RESEARCH ARTICLE

Firearm Ownership and Domestic Versus Nondomestic Homicide in the U.S.

Aaron J. Kivisto, PhD,[1] Lauren A. Magee, PhD,[2] Peter L. Phalen, PsyD,[3] Bradley R. Ray, PhD[4]

Introduction: Gun ownership is associated with firearm mortality, although this association differs across victim−offender relationships. This study examines the relationship between gun ownership and domestic versus nondomestic homicide rates by victim sex.

Methods: Several sources of state-level panel data from 1990 through 2016 were merged from each of the 50 states to model domestic (i.e., family and intimate partners) and nondomestic firearm homicide as a function of state-level household firearm ownership. Firearm ownership was examined using a validated proxy measure and homicide rates came from the *Supplemental Homicide Reports* of the Federal Bureau of Investigation's *Uniform Crime Reports*. Negative binomial regression with fixed effects was used to model the outcomes and employed generalized estimating equations to account for clustering within states. Statistical analyses were completed in 2018.

Results: State-level firearm ownership was uniquely associated with domestic (incidence rate ratio=1.013, 95% CI=1.008, 1.018) but not nondomestic (incidence rate ratio=1.002, 95% CI=0.996, 1.008) firearm homicide rates, and this pattern held for both male and female victims. States in the top quartile of firearm ownership had a 64.6% ($p<0.001$) higher incidence rate of domestic firearm homicide than states in the lowest quartile; however, states in the top quartile did not differ significantly from states in the lowest quartile of firearm ownership in observed incidence rates of nondomestic firearm homicide.

Conclusions: State-level firearm ownership rates are related to rates of domestic but not nondomestic firearm homicide.

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INTRODUCTION

As the number of deaths caused by firearm violence continues to rise in the U.S., researchers have started to examine potential causal factors, one of which has been the number of households that own a firearm. Several studies show an association between measures of firearm ownership, availability, and homicide rates but suggest that the association between homicide rates and firearm ownership may differ across victim−offender relationships.[1−7] For example, one recent study found no relationship between firearm ownership and stranger homicide rates, but did find a significant relationship between firearm ownership and nonstranger homicide,[8] which included a heterogeneous combination of victim−offender relationships, including domestic homicides, which account for more than a quarter of all homicides,[9,10] as well as nondomestic acquaintance homicides, which account for approximately half of all homicides. The present study defines domestic homicides as those involving intimate partner or other family victims.

Statistics indicate that most domestic homicide victims are women[9−12] and approximately nine in ten female

From the [1]School of Psychological Sciences, University of Indianapolis, Indianapolis, Indiana; [2]Department of Pediatrics, Indiana University School of Medicine, Indianapolis, Indiana; [3]Department of Psychiatry, School of Medicine, University of Maryland, Baltimore, Maryland; and [4]School of Public and Environmental Affairs, Indiana University−Purdue University Indianapolis, Indianapolis, Indiana

Address correspondence to: Aaron J. Kivisto, PhD, University of Indianapolis, School of Psychological Sciences, 1400 E. Hanna Avenue, Indianapolis IN 46227. E-mail: kivistoa@uindy.edu.

homicides are committed in nonstranger relationships.[13] Firearms are used in approximately half of all domestic homicides,[9,14] and research shows that firearm ownership can increase the risk of domestic homicide for female victims. For example, cases of intimate partner violence where male perpetrators have access to or own a firearm are more likely to result in a female homicide compared with cases where nonfirearm weapons are used[15,16]; in fact, access to a firearm has been shown to increase the likelihood of homicide as much as fivefold in situations of intimate partner violence.[16,17] Therefore, although keeping a firearm in the home is associated with an increased risk of homicide by a family member or intimate partner,[18] these studies suggest that women, but not men, are at an increased risk of homicide victimization related to household firearm ownership.[3]

The present study focuses on the relationship between firearm ownership and homicide from a statewide perspective by examining victim−offender relationships, specifically domestic versus nondomestic homicide, by sex. In doing so, several sources of state-level panel data from 1990 through 2016 are merged from each of the 50 states to model domestic and nondomestic firearm homicide as a function of household firearm ownership. To determine domestic and nondomestic firearm homicide rates, the *Supplemental Homicide Reports* (SHR) of the Federal Bureau of Investigation's *Uniform Crime Reports*[19] is used, which is the only national data source with incident-level information on the relationship between the victim and the perpetrator. A recently developed proxy measure is used to measure firearm ownership, which integrates the ratio of firearm suicides to total suicides with per capita state hunting license data.[1,13,17] The overarching goal is to use these data to determine whether there is a unique association between firearm ownership at the state level and the rates of female and male domestic and nondomestic firearm homicide, which extends prior work by including different victim−offender relationship types. This will allow for suggested avenues for policy, practice, and future research.

METHODS

Study Sample

Domestic and nondomestic firearm homicide rates per 100,000 came from the SHR, which provides incident-level information on the relationship between the victim and the perpetrator. The SHR victim−offender relationships are categorized as intimate partner, other family, friend/acquaintance, and stranger. To measure intimate partner homicides, incidents with spouses, common-law spouses, former spouses, and dating partners were used; other family victims were defined as parents, children, stepparents, stepchildren, in-laws, and other family members.

Friends/acquaintances included neighbors, acquaintances, employees, employers, and friends; strangers were defined when victims did not know the offender or knew them only by sight. Domestic homicides were defined as those with victims categorized as intimate partners or other family, and nondomestic homicides were categorized as either friends/acquaintances or strangers. Annual rates per 100,000 were calculated for the total sample and separately by sex.

The SHR is limited by the fact that approximately one third of homicides reported by local law enforcement agencies to the Federal Bureau of Investigation are missing data on the victim−offender relationship.[20] To address this limitation, Fox and Swatt[21,22] developed a multiply imputed SHR to address missing data. The multiply imputed SHR applies log-linear models to impute missing case data and a weighting scheme for unit missingness to model annual homicide rates reported to the National Center for Health Statistics.[23]

Measures

Annual household firearm ownership rates served as the main predictor variable. A proxy measure of firearm ownership was employed because of the absence of annual state survey data. Whereas the ratio of firearm suicides to total suicides (FS/S) has provided a widely used proxy, its correlation with survey estimates of firearm ownership is only 0.80.[8] Thus, a recently developed proxy measure of firearm ownership that integrates the FS/S ratio with per capita state hunting license data (firearm ownership % = (0.62 × FS/S) + (0.88 × per capita hunting licenses) − 4.48)[8] was used. This new proxy measure, which has been employed in recent research,[1,13,17] has been shown to increase the correlation between proxy measures of firearm ownership and survey data from 0.80 using the FS/S ratio to 0.95 when combining the FS/S ratio with per capita hunting licenses.[8] Data on annual state firearm and total suicide rates came from the Centers for Disease Control and Prevention's Web-Based Injury Statistics Query and Reporting System[24] and data on annual state hunting licenses were obtained from the U.S. Fish and Wildlife Service.[25]

A range of factors that could confound the association between firearm ownership and firearm homicide, including age, sex, race, high school completion, poverty, unemployment, alcohol consumption, nonhomicide violent and property crime, population density, urbanicity, region, and income inequality, were evaluated. U.S. Census data were used to calculate the percentage of each states' population that is aged 15−24 years, white, African American, and Hispanic; percentage of adults with a high school diploma, divorced, below the federal poverty threshold, and male; as well as state-level urbanicity, population density, and income inequality (Gini index). Data from the Bureau of Labor Statistics were used to calculate the annual unemployment rate, and data from the National Institute on Alcohol Abuse and Alcoholism were used to calculate average per capita rates of alcohol consumption. The Federal Bureau of Investigation's *Uniform Crime Report* provided annual state-level nonhomicide violent and property crime rates.

Statistical Analysis

Negative binomial regression was used to model the outcomes because of skewness and overdispersion in homicide rates that departed from the Poisson distribution. Following previous research examining the effects of firearm ownership on firearm

suicide[3] and homicide,[26] analyses accounted for secular trends in homicide rates by entering year as a fixed effect in all models and employed generalized estimating equations to account for clustering within states. Huber−White sandwich SE estimators were used to relax the assumption of independence of observations within states. Statistical analyses were completed in 2018.

Homicide rates were modeled as a function of firearm ownership across three models. Model 1 examined homicide rates for the overall sample, and Models 2 and 3 were separated by victim sex. Each model controlled for sociodemographic differences. Then, states were grouped by quartiles of firearm ownership and calculated absolute rate differences. Incidence rate ratios (IRRs) for states in the second, third, and fourth quartiles were referenced to states in the first (lowest) quartile of firearm ownership, with raw homicide counts as the outcome and population included as an offset to allow each state to contribute to its respective quartile proportional to its population size. Regional differences were examined across the nine U.S. Census districts with New England serving as a reference following the above approach.

The authors employed a forward and backward selection approach to covariate inclusion to avoid overfitting the adjusted regression models. Step 1 examined univariate associations between each potential covariate and the outcome, retaining each variable related to the outcome at a significance level of 0.05. In Step 2, each remaining covariate was entered simultaneously, retaining each variable remaining significant after controlling for other potential covariates. Finally, previously excluded variables were re-entered into the model and retained if significantly related to the outcome in the presence of the other variables. The final model retained as covariates region; percentage of the male population, African American, aged 15−24 years; and nonhomicide violent crime rate. Following prior research,[1,8,13,24] sensitivity analyses were conducted to examine the robustness of the association between firearm ownership and homicide rates across an alternative firearm proxy and non-imputed SHR homicide rates. First, homicide rates as a function of firearm ownership were analyzed using the FS/S ratio as a proxy for firearm ownership. Second, homicide rates as a function of firearm ownership were examined with homicide rates derived from non-imputed SHR data. All analyses were conducted using Stata, version 15.

RESULTS

Average rates of firearm ownership during the study period varied widely across states, ranging from 10.4% to 68.8% with a mean of 39.2% (SD=12.9). Differences were observed by regions of the U.S.; for example, higher rates were found in states in the South and West, whereas lower firearm ownership was observed in the Northeast region. Nearly one in three homicides were classified as domestic (mean=30.3%, SD=7.5) and variation was observed across states. Higher domestic firearm homicide rates were observed in Southern states and lower rates occurred in the Northeast.

Approximately half (mean=49.1%, SD=4.1) of all homicide victims were classified as friends/acquaintances, followed by strangers (mean=20.6%, SD=5.9), intimate partners (mean=17.0%, SD=4.4), and other family

(mean=13.3%, SD=3.4) (Table 1). Mean rates of state firearm ownership and firearm homicide rates by victim and perpetrator relationship are available in Appendix Table 1 (available online).

The relationship between victim and perpetrator varied considerably by sex. Female victims represented an average of 28.1% (SD=6.7) of all homicide victims and 22.4% (SD=8.3) of firearm homicide victims. However, female victims comprised a disproportionate number of all victims of intimate partner homicide (mean=72.9%, SD=5.8) and intimate partner homicides by firearm (mean=72.2%, SD=6.6). Mean percentages of female victims to total victims by victim−perpetrator relationship and firearm use are available in Appendix Table 2 (available online).

Firearm ownership was associated with domestic, but not nondomestic, firearm homicide rates (Table 2). Across both sexes, the association between firearm ownership and firearm homicide victimization was specific to domestic homicides (IRR=1.013, 95% CI=1.008, 1.018). No association was found between firearm ownership and nondomestic firearm homicide (IRR=1.002, 95% CI=0.996, 1.008). The increased incidence of domestic firearm homicide as a function of firearm ownership was evident for both male (IRR=1.012, 95% CI=1.005, 1.020) and female (IRR=1.014, 95% CI=1.011, 1.018) victims, whereas nondomestic firearm homicide rates for male and female victims were unrelated to firearm ownership.

The increased incidence of domestic homicide of male and female victims as a function of firearm ownership was specific to homicides by firearm, whereas firearm ownership was unrelated to nonfirearm domestic homicides. Among female victims, each 1% increase in firearm ownership was associated with a 1.4% increased incidence of firearm homicide victimization by an intimate partner and a 2.1% increased incidence of firearm homicide victimization by another family member. Among male victims, each 1% increase in firearm ownership was associated with a 1.2% increased incidence of firearm homicide victimization by an intimate partner and a 1.7% increased incidence of firearm homicide victimization by another family member. Whereas there was no association between firearm ownership and the incidence of friend/acquaintance firearm homicide for male victims, each 1% increase in firearm ownership was associated with a 0.8% increase in friend/acquaintance firearm homicides for female victims. No relation was found between firearm ownership and stranger firearm homicide of female victims, though each 1% increase in firearm ownership was associated with a 1.1% decrease in stranger firearm homicides of male victims. Given the above, the association between firearm ownership and all-cause female homicide victimization (IRR=1.005, 95% CI=1.001, 1.010) appeared to be related to the

Table 1. Firearm Ownership Rate and Ratio of Homicides Committed by Relationship to Perpetrator and Firearms[a]

State	Firearm ownership rate (mean)	All cause homicides				Nonfirearm homicides				Firearm homicides			
		Intimate partners, %	Other family, %	Stranger, %	Friend/ acquaintance, %	Intimate partners, %	Other family, %	Stranger, %	Friend/ acquaintance, %	Intimate partners, %	Other family, %	Stranger, %	Friend/ acquaintance, %
Alabama	48.3	16.4	13.5	20.4	49.7	21.3	19.9	15.6	43.2	14.3	11.0	22.4	52.4
Alaska	54.6	17.9	13.5	19.7	48.9	20.3	16.4	16.6	46.7	17.5	11.2	21.4	49.9
Arizona	37.1	12.8	10.5	32.9	43.8	14.8	18.3	22.9	44.0	12.0	7.0	37.3	43.7
Arkansas	52.0	17.2	13.5	16.0	53.3	20.7	19.2	11.8	48.3	15.6	10.9	17.9	55.6
California	25.1	10.0	8.8	35.6	45.7	15.2	17.1	27.2	40.5	7.8	5.3	39.1	47.7
Colorado	36.5	18.4	13.0	23.8	44.8	19.1	19.6	17.6	43.6	17.9	8.3	28.4	45.4
Connecticut	19.8	14.5	9.1	23.5	52.9	22.3	15.4	15.1	47.3	10.3	5.8	28.3	55.6
Delaware	26.9	19.3	11.3	21.4	48.0	23.5	14.2	15.6	46.7	18.0	9.9	25.4	46.6
Florida	29.8	15.6	16.0	24.6	43.8	19.0	25.0	18.7	37.4	13.7	11.1	27.9	47.3
Georgia	42.9	15.1	11.6	22.0	51.3	20.4	19.4	13.2	47.0	13.0	8.6	25.4	52.9
Hawaii	10.4	18.0	15.0	23.3	43.7	19.1	19.0	24.3	37.6	15.5	5.7	24.6	54.1
Idaho	57.4	23.6	18.4	11.5	46.5	21.2	23.7	10.5	44.6	24.4	13.4	13.1	49.1
Illinois	24.2	9.3	8.8	29.3	52.6	19.7	18.9	17.5	43.9	6.1	5.5	33.0	55.3
Indiana	36.4	14.2	11.3	19.2	55.4	19.5	19.5	13.3	47.7	12.1	8.1	21.5	58.3
Iowa	35.8	22.6	16.5	14.9	46.0	22.7	21.8	13.1	42.4	22.5	10.5	16.7	50.3
Kansas	39.6	17.6	14.9	19.9	47.6	20.6	21.8	14.8	42.8	15.7	10.7	23.1	50.5
Kentucky	46.7	17.7	14.4	19.3	48.6	17.8	20.4	16.0	45.8	17.6	11.5	20.9	50.0
Louisiana	46.6	11.9	9.4	23.6	55.2	19.6	17.7	13.4	49.3	9.8	7.1	26.4	56.7
Maine	46.4	26.9	18.5	14.0	40.6	20.6	22.0	16.6	40.8	36.2	15.0	10.4	38.4
Maryland	29.6	10.7	9.4	29.2	50.7	17.8	17.6	18.9	45.7	7.9	6.2	33.3	52.6
Massachusetts	12.5	14.7	8.8	24.2	52.3	23.1	13.0	20.0	43.9	8.1	5.4	27.5	59.0
Michigan	38.5	11.9	10.6	21.2	56.3	17.6	17.8	14.5	50.1	9.6	7.4	23.9	59.0
Minnesota	38.8	15.4	13.3	18.8	52.5	17.0	18.3	15.3	49.4	14.6	9.0	21.4	55.1
Mississippi	50.9	14.8	11.5	16.8	56.8	19.3	16.9	11.3	52.4	13.1	9.4	18.8	58.6
Missouri	42.2	13.2	11.8	20.4	54.7	18.3	19.4	14.2	48.1	11.2	8.7	22.8	57.3
Montana	65.9	23.6	21.5	11.6	43.3	19.7	18.5	15.6	46.1	27.0	22.9	8.1	42.1
Nebraska	41.0	21.3	14.4	15.9	48.3	21.0	20.8	11.6	46.7	22.5	8.0	19.7	49.8
Nevada	36.0	15.4	10.6	28.6	45.3	17.7	16.8	22.1	43.5	14.0	6.6	32.9	46.5
New Hampshire	32.8	27.5	16.8	14.9	40.8	22.0	19.6	16.3	42.1	35.3	11.6	13.9	39.2
New Jersey	15.2	12.8	10.0	26.5	50.7	19.8	16.9	20.9	42.3	8.6	5.5	30.6	55.3
New Mexico	37.0	13.4	12.0	24.9	49.8	14.2	16.0	21.6	48.2	12.7	8.8	27.6	51.0
New York	20.5	11.9	9.2	29.2	49.6	18.3	15.5	23.3	42.9	7.8	5.2	32.9	54.0
North Carolina	40.4	16.2	12.0	21.4	50.4	19.9	16.6	16.2	47.3	14.2	9.6	24.2	52.0

Table 1. Firearm Ownership Rate and Ratio of Homicides Committed by Relationship to Perpetrator and Firearms[a] (*continued*)

State	Firearm ownership rate (mean)	All cause homicides				Nonfirearm homicides				Firearm homicides			
		Intimate partners, %	Other family, %	Stranger, %	Friend/ acquaintance, %	Intimate partners, %	Other family, %	Stranger, %	Friend/ acquaintance, %	Intimate partners, %	Other family, %	Stranger, %	Friend/ acquaintance, %
North Dakota	52.1	23.8	19.3	9.7	47.2	16.8	22.5	9.6	51.1	29.1	14.4	7.8	48.7
Ohio	33.2	13.8	11.5	21.2	53.5	17.9	17.6	15.7	48.8	11.4	8.0	24.2	56.4
Oklahoma	44.8	16.1	15.2	19.5	49.2	16.3	20.9	15.1	47.8	16.3	11.8	21.4	50.5
Oregon	41.6	19.2	15.1	18.9	46.8	17.4	19.6	17.4	45.6	20.6	11.4	20.1	48.0
Pennsylvania	37.2	12.2	9.3	22.4	56.1	19.2	18.8	15.2	46.7	9.6	5.5	25.2	59.7
Rhode Island	15.0	14.2	9.6	23.8	52.4	20.8	14.0	19.5	45.7	8.4	6.7	27.0	57.9
South Carolina	42.8	18.5	12.9	19.0	49.6	22.8	20.1	12.5	44.7	16.7	9.9	21.9	51.6
South Dakota	60.5	24.1	17.3	9.5	49.1	23.3	16.9	10.1	49.8	28.5	19.8	7.6	44.1
Tennessee	49.5	15.2	11.3	21.7	51.8	18.7	17.1	15.0	49.2	13.6	8.4	25.0	53.0
Texas	39.6	15.1	12.5	27.4	45.0	17.9	19.4	19.8	42.9	13.7	9.1	31.2	46.0
Utah	39.9	21.4	16.6	19.7	42.3	19.6	22.6	15.3	42.5	22.6	11.5	24.1	41.8
Vermont	49.0	22.3	18.8	12.1	46.8	17.1	20.8	11.9	50.2	26.3	13.0	12.4	48.3
Virginia	38.6	16.8	12.5	20.7	50.0	21.0	19.6	13.7	45.7	14.9	9.2	23.9	51.9
Washington	32.7	16.2	13.3	20.9	49.6	18.1	18.2	16.4	47.3	14.8	9.5	24.2	51.4
West Virginia	53.6	21.9	17.0	11.4	49.7	19.7	19.5	10.8	49.9	23.9	14.4	12.2	49.6
Wisconsin	41.8	13.2	11.1	23.3	52.5	20.1	18.9	12.2	48.8	9.1	6.8	29.4	54.7
Wyoming	68.8	21.8	21.5	11.6	45.2	11.2	23.3	12.3	53.2	31.2	15.0	12.7	41.0
State, mean	39.2	17.0	13.3	20.6	49.1	19.2	18.9	16.0	46.0	16.4	9.7	23.0	50.9
State, SD	12.9	4.4	3.4	5.9	4.1	2.4	2.5	3.9	3.5	7.4	3.6	7.4	5.4
National, mean	35.1	13.6	11.2	25.5	49.8	18.3	18.4	18.5	44.8	11.3	7.7	28.8	52.2
National, SD	3.2	0.7	1.2	1.0	1.8	1.2	2.3	1.6	2.2	0.6	0.8	1.4	1.7

[a]U.S., 1990–2016.

Table 2. Effects of Firearm Ownership on Victim-Specific Homicide Rates in the U.S., 1990–2016

Homicide rates	Total victim count[a]	All victims		Male victims		Female victims	
		IRR (95% CI)	*p*-value	IRR (95% CI)	*p*-value	IRR (95% CI)	*p*-value
Total, all cause	469,279	1.004 (0.999, 1.009)	0.08	1.003 (0.998, 1.007)	0.23	1.005 (1.001, 1.010)	**0.01**
Total, firearm	316,108	1.004 (0.999, 1.009)	0.12	1.001 (0.995. 1.006)	0.74	1.010 (1.006, 1.014)	**<0.001**
Total, nonfirearm	153,170	1.001 (0.995, 1.008)	0.66	1.002 (0.996, 1.007)	0.59	1.000 (0.995, 1.006)	0.89
Intimate partner, all cause	63,314	1.008 (1.003, 1.012)	**0.002**	1.010 (1.003, 1.016)	**0.003**	1.007 (1.002, 1.012)	**0.005**
Intimate partner, firearm	35,526	1.012 (1.007, 1.017)	**<0.001**	1.012 (1.005, 1.019)	**0.001**	1.014 (1.009, 1.018)	**<0.001**
Intimate partner, nonfirearm	27,788	1.001 (0.994, 1.007)	0.83	1.009 (1.001, 1.016)	**0.02**	0.996 (0.990, 1.002)	0.16
Other family, all cause	51,808	1.008 (1.004, 1.013)	**<0.001**	1.010 (1.005, 1.015)	**<0.001**	1.008 (1.004, 1.012)	**<0.001**
Other family, firearm	24,124	1.017 (1.008, 1.027)	**<0.001**	1.017 (1.008, 1.027)	**<0.001**	1.021 (1.012, 1.029)	**<0.001**
Other family, nonfirearm	27,684	1.003 (0.999, 1.007)	0.18	1.003 (0.998, 1.009)	0.24	1.002 (0.997, 1.007)	0.46
Friend/acquaintance, all cause	234,837	1.004 (0.999, 1.010)	0.10	1.004 (0.999, 1.009)	0.13	1.006 (1.000, 1.011)	**0.04**
Friend/acquaintance, firearm	165,707	1.005 (0.999, 1.011)	0.12	1.003 (0.997, 1.009)	0.31	1.008 (1.001, 1.015)	**0.02**
Friend/acquaintance, nonfirearm	69,130	1.002 (0.996, 1.009)	0.42	1.003 (0.997, 1.008)	0.39	1.006 (1.000, 1.012)	0.06
Stranger, all cause	119,320	0.997 (0.991, 1.004)	0.41	0.995 (0.988, 1.001)	0.09	0.999 (0.992, 1.005)	0.67
Stranger, firearm	90,751	0.995 (0.988, 1.001)	0.10	0.989 (0.982, 0.995)	**0.001**	1.001 (0.988, 1.015)	0.84
Stranger, nonfirearm	28,569	0.993 (0.986, 0.999)	**0.03**	0.992 (0.985, 0.999)	**0.03**	0.995 (0.986, 1.003)	**0.01**
Domestic and nondomestic homicide rates							
Domestic, all cause	115,122	1.007 (1.004, 1.011)	**<0.001**	1.008 (1.004, 1.012)	**<0.001**	1.007 (1.003, 1.010)	**<0.001**
Domestic, firearm	59,651	1.013 (1.008, 1.018)	**<0.001**	1.012 (1.005, 1.020)	**0.001**	1.014 (1.011, 1.018)	**<0.001**
Domestic, nonfirearm	55,471	1.002 (0.997, 1.007)	0.52	1.004 (0.999, 1.010)	0.11	0.998 (0.993, 1.002)	0.35
Nondomestic, all cause	354,157	1.003 (0.998, 1.009)	0.230	1.003 (0.997, 1.008)	0.31	1.003 (0.998, 1.009)	0.23
Nondomestic, firearm	256,458	1.002 (0.996, 1.008)	0.50	1.000 (0.994, 1.005)	0.88	1.004 (0.997, 1.011)	0.23
Nondomestic, nonfirearm	97,699	1.001 (0.994, 1.009)	0.75	1.001 (0.994, 1.008)	0.74	1.003 (0.997, 1.009)	0.33

Note: Boldface indicates statistical significance (*p*<0.05). Models include fixed effects for year, errors are adjusted for clustering within states, and controls for region, nonhomicide violent crime rate, percentage of African American, young (15–24 years), and male.
[a]Total victim count estimates across 26-year study period derived from multiply imputed SHR data.
IRR, incidence rate ratio; SHR, Supplemental Homicide Reports.

specific influence of firearm ownership on domestic homicide and the disproportionate domestic homicide rate among female victims. Sensitivity analyses utilizing the FS/S firearm ownership proxy and non-imputed SHR data supported the unique relation between firearm ownership and domestic, but not nondomestic, firearm homicide rates (Appendix Tables 3 and 4, available online).

To fully capture the effect of the wide variability in firearm ownership across states on domestic and nondomestic homicide rates, states were separated into quartiles of firearm ownership. Figure 1 displays rates of firearm ownership and domestic firearm homicide. States in the lowest quartile of firearm ownership (mean=22.7, SD=8.3) served as the reference for states in the second (mean=37.1, SD=4.3), third (mean=42.8, SD=4.8), and fourth (mean=55.2, SD=8.4) quartiles. As shown in Table 3, states in the highest quartile of firearm ownership evidenced a 64.6% increased incidence rate of domestic firearm homicide relative to states in the lowest quartile of ownership (IRR=1.646, 95% CI=1.356, 1.998). This large increase in domestic firearm homicide rates as a function of firearm ownership appeared to drive a 35.3% increased incidence rate for all-cause domestic homicide (IRR=1.353, 95% CI=1.207, 1.518). By contrast, no differences were observed across firearm ownership quartiles for nondomestic firearm homicide.

Geographic variations in homicide rates were tested with New England as the reference for the remaining eight U.S. Census districts. Though only one district differed significantly from New England in nondomestic firearm homicide rates, the incidence of domestic firearm homicide was significantly higher in five of the eight districts (Appendix Table 5, available online). This included increased incidence rates of 60.9% in the East North Central District (IN, IL, MI, OH, WI), 100.3% in the Mountain District (AZ, CO, ID, NM, MT, UT, NV, WY), 117.2% in the South Atlantic (DE, DC, FL, GA, MD, NC, SC, VA, WV), 165.3% in the East South Central (AL, KY, MS, TN), and 192.5% in the West South Central District (AR, LA, OK, TX). As shown in Appendix Table 5 (available online), the districts with the largest increases in domestic firearm homicide incidence were generally in the South and in districts with the highest firearm ownership rates.

DISCUSSION

Although prior research has highlighted the increased risk of firearm-related homicide for female victims, none have attempted to disentangle the victim−offender relationship in these homicides at the state level and examine the association with firearm ownership. In using the SHR to measure victim−offender relationships, these results suggest that one third of all homicides are classified as domestic,

Figure 1. Firearm ownership and domestic firearm homicide rates in the U.S., 1990−2016.

Table 3. Effects of Gun Ownership on Domestic and Nondomestic Homicide Rates, U.S., 1990–2016

Homicide by firearm use/gun ownership quartile	Absolute rate	Absolute rate difference	IRR (95% CI)	*p*-value
Domestic, all cause				
1	1.29	1 (ref)	—	—
2	1.47	0.18	1.339 (1.186, 1.512)	**<0.001**
3	1.70	0.41	1.288 (1.131, 1.466)	**<0.001**
4	1.91	0.62	1.353 (1.207, 1.518)	**<0.001**
Domestic, firearm				
1	0.60	1 (ref)	—	—
2	0.78	0.18	1.571 (1.293, 1.909)	**<0.001**
3	0.95	0.35	1.514 (1.234, 1.858)	**<0.001**
4	1.11	0.51	1.646 (1.356, 1.998)	**<0.001**
Domestic, nonfirearm				
1	0.69	1 (ref)	—	—
2	0.69	0.00	1.167 (1.042, 1.307)	**0.008**
3	0.75	0.06	1.128 (1.005, 1.266)	**0.04**
4	0.80	0.11	1.144 (1.004, 1.302)	**0.04**
Nondomestic, all cause				
1	4.74	1 (ref)	—	—
2	4.33	−0.41	1.280 (0.954, 1.717)	0.10
3	4.50	−0.24	0.936 (0.692, 1.265)	0.67
4	4.54	−0.20	0.809 (0.602, 1.088)	0.16
Nondomestic, firearm				
1	3.45	1 (ref)	—	—
2	3.11	−0.34	1.348 (0.902, 2.014)	0.15
3	3.27	−0.18	0.902 (0.597, 1.362)	0.62
4	3.24	−0.21	0.734 (0.485, 1.112)	0.15
Nondomestic, nonfirearm				
1	1.29	1 (ref)	—	—
2	1.22	−0.07	1.176 (0.999, 1.385)	0.05
3	1.22	−0.07	1.016 (0.869, 1.188)	0.85
4	1.29	0.00	1.001 (0.848, 1.181)	0.99

Note: Boldface indicates statistical significance (*p*<0.05). Domestic combines victims classified as intimate partners and other family members. Nondomestic combines victims classified as friends/acquaintances and strangers. Model includes fixed effects for year; errors are adjusted for clustering within states, and controls for region, percentage of African American, young (15–24 years), male, and nonhomicide violent crime rate. Mean gun ownership rates by quartile are as follows: Quartile 1, 22.66 (SD=8.30); Quartile 2, 37.06 (SD=4.30); Quartile 3, 42.82 (SD=4.80); Quartile 4, 55.23 (SD=8.40).
IRR, incidence rate ratio.

and most of these cases involve female victims. Furthermore, domestic homicides committed by family members and intimate partners increase as the levels of firearm ownership increase for both female and male victims. By contrast, there is no association between firearm ownership and nondomestic firearm homicide rates for either male or female victims. This is a novel finding as most prior research, which has tended to aggregate domestic and nondomestic homicides, has consistently demonstrated an association between firearm ownership and homicide rates. Thus, in agreement with prior research showing that firearms in the home increase risk of domestic homicide,[15] these findings support a specific association between firearm ownership and domestic, but not

nondomestic, homicide at the population level. It is plausible that nondomestic firearm homicides are driven more by street-related violence[27] where perpetrators are more likely to illegally obtain their weapons, which are frequently traded across state lines.[28] In addition, among all homicides and victim—perpetrator relationships, most female homicide victims were killed with a firearm. Moreover, rates of firearm ownership affect the likelihood of a female victim being killed, which is consistent with prior research that found that a perpetrator's access to a firearm increased the likelihood of an intimate partner homicide occurring by almost five times.[15] Although female partners are more likely to be victims of domestic homicides,[29] the present results

display an increased risk to both men and women as the rate of firearm ownership increased. This suggests that victims of intimate partner and family-related disputes are more likely to be killed if a firearm is present in the home.

Limitations

This research has several limitations. For example, the data sources are limited because of missing information about the victim−offender relationship. However, to account for this limitation, the authors implemented a multiply imputed approach as developed by Fox and Swatt[21] to address the missing data on the victim-offender relationship. Moreover, because ex-dating partners are not classified as intimate partners in the SHR coding scheme, the results are likely underestimating the prevalence of intimate partner homicides. The reliance on a proxy, albeit well validated, for firearm ownership introduces additional noise. Furthermore, despite the use of panel data, this study cannot address the directionality of the association between firearm ownership and homicide rates because the statistical approach tested variation across states and not within states over time.

CONCLUSIONS

There was considerable variation in the rates of firearm ownership across states, and states with the highest firearm ownership had a 64.6% higher incidence rate of domestic firearm homicide relative to states with lower firearm ownership rates. There are several federal laws aimed at reducing domestic firearm homicide. For example, the Violence Against Women Act of 1994 prohibits firearm possession by individuals subjected to permanent intimate partner violence restraining orders,[30] and the Gun Control Act of 1968 prohibits firearm possession by people convicted of felony intimate partner violence.[31] However, little has been done at the federal level to enforce these laws and as a result a number of states have sought to prevent domestic firearm homicide through additional state legislation. Studies into these policies suggest that states with laws that prohibit individuals at high risk of intimate partner violence from possessing firearms and require them to relinquish any firearms they currently own have a lower incidence of domestic firearm homicide.[17,32] The current results suggest that firearm ownership is associated with higher levels of domestic, but not nondomestic, firearm homicide, suggesting that homicide rates vary as a function of firearm ownership only within specific victim−offender relationships. Firearm ownership not being associated with nondomestic homicide is an area for further research to better understand the social dynamics at play and where

firearms used in these incidents are being obtained. Overall, these findings support the need for state firearm legislation directed toward protecting victims of domestic violence, as access to firearms uniquely increases the likelihood of homicide among this population.[16,17]

SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at https://doi.org/10.1016/j.amepre.2019.04.009.

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