for state-level estimates. These surveys were conducted by using the random-digit-dial technique in 1996 and 1999, with sample sizes of 1900 and 2500 respectively. States were sampled in proportion to their population relative to that of the United States, yielding a basis for possibly unbiased estimates of state-level household gun ownership, albeit with small sample sizes. Detailed information on these surveys has been published previously (Azrael and Hemenway, 2000; Hemenway *et al.*, 2000; Miller *et al.*, 2000; Powell *et al.*, 1998).

"Prevalence of gun ownership" may be usefully defined with respect to individuals or households, and with respect to all types of guns or just

[5] The median proportion of homes with telephones was 95.6%, and the median refusal rate for the firearm section was 2.0%. For states that asked firearm questions in more than one year, the most recent data were used.

Table I. Alternative Definitions of Gun "Prevalence" Correlation Coefficients Across 9 Census Divisions. GSS Estimates from 1994, 1996, 1998 Combined

	Household gun	Household handgun	Individual gun
Household handgun	0.93	1.00	
Individual gun	0.97	0.91	1.00
Individual handgun	0.92	0.98	0.94

Source. Gun prevalence estimates from NORC General Social Survey, unpublished data.
Note. All coefficients are significantly different from zero, $p < 0.001$.

handguns. (Handguns are of particular interest because they are vastly over represented in crime in comparison with long guns.)[6] The GSS provides enough detail in recent years to estimate all four variants: the percent of households with some type of gun, the percent of households with a handgun, the percent of adult individuals who possess a gun, and the percent of adult individuals who possess a handgun. These four prevalence measures are highly correlated across the nine Census divisions. As shown in Table I, the inter-division correlations are in every case above 0.90 (based on estimates from the GSS for 1994, 1996, and 1998 combined). Hence a proxy that provides a valid approximation to the geographic structure of, say, household handgun prevalence, likely also provides a valid approximation of other measures of prevalence. On the other hand, the four measures have followed somewhat different trajectories over time at the national level.[7]

3. ALTERNATIVE PROXY MEASURES

When survey-based estimates or other direct estimates of gun availability have not been available, social scientists have used proxy measures. Perhaps the first proxy employed in the social-science literature was the fraction of criminal homicides committed with a gun; Brearley (1932) utilized this measure in analyzing the effect of gun ownership on interstate patterns of homicide. Since then it has been used to study the effect of gun availability on homicide rates over time (Fisher, 1976) and across nations (Curtis, 1974; Etzioni and Remp, 1973).

Cook (1979) proposed and validated a related measure, namely the average of the percentages of homicide and suicide involving guns,

[6] The "handgun" category includes pistols and revolvers, while the long-gun category includes rifles and shotguns. While handguns make up only about one-third of the total guns in private hands, they account for over 80% of gun crimes and injuries (Cook, 1991).

[7] Since 1980 the household gun prevalence in the United States has trended down, while the prevalence of individual ownership has been close to constant. The explanation for the difference in trends is in the downward trend in the size of households, and in particular the declining percentage of households that include a man.

demonstrating its application in a study of city robbery rates; other analysts have utilized this "Cook Index" as well (Lester, 1985; Miller *et al*., 2001; Sloan *et al*., 1990). Kleck and Patterson (1993) have offered the most-elaborate proxy, a 5-item factor computed from the percentage gun use in homicide, suicide, assault, and robbery, as well as the value of stolen guns relative to the total property stolen. These and other studies that utilized proxies computed from crime statistics and mortality statistics are summarized in Kleck (1997, pp. 260–261).

An alternative source of proxy measures of gun-ownership levels is statistical information on participation in gun-related activities. Krug (1968), e.g. utilized data on the rate of hunting licenses issued per capita. Recently a prominent study made use of county-level subscription rates to *Guns & Ammo* (Duggan, 2001), a magazine oriented to handgun users.

In what follows, we do not attempt an exhaustive analysis of possible proxies, but focus on two types: those based on U.S. Vital Statistics mortality data, and those based on subscription and membership information. The Vital Statistics data have the virtues of being consistent across time and space, of high quality, and readily available for annual estimates at the national, state, or county level (though only counties with large populations are identified in the public-use data files). We also assess measures based on subscription data for *Guns & Ammo*, and on membership information for the National Rifle Association; these data are available for a number of years at the county level.

The specific list of proxy measures is as follows:

FS/S	Firearms suicides divided by suicides, 1995–1997
FH/H	Firearms homicides divided by homicides, 1995–1997
Cook	The average of FS/S and FH/H
UFDR	Death rate per 100,000 due to unintentional injury from firearm
G&A	Subscriptions to *Guns & Ammo Magazine* per capita, 1996
NRA	NRA members per capita, 1996

Appendix Tables AI and AII provide descriptive statistics and source information.

These measures are for the most part positively correlated with each other, as shown in Table II. Using data for the 50 states, the correlation between NRA (National Rifle Association membership) and G&A (subscription rate for *Guns & Ammo Magazine*) is 0.90.[8] FS/S (the gun fraction in suicide) is highly correlated with UFDR (0.73) but less so with FH/H

[8] We also experimented with the subscription rates for *American Rifleman* and *American Hunter*. The interstate correlation with NRA is 97% for each of them. Presumably it is so high because a subscription to one of these magazines is a benefit of NRA membership.

Table II. Correlation Matrix for Proxy Variables (50 States)

Proxy	FS/S	FH/H	Cook	UFDR	G&A
FH/H	0.37 ($p<0.01$)				
Cook	0.88 ($p<0.001$)	0.78 ($p<0.001$)			
UFDR	0.73 ($p<0.001$)	0.34 ($p=0.02$)	0.67 ($p<0.001$)		
G&A	0.44 ($p<0.01$)	−0.13 ($p=0.36$)	0.23 ($p=0.11$)	0.43 ($p<0.01$)	
NRA	0.35 ($p=0.012$)	−0.14 ($p=0.33$)	0.17 ($p=0.25$)	0.35 ($p=0.012$)	0.90 ($p<0.001$)

Source. See text.

(just 0.37). Correlations between NRA and mortality measures are low or even negative: 0.35 (FS/S), −0.19 (FH/H), 0.55 (UFDR). Thus these proxies are not interchangeable.

4. EVALUATION OF THE PROXY MEASURES

The validity of these proxy measures can be evaluated by correlating them with gun ownership rates estimated from survey data. (See Appendix Table AIII for descriptive statistics and source information.) We note that the survey data are subject to sampling error, which may be quite large for small states, and to both response and non-response errors.[9] But surveys provide the only direct measure of the household prevalence of gun ownership in a population.

This comparison demonstrates that one proxy is of higher quality than all others, as shown in Table III:

- FS/S has the highest correlation with survey-based estimates of household prevalence for all three sources of survey data. The correlation coefficient is 0.90 across the 21 BRFSS states, and not much lower (0.81) across the contiguous 48 states using the HICRC surveys, despite the large sampling errors for the smaller states in those surveys.
- On the other hand, FH/H performs poorly in the cross-state analysis, and averaging it with FS/S (the Cook index) is not as good as simply using FS/S by itself.

[9] A "response" error would occur, for example, if the respondent reported that there was no gun in the household when in fact there was one. The importance of response error is suggested by the fact that wives are less likely to report a gun in the home than husbands (Ludwig *et al.*, 1998). A "non-response" error would occur if there was a difference between gun owners and non-owners in participation with the survey.

Table III. Validity of Proxies for Household Gun Prevalence
Correlation Coefficients

	HICRC $N = 48$ states	BRFSS $N = 21$ states	GSS[a] $N = 9$ divisions
FS/S	0.81	0.90	0.93
FH/H	0.02 ($p = 0.9$)	0.19 ($p = 0.39$)	0.52 ($p = 0.16$)
COOK	0.52	0.77	0.88
UFDR	0.61	0.68	0.85
G&A	0.75	0.67	0.51 ($p = 0.16$)
NRA	0.67	0.55	– 0.06 ($p = 0.88$)

[a] GSS prevalence estimates are here based on pooled data from 1994, 1996 and 1998.
Source. See text.

- UFDR performs well enough but not as well as FS/S, and in any event is based on such a relatively rare event (unintentional shooting death) as to render it useless for small-area estimates.
- NRA membership and the G&A subscription rate are also dominated by FS/S in these comparisons, and in the divisional comparisons appear to be uncorrelated with gun prevalence.

We conclude that FS/S is a superior proxy measure for cross-section analysis, easily computed from available data for state jurisdictions and highly correlated with survey-based estimates.

FS/S can also be calculated for larger counties and other sub-state levels from readily available mortality statistics. To explore the performance of FS/S as a sub-state proxy of firearm ownership we needed to identify states for which sub-state firearm ownership estimates are available. Few states, however, have such estimates. Of the 21 states that included the firearms module in the BRFSS only one state, Colorado, was able to provide us with sub-state survey estimates of household firearms ownership that corresponded to geographic units for which we could calculate FS/S.[10] Colorado collected firearm-ownership estimates (and mortality data) for 12 of the state's 14 Planning and Management Regions (PMRs) in 1996. The 14 PMRs are a partition of the state's counties. Colorado did not estimate household firearm ownership rates for 2 of the 14 PMRs because sample sizes from these 2 PMRS contained too few people ($N < 50$). For the 12 PMRs for which household firearm estimates were available (median sample

[10] Alaska, the only other state that could provide sub-state geographic estimates, could only provide these estimates for four geographic areas.

size = 416, ranging from 57 to 2752) the correlation between FS/S and survey estimates of firearm ownership rates was 0.75 (unweighted). Weighting by sample size increased the correlation to 0.87.

5. ESTIMATION OF GUN PREVALENCE FROM FS/S

The household or individual prevalence of guns in a particular jurisdiction can be estimated from knowledge of FS/S for that jurisdiction. As it turns out, there is a linear (but not proportional) relationship between FS/S and prevalence over the relevant range. Equations for doing the conversion from proxy value to prevalence estimate are presented below. In order to correct for heteroskedasticity due to sampling error in the surveys, these regression equations are estimated using weighted least squares (WLS), with weights equal to the square root of the sample size for each jurisdiction. The weights take account of the fact that the survey-based prevalence estimates are much more precise in some states than others, given that the smaller states have sample sizes as low as 7.

To begin, Fig. 1 depicts a scatterplot of state-level prevalence estimates (from BRFSS and HICRC) against FS/S. The WLS line is superimposed. Note that the linear fit appears quite good for the range that we observe, even though the underlying relationship must be curvilinear at the endpoints (since the gun prevalence must necessarily lie between 0 and 1). It should be noted that for 12 states the proxy value is substantially less (at least 10% points) than the survey estimate; this problem is discussed in a Section 7 below.

Figure 2 depicts a scatterplot of division-level GSS estimates for household and individual prevalence of both firearms and handguns, all plotted against FS/S. The four WLS lines are superimposed. The "fit" is excellent in every case.

Table IV provides coefficient estimates and statistics on "fit" for these and other WLS regression lines depicted in Figs. 1 and 2. It also reports the equation for the regression of household prevalence (estimated from the HICRC surveys) against FS/S across the contiguous 48 states.

As shown in Table IV, there are three equations for estimating household prevalence of firearms, based on quite different sources—GSS for 9 divisions, BRFSS surveys for 21 states, and HICRC surveys for 48 states. The three equations are remarkably similar, particularly with respect to the slope coefficient, which is in every case close to 1.0 (implying a one-to-one relationship between household prevalence percentage and gun percentage in suicide).

Appendix Table AIV provides survey-based prevalence estimates for each state together with the fitted values. The largest disparities, unsurprisingly, show up in the states with small sample sizes.

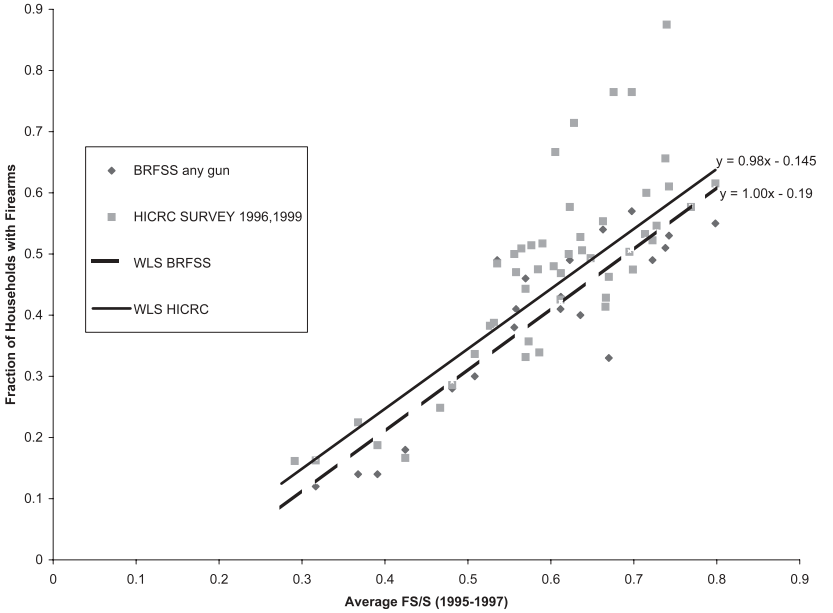

Fig. 1. Survey based state-level household gun ownership vs. FS/S.

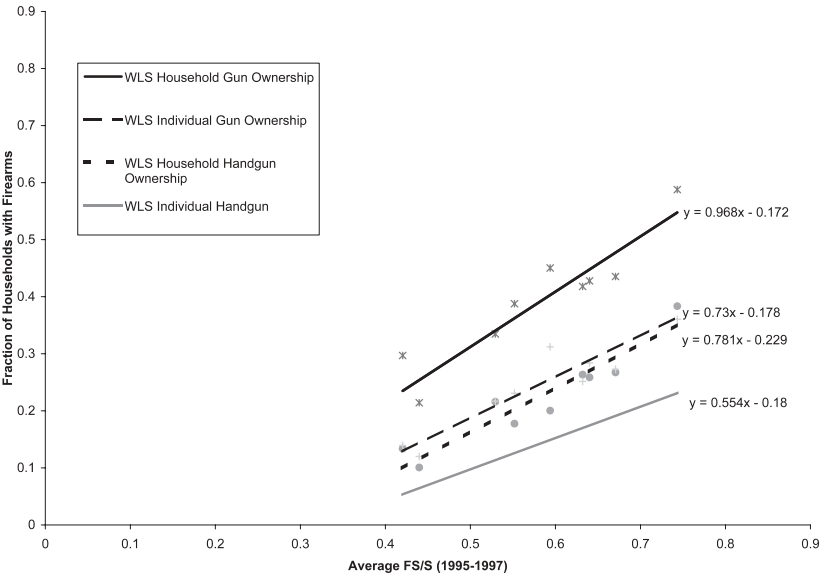

Fig. 2. GSS division-level firearm ownership.

Table IV. Predicting Gun Prevalence from FS/S Weighted Least Squares Regression Results

Data	Intercept (SE)	Coefficient on FS/S (SE)	R^2/Adj-R^2	SEE	Number of observations
HICRC	– 0.145	0.980	0.78/0.77	0.063	48 states
Household	(0.045)	(0.078)			
BRFSS	– 0.202	1.018	0.82/0.81	0.060	21 states
Household	(0.060)	(0.109)			
GSS[a]	– 0.172	0.968	0.87/0.85	0.038	9 divisions
Household	(0.083)	(0.142)			
GSS[a]	– 0.178	0.730	0.92/0.91	0.021	9 divisions
Individual	(0.048)	(0.082)			
GSS[a]	– 0.229	0.781	0.93/0.93	0.021	9 divisions
Household (handgun)	(0.046)	(0.079)			
GSS[a]	– 0.180	0.554	0.96/0.95	0.012	9 divisions
Individual (handgun)	(0.026)	(0.046)			

[a] 1996 data only.

6. THE GEOGRAPHIC STRUCTURE OF GUN OWNERSHIP

The prevalence of gun ownership has a strong regional pattern, with relatively low rates in the Northeast and Pacific Coast, and high rates in the South and Mountain states. This geographic pattern has been quite stable over time, suggesting that the determinants of gun prevalence have more to do with tradition, culture and childhood experience than with concern about crime or other relatively volatile matters.[11]

To explore the evolution of interstate patterns over time, FS/S was calculated for all 50 states and District of Columbia for each of three different periods. As shown in Table V, over a 19-year interval the pattern remained essentially unchanged: the correlation across the states between the earliest period (1979–1981) and the most recent (1995–1997) is 0.95.

What underlies this structure? The answer, to a large extent, is rural tradition (Cook and Ludwig, 1996). The percent of the state's population that was rural in 1950 is highly correlated (across states) with household gun ownership over four decades later: the correlation with FS/S is 0.80 (for the years 1994, 1996, and 1998 combined), and is almost as high for the survey-based estimates.[12]

[11] Cook and Ludwig (1996) found that 80% of adult gun owners had grown up in a household with guns.

[12] The correlation across 48 states between "percent rural in 1950" and household gun prevalence estimated from the HICRC survey is 74%; the correlation across 21 states using the BRFSS data is 79%.

Table V. Stability of Cross-Section Structure of Gun Ownership (FS/S) Correlation Coefficients (50 States)

Period	1995–1997	1987–1989
1987–1989	0.97	
1979–1981	0.94	0.97

Source. State suicide statistics from Vital Statistics Mortality data.

Nonetheless, this geographic structure is not immutable. In fact, there is a pronounced tendency of increasing homogeneity. When the states are sorted by values for the middle period, 1987–1989 (to avoid regression to the mean), then 13 of the bottom 15 have increased between 1980 and 1996, while all 15 of the highest have decreased. Measures of dispersion tell the same story: From 1980 to 1996, the inter-quartile range declined from 45% to 37%, while the inter-decile range declined from 50% to 42%.[13]

7. THE VALIDITY OF FS/S OVER TIME

Although the results presented above demonstrate that FS/S is a valid proxy for cross-section variation, it is not necessarily true that it is also valid as a proxy for inter-temporal variation. It is possible, for example, that trends in weapon preferences by suicidal individuals, or in the demographic composition of suicide, create a shifting relationship between gun availability and weapon choice.

To explore the validity of FS/S as a proxy for changes in gun-ownership prevalence over time, we once again use data from the General Social Survey. It has included identical items on gun ownership for 14 of the years between 1980 and 1998. As noted above, the GSS sample is designed to be representative at the level of the Census division. Thus it is possible to estimate gun prevalence for a panel of the nine divisions by year with only a few gaps. We construct such a panel for the four measures of gun ownership: Individual gun and handgun ownership, and household gun and handgun ownership.

Table VI reports the results of regressing each of the four measures against FS/S. All regressions include division fixed effects, so the coefficient estimates on FS/S reflect only inter-temporal covariance with gun ownership.

FS/S performs reasonably well in these trials. The estimated coefficients are statistically significant in each case. The size of these coefficients is

[13] Details available from the authors on request. We have not attempted to explore the reasons for increasing homogeneity. It may reflect increased immigration and inter-state migration.

Table VI. Inter-Temporal Validity of FS/S Relative to Measures of Gun Ownership. GSS Panel Data, 1980–1998, for 9 Census Divisions, Regression Coefficients and Standard Errors

	Individual ownership prevalence	Individual ownership prevalence (handgun)	Household ownership prevalence	Household ownership prevalence (handgun)
FS/S coefficient	0.602[a]	0.341[b]	0.701[a]	0.478[a]
(Standard error)	(0.247)	(0.174)	(0.303)	(0.203)

[a] Significantly different from zero at the 5% level.
[b] Significantly different from zero at the 10% level.
Notes. Each cell contains the key coefficient estimate and SE from a different regression. Each regression includes division dummies; the coefficients are not reported in this table. $N = 126$, annual observations for the following 14 years: 1980–1982, 1984–1985, 1987–1991, 1993–1994, 1996 and 1998. (The GSS was not fielded or did not include the relevant items during the missing years.) FS/S = % of suicides in region committed with a gun, from Vital Statistics data.

somewhat less than in the cross section results (reported in Table IV), as seen below:

	Coefficient estimates	
	Cross-section	*Panel data*
Household gun	0.97	0.70
Individual gun	0.73	0.60
Household handgun	0.78	0.48
Individual handgun	0.55	0.34

The intertemporal correlation between FS/S and gun prevalence, while significantly positive, is quite weak. For example, when we combine results from all years and regions ($N = 126$), the correlation for household gun ownership (after removing division means for this time period) is just 0.21 (p-value < 0.02), far less than for the cross-section comparisons. The explanation for this relatively weak correlation may be that there is far less true variation over time than over space, so that a high percentage of the variation in the survey statistics is due to random sampling error. At this point we cannot determine whether FS/S serves as a good proxy for intertemporal variation in gun prevalence.

8. EXTENSIONS AND LIMITATIONS

Our favored proxy variable, the percent suicide with guns, has been used in recent empirical research on how gun prevalence affects crime and

Table VII. Estimates of the Relationship between Gun Prevalence and Homicide State-Level Data. Regression Coefficients on Four Proxies

	Coefficient	*t*-Statistic	*R*-Squared
FS/S	1.86	7.62	87
UFDR	1.57	5.69	83
G&A	0.78	2.04	73
NRA	0.53	1.27	72

Notes. Each row is based on a different regression. In each case the dependent variable is the homicide rate per 100,000 (FBI Uniform Crime Reports) for 1996, and the independent variables are the robbery rate per 100,000 and the indicated proxy for gun prevalence. All regressions are run on just 49 observations, since UCR homicide data for Montana is not available.

violence, authored by the current authors and others.[14] There is a somewhat obvious point to be made, namely that the results reported in these studies would likely have been different if a different proxy variable had been used. To illustrate using a simple example (from Cook and Ludwig, 2002), we report the results of cross-section regressions of the homicide rate on four alternative proxies for gun prevalence using state-level data (Table VII). All four regressions include a single covariate, the robbery rate, as a rough-and-ready method of controlling for all other relevant differences among the states (Blumstein, 2000). The proxies have been standardized (divided by the standard deviation) to allow ready comparison of the coefficients. The estimated coefficients are all positive but of differing magnitudes and levels of significance. With FS/S as the proxy, we see that gun prevalence has a relatively important and highly statistically significant effect on homicide rates, whereas with NRA membership as a proxy it is not clear in a statistical sense that gun prevalence has any effect. Note that this comparison does not demonstrate which of these proxies is best, but only that it matters which one is used.

Our demonstration that FS/S is in fact the best of several common proxies utilizes survey data on gun ownership as the standard of comparison. But survey data are themselves flawed, not only because of small sample sizes but also because of possible bias introduced by non-response and by systematic errors in reporting by respondents. The problems with survey data may help explain the existence of large disparities between FS/S and survey results in some states.

In Table AIV, there are a dozen states in which prevalence estimated from the HICRC surveys exceeds prevalence estimated from FS/S by over

[14] See, for example, Miller *et al*. (2002a, b, c), Hemenway *et al*. (2000), Hemenway and Miller (2000), Cook and Ludwig (2002, 2003).

10% points. The largest gaps are associated with very small sample sizes (e.g., Vermont with a sample size of 7, Wyoming of 8, and Montana and Idaho with 17 each), and sampling error is surely part of the explanation. That it is not a *complete* explanation follows from the fact that the large gaps are all in the same direction—the survey estimate exceeds the FS/S estimate. From further analysis we have found that across all 50 states, the difference between the two types of estimate is strongly related to the fraction of the population living in rural areas. That result suggests two lines of explanation for the large gaps. The problem may be with FS/S—e.g., if rural residents are less likely to use a household gun to commit suicide than are urban residents. Alternatively, the problem may be with survey-based measures of gun ownership, since it seems plausible that respondents living in rural states may be more likely to report a gun in the home than urban respondents.[15]

If the "problem" is indeed with the proxy FS/S, rather than with the survey, then it may be possible to improve the proxy by adjusting for the rural-urban mix of the state's population. The same logic suggests that it may be beneficial to adjust for other demographic characteristics that are related both to the likelihood of suicide and the likelihood of gun ownership, such as age and gender. We note that these adjustments come at the cost of one of the great virtues of FS/S, ease of computation, and based on our experience are likely to yield results that are very highly correlated with the unadjusted version.

9. CONCLUSION

Of the readily computed proxies for the prevalence of gun ownership, one, the percentage of suicides committed with a gun, performs consistently better than the others in cross-section comparisons. It is readily computed for states and counties and has a high degree of validity when tested against survey-based estimates.

FS/S also appears to provide some information on changes over time in gun prevalence, at least at the regional level.

Our analysis of this proxy measure for the period 1979–1997 demonstrates that the geographic structure of gun ownership has been highly stable.

[15] This difference in reporting could be the result of differences in how well informed the typical respondent is about whether there is a gun in the home. For example, rural gun-owning households are probably more likely to have hard-to-conceal long guns (rifles or shotguns) in their collection. Another plausible possibility is that the typical rural respondent may be more comfortable in admitting the presence of a gun to an interviewer, since gun ownership is more common and accepted as part of the mainstream culture.

That structure is closely linked to rural tradition. There is, however, some tendency toward homogenization over this period, with high-prevalence states trending down and low-prevalence states trending up.

We conclude that FS/S provides the best of the readily computed proxies for analyzing the influence of gun prevalence on gun use in criminal violence and suicide.

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APPENDIX

Table AI. Proxies from Vital Statistics Mortality Data (50 States, 1995–1997)

Proxy	Definition	Minimum # of events[a]	Maximum # of events
FS/S	Firearm suicides divided by Suicides	109	10,519
FH/H	Firearm homicides divided by Homicides	31	9209
UFDR	Unintentional injury deaths by firearm	0	333

[a] Least number of suicides, homicides or unintentional deaths across the 50 states for the indicated period.

Table AII. Proxies from Subscription and Membership Data (50 States, 1996)

Proxy	Definition	Minimum no.[a]	Maximum no.
G&A	Subscriptions to *Guns & Ammo Magazine* per capita	1388	59,729
NRA	NRA members per capita	6250	224,753

[a] Least number of subscriptions across 50 states for 1996.

Table AIII. Definitions and Characteristics of Survey-Based Estimates of Prevalence of Gun Ownership

Survey	Definition and source	Jurisdictions	No. obs.	
			Smallest	Largest
HICRC[a]	HICRC RDD Survey 1996 & 1999 combined	48 states	7	517
BRFSS[b]	1990s	21 states		
GSS[c]	1996	9 census divisions	101	353
GSS[c]	1994, 1996, 1998 combined	9 census divisions	288	1087

[a] Data come from a national random-digit-dial (RDD) telephone survey, conducted by Fact Finders, Inc., a social science survey firm, in 1996 (n = 1900) and again in 1999 (n = 2500). The sample is representative of United States households with telephones. (These surveys are described in detail in Hemenway *et al*., 2000.) Alaska and Hawaii were not included in the 1996 survey and so are excluded from analysis.

[b] Data were obtained from 1991 through 1995 surveys of the Behavioral Risk Factor Surveillance System (BRFSS). Details have been published elsewhere (Siegel *et al*., 1993). Briefly, state health departments conduct monthly telephone surveys of randomly selected persons 18 years old and older. Over the 5-year study period, 22 states asked about household firearms [Table I]. The median sample size was 2061, the median response rate was 66.9%, the median proportion of homes with telephones was 95.6%, and the median refusal rate for the firearm section was 2.0%. For states that asked firearm questions in more than 1 year, the most recent data were used.

[c] The General Social Survey (GSS) is fielded on a regular basis by the University of Chicago's National Opinion Research Center. The GSS utilizes personal interviews with an area probability sample. It has included items on household gun ownership since 1972, and on individual ownership since 1980. The most recent firearms data available from the GSS are for the even-numbered years of the 1990s. The GSS sample is structured so as to be representative of the populations of each of the 9 census regions, but not necessarily of individual states (Davis and Smith, 1998).

Table AIV. Firearms Prevalence by State Estimated from HICRC and from FS/S

Rank (1)	State (2)	Est. prevalence from FS/S (3)	Est. prevalence HICRC (N) (4)	Difference (4) – (3) (5)
1	Hawaii	11.59		
2	Massachusetts	13.08	16.16 99	3.08
3	New Jersey	15.44	16.26 123	0.82
4	D.C.	20.13		
5	New York	20.19	22.48 298	2.30
6	Rhode Island	22.36	18.75 16	– 3.61
7	Connecticut	25.48	16.67 48	– 8.81

Table AIV. Continued.

Rank (1)	State (2)	Est. prevalence from FS/S (3)	Est. prevalence HICRC (*N*) (4)	Difference (4) – (3) (5)
8	Illinois	29.39	24.86 181	– 4.53
9	Delaware	30.74	28.57 14	– 2.17
10	California	33.26	33.66 517	0.39
11	Maryland	34.97	38.27 81	3.31
12	Minnesota	35.42	38.75 80	3.33
13	Wisconsin	35.78	48.45 97	12.67
14	Colorado	37.70	50.00 62	12.30
15	Pennsylvania	37.90	47.03 219	9.13
16	Iowa	38.49	50.91 55	12.42
17	Michigan	38.96	44.31 167	5.35
18	Ohio	38.97	33.15 184	– 5.82
19	New Hampshire	39.30	35.71 28	– 3.59
20	Utah	39.61	51.43 35	11.82
21	Washington	40.35	47.50 80	7.15
22	Florida	40.51	33.91 230	– 6.59
23	Nebraska	40.85	51.72 29	10.87
24	Maine	42.12	48.00 25	5.88
25	South Dakota	42.30	66.67 21	24.37
26	Kansas	42.88	42.55 47	– 0.33
27	New Mexico	42.92	46.88 32	3.96
28	North Dakota	43.80	50.00 14	6.20
29	Oregon	43.92	57.69 52	13.77

Table AIV. Continued.

Rank (1)	State (2)	Est. prevalence from FS/S (3)	Est. prevalence HICRC (*N*) (4)	Difference (4) – (3) (5)
30	Vermont	44.40	71.43 7	27.03
31	Indiana	45.11	52.78 108	7.67
32	Missouri	45.30	50.60 83	5.30
33	Texas	46.26	49.32 294	3.06
34	Oklahoma	47.64	55.36 56	7.72
35	Virginia	47.92	41.38 116	– 6.54
36	Nevada	47.97	42.86 21	– 5.12
37	Arizona	48.30	46.27 67	– 2.03
38	Montana	48.83	76.47 17	27.64
39	North Carolina	50.61	50.36 139	– 0.25
40	Idaho	50.87	76.47 17	25.60
41	Alaska	50.91		
42	South Carolina	51.00	47.46 59	– 3.54
43	Tennessee	52.35	53.26 92	0.91
44	Arkansas	52.51	60.00 45	7.49
45	Kentucky	53.20	52.24 67	– 0.96
46	Georgia	53.65	54.62 119	0.97
47	West Virginia	54.64	65.63 32	10.98
48	Wyoming	54.78	87.50 8	32.72
49	Louisiana	55.04	61.04 77	6.00
50	Alabama	57.51	57.69 78	0.19
51	Mississippi	60.25	61.54 52	1.29

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