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Variation in Rates of Fatal Police Shootings across US States: the Role of Firearm Availability

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Abstract The USA has very high rates of homicide by police compared to other high-income countries, with approximately 1000 civilians killed annually. The overwhelming majority of these police homicides are fatal shootings. Over the past 5 years, several comprehensive, real-time, data repositories, drawn largely from news reporting, have kept track of incidents in which civilians die during an encounter with the police and have become widely available. Data from these repositories, which are more complete than data available from federal data systems, have been used to explore fatal police shootings of civilians, often with a focus on racial disparities in police shootings of unarmed civilians, and have consistently found that police are more likely to shoot unarmed African American men than unarmed White men. Although numerous studies have examined how rates of police killings of civilians are related to several ecologic determinants of these events, no peer-reviewed study to date has examined the extent to which variation in police involved firearm homicides is explained by firearm prevalence while adjusting for violent crime rates (the most well-established ecologic factor associated with fatal police shootings). The current cross-sectional state-level analysis uses data on the number of civilians shot and killed by police in the line of duty, aggregated over 2015–2017. Data come from the *Washington Post's* "Fatal Force Database", which assembles the information from news reports and other sources. Data provided include information on whether the victim was armed, and, if so, with what weapon. Explanatory ecologic variables in our models include the violent crime rate, the percentage of the state population that is non-White, poverty rate, and urbanization, along with a validated proxy for firearm prevalence. We find that rates of police shooting deaths are significantly and positively correlated with levels of household gun ownership, even after accounting for the other explanatory variables. The association is stronger for the shooting of armed (with a gun) rather than unarmed victims.

Keywords Police shootings · Legal intervention homicide · Police involved shootings · Firearms · Guns · Officer involved shooting · Officer involved homicide

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Introduction

In the USA, law enforcement officers kill more than 1000 civilians annually. The rate of killings by US police is higher than in other developed nations: 4 times

the rate in Canada, 22 times the rate in Australia, 40 times the rate in Germany, and 125 times the rate in England/Wales [1].

US data for these estimates come from real-time, data repositories, drawn largely from news reporting, which have compiled incidents in which civilians die during an encounter with the police as early as 2013 (Mapping Police Violence, Fatal Encounters, the *Guardian*, the *Washington Post*). Data from these repositories are more complete than data available from federal data systems [2]. Until recently, national studies of killings by US police have typically used data from the Supplementary Homicide Reports (SHR) or mortality data from the CDC's National Vital Statistics System (Web-based Injury Statistics Query and Reporting System). Unfortunately, these two national data systems along with the more recent Bureau of Justice Statistics' Arrest Related Deaths Reporting Program seriously under-report law enforcement homicides of civilians and cannot be used to accurately measure differences in rates of police killings across states or cities [3–5].

In the past few years, new non-governmental data repositories have occasionally been used to explore fatal police shootings of civilians [6], often with a focus on racial disparities in police shootings of unarmed civilians (where armed is defined as the victim having any weapon). These studies have consistently found that police are more likely to shoot unarmed African American men than unarmed White men [7–9].

A recent study of killings OF police found that what primarily explains the large differences across states in rates OF violent police deaths on the job is the level of household gun ownership [10]. For example, going to a domestic violence dispute is much more dangerous for the law enforcement officer if there is a gun in the home (almost all police killed on the job are killed with firearms). It is plausible, therefore, that similar to killings OF police, that the substantial variation across states in rates of killings BY police may be explained by differences in levels of civilian gun ownership.

While numerous studies have examined how rates of police killings of civilians are related to potential ecologic determinants [7, 11–20], we could identify only two studies that used civilian gun ownership levels as an independent variable. The first study, a city-level study from 1979, reported that firearm availability was correlated with fatal police shootings (unadjusted correlation coefficient = 0.25–0.54 depending on the level of geographic aggregation used in the analysis) [21]. The second study, a recent cross-sectional analysis, used the percent of suicides involving firearms, a validated proxy for firearm prevalence, as a covariate in adjusted analysis focusing on the strength of firearm laws in relation to fatal police shooting rates [6]. In that study, however, the proxy (the fraction of suicides committed with a firearm) and the firearm legislation scoring system were entered into models simultaneously, despite the strong collinear relationship between the two (i.e., it is easier to pass strong firearm legislation in states where fewer people own firearms). No analyses assessed whether firearm prevalence, untethered from the collinear legislative score, is related to fatal police shootings, while adjusting for violent crime rates (the most well-established ecologic factor associated with fatal police shootings).

The current study helps fill this research gap by examining state-level ecologic factors that help explain why legal intervention homicide rates in the USA vary several-fold across the 50 states. Specifically, we examine the extent to which firearm prevalence explains the variation in fatal police shootings of civilians, and, in turn, the extent to which the association between firearm prevalence and police shootings of civilians depends on whether victims were armed with a firearm. In our analyses, we control for ecologic characteristics that prior work has identified as key structural determinants of police fatal use of force, including rates of violent crime.

Methods

We use a cross-sectional, state-level study design to examine the association between the availability of firearms and the rate of fatal police shootings across the 50 states averaged over a 3-year period (2015–2017). The number of observations is 50.

Data for our outcome measure, the number of fatal police shootings per state population, come from the *Washington Post's* "Fatal Force Database." These data are publicly available and were obtained freely. Since January 1, 2015, the *Washington Post* has been compiling an incident-level database of every fatal shooting in the USA by a police officer in the line of duty. The data come from local news reports, law enforcement websites, and social media; the *Washington Post* also monitors other crowdsourced databases such as KilledbyPolice.net and FatalEncounters.org. Unlike

most other public data repositories, the *Washington Post* database only includes shootings in which a police officer, in the line of duty, shoots and kills a civilian and does not include deaths of people in police custody, fatal shootings by off-duty officers, or non-shooting deaths [22].

Each incident in the *Washington Post* database includes demographic information about the deceased (i.e., age, sex, race/ethnicity), the date and location of the incident (i.e., state and city), and some circumstantial information (including whether the deceased was armed and with what). At the time of this study, there were three full calendar years of data available: January 1, 2015 to December 31, 2017. We aggregate data at the state level to produce counts for each state over the 3-year period. To determine rates per capita, we use state-level population estimates from the US Census Bureau [23].

Our primary outcome is the number of fatal police shootings per 1 million residents, overall, and by whether the victim was armed with a firearm or not. Secondary analyses estimate fatal police shootings per 100,000 *arrests*. To determine rates per arrests, we use state-level arrest data the Federal Bureau of Investigation's (FBI) Uniform Crime Reports (UCR) [24]. To account for non-reporting of arrests by some law enforcement agencies to UCR, we first calculate 2015 and 2016 state-specific arrest rates by dividing the number of arrests reported to UCR by the estimated population under the jurisdiction of the reporting agencies within each state and assumed the non-reporting areas had similar arrest rates. State-level arrest data for 2017 are not yet available from UCR. We assume that the arrest rates for 2017 are the average of 2015–16.

Our main independent variable is a validated proxy for state-level household firearm ownership: the fraction of all suicides that involve a firearm (referred to as FS/S). FS/S has been extensively used in cross-sectional studies within the USA and is highly correlated with survey-based measures of firearm ownership at the state level [25, 26]. A sensitivity analysis substitutes household gun ownership rates from the Behavioral Risk Factor Surveillance System (BRFSS), an annual nationwide survey that collects data on various health-related domains [27]. BRFSS estimates for state-level household gun ownership are available for 2001, 2002, and 2004 only.

We adjust for structural factors that have been found to be correlated with rates of lethal force by law enforcement: the violent crime rate [11–14, 16–18, 20, 21], the proportion of the population that is non-White [12, 14, 16, 17, 19], the proportion of the population living in poverty [14, 28], and urbanization [29].

We first compare the unadjusted rate of fatal police shootings and the percent of descendants armed with a firearm in the states with the highest levels of household gun ownership to those in the states with the lowest levels of household gun ownership. For this comparison, we select states with the highest FS/S and states with the lowest FS/S until the number of person-years were approximately equal. The states with the lowest rates of firearm ownership tend to be more populated than the states with the highest levels. To ensure that the population at risk (i.e., the number of person-years in these states) is approximately equal across these groupings, we compare the five states with the lowest FS/S and the ten states with the highest FS/S. Each group had 122 million person-years of exposure during the 3-year period.

For the full analyses, we use negative binomial models to estimate the association between rates of police shooting of civilians and our key independent variable, firearm prevalence (as proxied by FS/S) across the 50 states. We use state population as the offset term in primary analyses and arrest rates as the offset term in secondary analyses. Specifically, we regress firearm prevalence rates and other covariates on (1) the total number of fatal police shootings, (2) the number of fatal police shootings in which the decedent was armed with a firearm, and (3) the number of fatal police shootings in which the decedent was not armed with a firearm. First, we include our key independent variable (FS/S—household gun ownership) but do not adjust for other covariates (Model 1). In Model 2, we also adjust for the violent crime rate and in Model 3 we included all explanatory covariates.

In sensitivity analyses, we (1) remove key outliers from the regressions and (2) substitute FS/S with the average estimate of state-level household gun ownership from the 2001, 2002, and 2004 BRFSS in the regressions. As further sensitivity analyses, we (a) replace the non-White variable with two variables, percent Black and percent Hispanic, and (b) add an additional explanatory variable. These single additional variables are the Gini Coefficient (income inequality), full-time law enforcement

Table 1 Firearm availability (FS/S), fatal police shooting rates, and proportion of descendants armed with a firearm by state: United States, 2015–2017

State	FS/S (standardized value)	Number of fatal police shootings	Fatal Police shooting rate per 1000,000 residents	Fraction of Descendants armed with a firearm	Fatal Police shooting rate of civilians armed with a firearm per 1000,000 residents	Fatal Police shooting rate of civilians not armed with a firearm per 1000,000 residents
Massachusetts	0.20 (− 2.54)	24	1.17	0.33	0.39	0.78
Hawaii	0.22 (− 2.43)	11	2.57	0.36	0.93	1.63
New Jersey	0.25 (− 2.17)	39	1.45	0.49	0.71	0.74
New York	0.27 (− 1.96)	52	0.87	0.58	0.50	0.37
Connecticut	0.27 (− 1.95)	12	1.11	0.33	0.37	0.74
Rhode Island	0.30 (− 1.77)	3	0.95	0.33	0.32	0.63
Illinois	0.36 (− 1.24)	67	1.74	0.69	1.19	0.55
California	0.37 (− 1.14)	490	4.16	0.42	1.75	2.41
Minnesota	0.43 (− 0.66)	35	2.11	0.57	1.21	0.90
Maryland	0.43 (− 0.63)	39	2.16	0.44	0.94	1.22
Washington	0.46 (− 0.40)	80	3.66	0.51	1.88	1.79
South Dakota	0.47 (− 0.36)	10	3.87	0.80	3.09	0.77
Iowa	0.48 (− 0.28)	15	1.60	0.67	1.06	0.53
Kansas	0.49 (− 0.21)	31	3.55	0.58	2.06	1.49
New Hampshire	0.49 (− 0.19)	8	2.00	0.50	1.00	1.00
Nebraska	0.49 (− 0.17)	15	2.62	0.47	1.22	1.40
Pennsylvania	0.49 (− 0.14)	63	1.64	0.56	0.91	0.73
Utah	0.50 (− 0.11)	25	2.74	0.52	1.42	1.31
Delaware	0.50 (− 0.11)	10	3.50	0.60	2.10	1.40
Wisconsin	0.50 (− 0.05)	52	3.00	0.56	1.67	1.33
Michigan	0.51 (− 0.02)	43	1.44	0.58	0.84	0.60
Colorado	0.51 (0.00)	91	5.49	0.68	3.74	1.75
Oregon	0.51 (0.02)	42	3.43	0.60	2.04	1.39
Nevada	0.52 (0.07)	49	5.56	0.63	3.51	2.04
Florida	0.52 (0.08)	179	2.89	0.58	1.66	1.23
Maine	0.52 (0.08)	13	3.25	0.62	2.00	1.25
Ohio	0.53 (0.18)	89	2.55	0.54	1.38	1.18
New Mexico	0.53 (0.19)	62	9.91	0.66	6.55	3.36
Indiana	0.56 (0.37)	52	2.61	0.54	1.41	1.21
North Carolina	0.57 (0.46)	78	2.56	0.74	1.90	0.66
Virginia	0.57 (0.49)	58	2.30	0.62	1.43	0.87
North Dakota	0.57 (0.51)	5	2.21	0.40	0.88	1.32
Arizona	0.57 (0.52)	136	6.56	0.56	3.67	2.89
Missouri	0.57 (0.53)	73	3.99	0.67	2.68	1.31
Vermont	0.58 (0.57)	4	2.14	0.25	0.53	1.60
Texas	0.58 (0.59)	251	3.00	0.65	1.94	1.06
Arkansas	0.59 (0.69)	32	3.57	0.56	2.01	1.56
Alaska	0.60 (0.73)	19	8.56	0.74	6.31	2.25
Tennessee	0.60 (0.76)	69	3.46	0.57	1.95	1.50
Wyoming	0.60 (0.78)	9	5.14	0.44	2.29	2.86
Idaho	0.61 (0.78)	19	3.77	0.89	3.37	0.40
Oklahoma	0.61 (0.83)	84	7.15	0.58	4.17	2.98

Table 1 (continued)

State	FS/S (standardized value)	Number of fatal police shootings	Fatal Police shooting rate per 1000,000 residents	Fraction of Descendants armed with a firearm	Fatal Police shooting rate of civilians armed with a firearm per 1000,000 residents	Fatal Police shooting rate of civilians not armed with a firearm per 1000,000 residents
Georgia	0.62 (0.91)	84	2.71	0.62	1.68	1.03
Montana	0.62 (0.93)	15	4.81	0.53	2.57	2.25
South Carolina	0.64 (1.05)	48	3.23	0.69	2.22	1.01
West Virginia	0.65 (1.11)	33	6.02	0.61	3.65	2.37
Kentucky	0.65 (1.14)	51	3.83	0.59	2.25	1.58
Louisiana	0.65 (1.14)	65	4.63	0.60	2.78	1.85
Mississippi	0.69 (1.46)	33	3.69	0.58	2.12	1.56
Alabama	0.70 (1.57)	67	4.59	0.61	2.81	1.78
State mean ± SD	0.51 ± 0.12	58.68 ± 76.88	3.43 ± 1.87	0.56 ± 0.12	2.02 ± 1.32	1.41 ± 0.70

officers employed (per 100,000 residents), and police officers assaulted per 1000 officers. We also run analyses using the arrest rate per population as an independent variable rather than the denominator for the outcome variable.

Because negative binomial models do not produce statistics that allow us to quantify the independent explanatory contribution of each of the independent variables in our analyses, we use OLS regression to calculate R^2 values.

We conduct all analyses using Stata IC version 15.1 (Stata Corp, College Station, TX). This study received Human Subjects Approval from the Harvard T.H. Chan School of Public Health IRB.

Results

There were 2934 fatal police shootings in the 50 states from 2015 through 2017 (978 per year) (Table 1). Fatal police shootings per capita ranged from a high of 9.91 in New Mexico to as low of 0.87 in New York (mean 3.43; SD 1.87) (Table 1).

On average, 56% of decedents who were fatally shot by police were armed with a firearm. The proportion of decedents who were armed with a firearm varied by state, ranging from a high of 89% in Idaho to a low of 25% in Vermont (Table 1).

The incident rate for fatal police shootings in the ten high-gun states was 3.6 times greater than in the five

Table 2 Fatal police shootings in the 5 states with the lowest and the 10 states with the highest firearm availability (FS/S): United States, 2015–2017

Characteristics	Low-gun states[a]	High-gun states[b]
Average state FS/S, %	24.3	64.3
Average state household firearm ownership[c], %	13.8	50.5
Total population 2015–2017, person-years	122 million	122 million
Total fatal police shootings 2015–2017, no.	138	499
Fatal police shooting rate per 1,000,000 residents	1.1	4.1
Victims who were armed with a firearm, %	47.1	61.7

[a] Low-gun states are CT, HI, MA, NJ, NY

[b] High-gun states are AL, GA, ID, KY, LA, MS, MT, OK, SC, WV

[c] The percentage of households who own firearms was measured using the average percentage of the 2001, 2002, and 2004 BRFSS, the most recent direct survey-based measure of gun ownership available at the state level

Table 3 Multivariate negative binomial regressions of firearm availability and fatal police shooting rates per resident population: United States, 2015–2017

Variable	Model 1, IRR (95% CI)	Model 2, IRR (95% CI)	Model 3, IRR (95% CI)
Total fatal police shootings			
FS/S	1.40 (1.24, 1.59)***	1.34 (1.19, 1.50)***	1.44 (1.21, 1.73)***
Violent crime rate[a]		1.22 (1.10, 1.37)***	1.17 (1.02, 1.34)*
Non-White population[b]			1.01 (1.00, 1.02)
Poverty rate[c]			0.98 (0.94, 1.03)
Urbanization[d]			1.00 (0.99, 1.01)
Fatal police shootings of civilians armed with a firearm			
FS/S	1.56 (1.36, 1.80)***	1.48 (1.30, 1.68)***	1.59 (1.31, 1.94)***
Violent crime rate[a]		1.27 (1.12, 1.43)***	1.22 (1.06, 1.42)**
Non-White population[b]			1.00 (0.99, 1.02)
Poverty rate[c]			0.99 (0.94, 1.04)
Urbanization[d]			1.00 (0.99, 1.02)
Fatal police shootings of civilians not armed with a firearm			
FS/S	1.23 (1.08, 1.41)**	1.19 (1.04, 1.36)*	1.29 (1.04, 1.61)*
Violent crime rate[a]		1.17 (1.02, 1.35)*	1.10 (0.93, 1.30)
Non-White population[b]			1.01 (1.00, 1.02)
Poverty rate[c]			0.99 (0.93, 1.05)
Urbanization[d]			1.00 (0.99, 1.02)

IRR incidence rate ratio, *CI* confidence interval

$p < 0.05$*; $p < 0.01$**; $p < 0.001$***

[a] Violent crime rate is defined as the number of reported offenses that involve force or threat of force (i.e., murder and nonnegligent manslaughter, rape, robbery, and aggravated assault) per 100,000 residents. Data come from the FBI's Uniform Crime Reporting system. Data were not available for 2017 and were averaged from 2015 to 2016 (mean = 370.1; SD = 141.6). Values were standardized for ease of interpretation

[b] Non-White population is defined as the percentage of the state population that is not White, non-Hispanic. Data come from CDC WISQARS. Data were not available for 2017, and were averaged from 2015 to 2016 (mean = 29.4; SD = 15.5)

[c] Poverty rate is defined as the percentage of the state population living in poverty. Data come from the US Census Bureau. Data were not available for 2017, and were averaged from 2015 to 2016 (mean = 14.6; SD = 3.1)

[d] Urbanization is defined as the percentage of the state population living in urbanized areas of 50,000 or more people or urban clusters of at least 2500 and less than 50,000 people. Data come from the US Census Bureau. Data were not available for 2015–2017. Data from the 2010 Census were used (mean = 73.6; SD = 14.6)

low-gun states. Compared with decedents who were fatally shot by police in the low-gun states, a greater proportion of those who were killed in high-gun states were armed with a firearm (61.7 vs 47.1%) (Table 2). The high-gun states also had modestly higher rates of violent crime (380 vs 307 per 100,000).

Across all 50 states, firearm prevalence (FS/S) was positively and significantly associated with fatal police shooting rates per population, more strongly so for police shooting of civilians armed with firearms than those not armed with a firearm (Table 3). For example, compared with states with average firearm prevalence, rates of overall police shootings of civilians were 40% higher in states where firearm prevalence was one standard deviation higher, IRR = 1.40 (CI, 1.24 to 1.59) (Table 3). In fully adjusted models that included the proportion of the population that was non-White, the proportion of the population living in poverty, and the proportion of the population living in urban areas, the IRR was similar, 1.44 (CI, 1.21 to 1.73). When the outcome was fatality rates for decedents armed with a firearm, the IRR in fully adjusted models was 1.59 (CI, 1.31 to 1.94); when the outcome was decedents not armed with a firearm, the IRR for FS/S was 1.29 (CI, 1.04 to 1.61).

Table 4 Multivariate negative binomial regressions of firearm availability and fatal police shooting rates per estimated number of arrests: United States, 2015–2017

Variable	Model 1, IRR (95% CI)	Model 2, IRR (95% CI)	Model 3, IRR (95% CI)
Total fatal police shootings			
FS/S	1.24 (1.10, 1.39)***	1.19 (1.07, 1.34)**	1.29 (1.09, 1.53)**
Violent crime rate[a]		1.17 (1.04, 1.30)**	1.12 (0.98, 1.28)
Non-White population[b]			1.00 (0.99, 1.02)
Poverty rate[c]			0.99 (0.94, 1.03)
Urbanization[d]			1.00 (0.99, 1.02)
Fatal police shootings of civilians armed with a firearm			
FS/S	1.37 (1.21, 1.56)***	1.32 (1.16, 1.49)***	1.44 (1.20, 1.72)***
Violent crime rate[a]		1.20 (1.07, 1.35)**	1.16 (1.01, 1.34)**
Non-White population[b]			1.00 (0.99, 1.01)
Poverty rate[c]			0.99 (0.94, 1.04)
Urbanization[d]			1.00 (0.99, 1.02)
Fatal police shootings of civilians not armed with a firearm			
FS/S	1.08 (0.94, 1.23)	1.05 (0.92, 1.20)	1.15 (0.93, 1.42)
Violent crime rate[a]		1.11 (0.97, 1.28)	1.05 (0.89, 1.24)
Non-White population[b]			1.01 (0.99, 1.02)
Poverty rate[c]			0.99 (0.93, 1.05)
Urbanization[d]			1.00 (0.99, 1.02)

IRR incidence rate ratio, *CI* confidence interval

$p < 0.05$*; $p < 0.01$**; $p < 0.001$***

[a] Violent crime rate is defined as the number of reported offenses that involve force or threat of force (i.e., murder and nonnegligent manslaughter, rape, robbery, and aggravated assault) per 100,000 residents. Data come from the FBI's Uniform Crime Reporting system. Data were not available for 2017 and were averaged from 2015 to 2016 (mean = 370.1; SD = 141.6). Values were standardized for ease of interpretation

[b] Non-White population is defined as the percentage of the state population that is not White, non-Hispanic. Data come from CDC WISQARS. Data were not available for 2017, and were averaged from 2015 to 2016 (mean = 29.4; SD = 15.5)

[c] Poverty rate is defined as the percentage of the state population living in poverty. Data come from the US Census Bureau. Data were not available for 2017, and were averaged from 2015 to 2016 (mean = 14.6; SD = 3.1)

[d] Urbanization is defined as the percentage of the state population living in urbanized areas of 50,000 or more people or urban clusters of at least 2500 and less than 50,000 people. Data come from the US Census Bureau. Data were not available for 2015–2017. Data from the 2010 Census were used (mean = 73.6; SD = 14.6)

For our secondary outcome, fatal police shootings per arrest, we observed a similar, albeit attenuated pattern: firearm prevalence (FS/S) was positively associated with fatal police shooting rates overall (IRR = 1.29 [CI, 1.09 to 1.53]); more so for police shooting of civilians armed with firearms (IRR = 1.44 [CI, 1.20 to 1.72]) than for those not armed with firearms (IRR = 1.15 [CI, 0.93 to 1.42]) (Table 4).

We also found that the violent crime rate explains a substantial part of the variation of police killings across states, but that rates of non-White population, poverty, and urbanization were not significantly associated with rates of police killings in multivariate analyses (Table 3). In ordinary least squares models that allow us to quantify the independent explanatory contribution of each of the independent variables in our analyses, we found that FS/S and violent crime rates explained 46% of the variation and that none of the other covariate made a significant contribution to the model's explanatory power (not shown).

Sensitivity analyses support these findings. Analyses that removed New Mexico (with an overall rate of fatal police shootings per capita more than 3 standard deviations higher than the average) and Alaska (an outlier with respect to fatal police shootings per capita among those armed with a firearm) did not substantively affect

Table 5 Sensitivity analyses: Multivariate negative binomial regressions of firearm availability and fatal police shooting rates per resident population: United States, 2015–2017; all results control for violent crime rate, racial composition, poverty rate, and urbanization

Variable	Model 1, IRR (95% CI)	Model 2, IRR (95% CI)	Model 3, IRR (95% CI)
Total fatal police shootings			
FS/S (primary analysis)[a]			1.44 (1.21, 1.73)***
FS/S (exclude NM AK)			1.49 (1.25, 1.78)***
BRFSS			1.54 (1.26, 1.90)***
FS/S (add Gini Coefficient)			1.41 (1.19, 1.69)***
FS/S (%Black %Hispanic)			1.49 (1.30, 1.71)***
FS/S (add Officers Assaulted)			1.42 (1.20, 1.69)***
FS/S (add Officer Employed)			1.41 (1.18, 1.68)***
Fatal police shootings of civilians armed with a firearm			
FS/S (primary analysis)[a]			1.59 (1.31, 1.94)***
FS/S (exclude NM AK)			1.66 (1.38, 1.99)***
BRFSS			1.79 (1.42, 2.26)***
FS/S (add Gini Coefficient)			1.55 (1.28, 1.88)***
FS/S (%Black %Hispanic)			1.66 (1.43, 1.93)***
FS/S (add Officers Assaulted)			1.57 (1.31, 1.89)***
FS/S (add Officer Employed)			1.55 (1.27, 1.88)***
Fatal police shootings of civilians not armed with a firearm			
FS/S (primary analysis)[a]			1.29 (1.04, 1.61)*
FS/S (exclude NM AK)			1.33 (1.07, 1.66)*
BRFSS			1.35 (1.04, 1.76)*
FS/S (add Gini Coefficient)			1.26 (1.02, 1.57)*
FS/S (%Black %Hispanic)			1.33 (1.10, 1.50)**
FS/S (add Officers Assaulted)			1.28 (1.04, 1.58)*
FS/S (add Officer Employed)			1.26 (1.02, 1.55)*

IRR incidence rate ratio, *CI* confidence interval

$p < 0.05$*; $p < 0.01$**; $p < 0.001$***

[a] Results from primary regressions, see Table 3

our main results (Tables 5 and 6). Analyses using direct state-level estimates of household gun ownership (the average of the 2001, 2002, and 2004 BRFSS) also yielded similar results (Tables 5 and 6).

The further sensitivity analyses also supported the findings. When adding various single additional variables such as the Gini Coefficient, the number of police officers per capita, or the number of officers assaulted (or changing the variable for race), the household gun ownership measure remained significantly associated with fatal police shootings per population and even more strongly associated with fatal police shootings of armed (with guns) civilians (e.g., Tables 5 and 6). The household gun ownership measure was always positively associated with police shootings of unarmed civilians, but only occasionally was that relationship statistically significant. Using the arrest rate as an independent variable also did not change the main results (not shown).

Discussion

We find that states with high levels of household gun ownership also have high rates of fatal police shootings of civilians, largely driven by higher rates of shootings of civilians armed with firearms, even after adjusting for crime, poverty, urbanization, and the fraction of the

Table 6 Sensitivity analyses: Multivariate negative binomial regressions of firearm availability and fatal police shooting rates per estimated number of arrests: United States, 2015–2017; all results control for violent crime rate, racial composition, poverty rate and urbanization

Variable	Model 1, IRR (95% CI)	Model 2, IRR (95% CI)	Model 3, IRR (95% CI)
Total fatal police shootings			
FS/S (primary analysis)[a]			1.29 (1.09, 1.53)**
FS/S (exclude NM AK)			1.31 (1.10, 1.56)**
BRFSS			1.30 (1.06, 1.59)*
FS/S (add Gini Coefficient)			1.27 (1.07, 1.51)**
FS/S (%Black %Hispanic)			1.34 (1.17, 1.54)***
FS/S (add Officers Assaulted)			1.28 (1.09, 1.51)**
FS/S (add Officer Employed)			1.24 (1.06, 1.45)**
Fatal police shootings of civilians armed with a firearm			
FS/S (primary analysis)[a]			1.44 (1.20, 1.72)***
FS/S (exclude NM AK)			1.46 (1.22, 1.75)***
BRFSS			1.52 (1.21, 1.90)***
FS/S (add Gini Coefficient)			1.41 (1.17, 1.69)***
FS/S (%Black %Hispanic)			1.50 (1.29, 1.73)***
FS/S (add Officers Assaulted)			1.43 (1.20, 1.69)***
FS/S (add Officer Employed)			1.37 (1.15, 1.63)***
Fatal police shootings of civilians not armed with a firearm			
FS/S (primary analysis)[a]			1.15 (0.93, 1.42)
FS/S (exclude NM AK)			1.16 (0.93, 1.45)
BRFSS			1.13 (0.87, 1.46)
FS/S (add Gini Coefficient)			1.13 (0.91, 1.39)
FS/S (%Black %Hispanic)			1.18 (0.98, 1.43)
FS/S (add Officers Assaulted)			1.14 (0.93, 1.40)*
FS/S (add Officer Employed)			1.10 (0.91, 1.34)

IRR incidence rate ratio, *CI* confidence interval

$p < 0.05$*; $p < 0.01$**; $p < 0.001$***

[a] Results from primary regressions, see Table 4

population that is non-White. An intuitive explanation of this finding is that in places in which more people are armed, the probability police will encounter an armed civilian (criminal or otherwise) is higher, and thus, to the extent that police fear people who are armed with firearms more than those armed only with knives or without weapons, they are more likely to shoot them. Getting shot is almost the only way that police are killed on the job, an observation that is reflected in arguments made by criminologists four decades ago: "gun density would be expected to be positively related to police homicide because greater gun density should increase the frequency of defense of life situation in which police homicides occur [21]."

Our main finding is consistent with a recent unadjusted analysis that found that household gun ownership levels were positively correlated with state-level rates of police killings [30], although state-level gun ownership data used in that analysis were derived from a survey not designed to be representative at the state level.

We also found that states with high levels of household gun ownership have somewhat higher rates of police killing unarmed (no firearm) civilians. One reason for this could be that police may be more likely to assume that a person is armed, with a gun, regardless of whether they are actually so armed, especially in situations where police feel compelled, rightly or not, to take action within seconds.

Our results are consistent whether police shooting rates are expressed as a rate per capita or as a rate per arrest. The attenuation of the association between firearm prevalence (FS/S) and rates of police shootings per arrest suggests that some of the variation observed in our primary analyses may be accounted for by higher rates of arrest where guns are more prevalent. To the extent that rates of arrests may loosely proxy rates of police-civilian encounters (data that are not available at the state level), part of the reason rates of fatal police shootings of civilians may be higher where household firearms are more prevalent may be due to higher rates of potentially adversarial police-civilian interactions in these states—and whether in those interactions the civilian has a gun.

We should note that our findings do not speak to whether any particular shooting was justified, let alone preventable. The fact that a victim is armed with a firearm does not, in itself, justify police use of force, nor does it imply that the victim was *ipso facto* a criminal. Moreover, the fact that a victim was armed with a gun, a weapon other than a gun, or unarmed, does not speak to whether or not the victim posed a credible threat to the life of the officer or civilians.

Our study has various limitations. First, our estimates are based on analysis of ecologic data in cross-section. Second, although we account for four potential confounders—violent crime, poverty, urbanization, and percent of the population that is non-White—it is likely that other potential confounders are missing. However, in OLS models, the two significant variables FS/S and violent crime rates explain almost half of the variation in police killing rates across states. Third, we examine only police killings with firearms; while these make up the vast majority of police homicides [6, 31], results could be slightly different if all mechanisms were included. The *Washington Post* database does not include non-firearm killings by police. Fourth, *Washington Post* data have not been validated, although they are likely to be accurate, given that most fatal incidents in which police shoot civilians are reported (either in newspapers or on other public sites that are reviewed by the *Washington Post*), and that systematically searched newspaper accounts have often been found to be a credible injury data source [32, 33].

Compared to other developed nations, the USA has many guns and much higher rates both of killings OF police (almost always by firearms) and killings BY police [1]. Within the USA, variations across states in killings OF police across states are strongly associated with levels of household gun ownership [10]. Our study shows that variations across states in fatal shootings of civilians BY police are also strongly associated with levels of household gun ownership, primarily because of the strong relationship between household gun ownership and fatal shootings of civilians armed with guns.

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