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Association of veteran suicide risk with state-level firearm ownership rates and firearm laws in the USA

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ABSTRACT

Background Veterans have higher suicide rates than matched non-veterans, with firearm suicides being especially prevalent among veterans. We examined whether state firearm laws and state firearm ownership rates are important risk factors for suicide among veterans.

Methods US veteran's and demographically matched non-veteran's suicide rates, 2002–2019, are modelled at the state level as a function of veteran status, lethal means, state firearm law restrictiveness, household firearm ownership rates and other covariates.

Results Marginal effects on expected suicide rates per 100 000 population were contrasted by setting household firearm ownership to its 75th versus 25th percentile values of 52.3% and 35.3%. Ownership was positively associated with suicide rates for both veterans (4.35; 95% credible interval (CrI): 1.90, 7.14) and matched non-veterans (3.31; 95% CrI: 1.11, 5.77). This association was due to ownership's strong positive association with firearms suicide, despite a weak negative association with non-firearm suicide. An IQR difference in firearm laws corresponding to three additional restrictive laws was negatively associated with suicide rates for both veterans (−2.49; 95% CrI: −4.64 to −0.21) and matched non-veterans (−3.19; 95% CrI: −5.22 to −1.16). Again, these differences were primarily due to associations with firearm suicide rates. Few differences between veterans and matched non-veterans were found in the associations of state firearm characteristics with suicide rates.

Discussion Veterans' and matched non-veterans' suicide risk, and specifically their firearm suicide risk, was strongly associated with state firearm characteristics.

Conclusions These results suggest that changes to state firearm policies might be an effective primary prevention strategy for reducing suicide rates among veterans and non-veterans.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Veterans have higher suicide rates than matched non-veterans, and these higher rates are associated with greater firearm suicides. We examined whether state firearm laws and state rates of household gun ownership were risk factors associated with suicide risk among veterans and matched non-veterans.

WHAT THIS STUDY ADDS

⇒ We found that restrictive state firearm laws and low state household firearm ownership are associated with lower total and, specifically, firearm suicide rates among veterans and matched non-veterans.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Community firearm characteristics determined in part by state and local policies are risk factors for firearm suicide among veterans and non-veterans. Interventions to modify these factors should be further investigated as candidate suicide prevention measures.

BACKGROUND

Suicide rates among veterans are higher than among non-veterans. They are especially high among some subgroups of veterans, such as those under the age of 45 for whom suicide was the second leading cause of death in 2021.[1]

Military experiences or exposures that might explain veterans' elevated suicide rates have been extensively studied. Such experiences may contribute to veterans having firearm ownership rates—a risk factor for suicide[2]—approximately twice those of non-veterans.[3] Similarly, risk factors for suicide have been examined in service members' military trauma,[4] military sexual trauma,[5] traumatic brain injuries associated with military service,[6] military deployments,[7] stressors associated with transitioning from military to civilian life,[8] interactions between psychopathology and military service[9] and other features of military service.

Risk factors unrelated to military service have received less consideration in the study of veteran suicide risk. These include factors known to be associated with suicide risk in the general population. State of residence is one such risk factor, with suicide risk varying by a factor of three across states.[10] This variation has been associated with state demographics,[11] welfare policies,[12] minimum wage laws,[13] firearm and alcohol availability and firearm laws,[14] among other state differences.

Veterans are more likely than non-veterans to die in suicides using a firearm. In 2020, 72% of veteran suicides involved a firearm, compared with 52% of non-veteran suicides[1] and firearm suicide rates in the general population vary by a factor of 10 across states. For example, over 2018–2021, Massachusetts had 2 firearm suicides per 100 000 population, whereas Wyoming had 21 per 100 000.[10] Differences of these magnitudes suggest that state of residence may be a more important risk factor for suicide than many of the individual-level characteristics that have been well studied, such as male gender which has been found to have an OR of 2.2, severe depression (OR=2.2), alcohol and

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drug misuse (OR=2.2), comorbid disorders (OR=1.6) or family histories of psychiatric disorder (OR=1.4).[15]

In this study, we investigate state differences in suicide risk among veterans. Specifically, we examine the association of state household firearm ownership rates and state firearm laws with veterans' suicide rates, and whether these associations are different than found for matched non-veterans. In the general population, household firearm ownership rates and state suicide rates are highly correlated (eg, r=0.7 for all suicides and r=0.8 for firearm suicides[16]). Similarly, many studies examining the association of firearm regulations with state suicide rates have suggested that restrictive state firearm laws, like safe storage laws, waiting periods and minimum age of purchase or possession laws, are associated with fewer suicides and firearm suicides.[14]

Whether state firearm characteristics are associated with veterans' suicide risk in a similar manner as found in the general population is not known. If they are then these potentially modifiable risk factors might point toward individual-level, community-level and policy interventions as effective or more effective than interventions more specifically targeted to veteran populations. However, veterans' military experience, firearm ownership rates and increased likelihood of settling in areas other than where they grew up[17] may all mitigate the influence of local community firearm ownership rates and state firearm laws, suggesting their suicide rates may be less associated with their states' firearm characteristics.

METHODS

Suicides and population data

Veteran suicide statistics were provided by the Veterans Affairs Administration (VA) Office of Mental Health and Suicide Prevention (OMHSP). This office collects identifiers on all current and former service members drawing from multiple data sources including paper service records prior to 1974. These identifiers are then matched to the National Death Index. Decedents are classed as veterans if they served on federal active duty and were not currently serving at the time of their death.[18] These records omit some veteran suicides that did not occur in a US state, and some that occurred among veterans who served before electronic personnel records were implemented by the U.S. Department of Defense (DoD) in 1974.[19] Nevertheless, they are the most comprehensive and well-vetted source of veteran suicide data available.[20] OMHSP provided RAND with a public use data extract from this data set consisting of veteran suicide counts by state and firearm/non-firearm method, and by state and age of death, for six 3-year periods beginning in 2002 and ending in 2019. This file included veteran population counts by state and period from the VetPop model maintained by the VA's National Center for Veterans Analysis and Statistics. Microdata and more detailed tables on veterans' suicide are not publicly releasable due to privacy concerns.

Non-veteran suicides and population data

Firearm and non-firearm suicides in each state and 3-year period were obtained for male and female decedents in three age groups (25–45, 46–64 and 65 and older) from the Centers for Disease Control (CDC),[10] which also provided population estimates for each group. Suicide counts and population estimates were weighted to match the estimated age and gender distribution of veterans in each state and period (see supplemental methods in the online supplemental materials). Non-veteran suicides and population counts were estimated as the difference between the weighted total suicide counts and veteran suicides as provided in the VA data for each state and time period.

Patient and public involvement

No patients were involved in this study.

Predictors

Annual state household firearm ownership rate estimates (HFR) were drawn from Schell *et al*,[21] which includes estimates for study years 1990–2016. HFR changes slowly, so we impute rates for the 2017–2019 by carrying forward the 2016 estimates (see figure 1).

An index of firearm policy restrictiveness was constructed for each state and 3-year period using data from RAND's State Firearm Law database.[22] The index tabulates the presence of seven laws selected because they are designed to reduce suicides (among other intended effects) or because they have been shown to be associated with suicide risk:[14] (1) background checks on private sales, (2) waiting periods of 24 hours or more to purchase firearms; (3) waiting periods of 7 days or more; (4) child-access prevention (safe storage) laws; (5) 'shall-issue' concealed carry

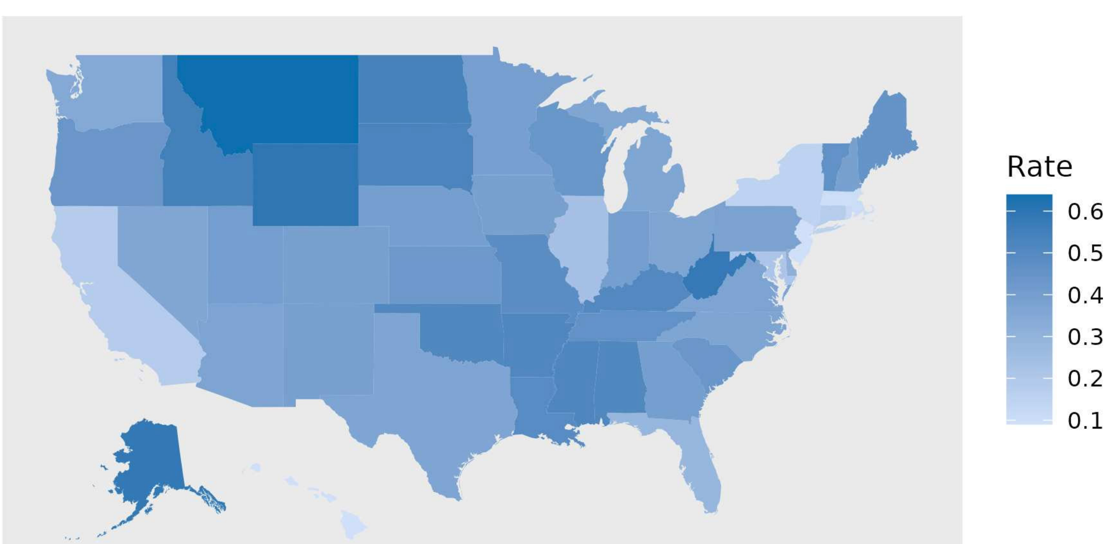

Figure 1 Mean household firearm ownership rates by US state, 2002–2019 (N=50 states).

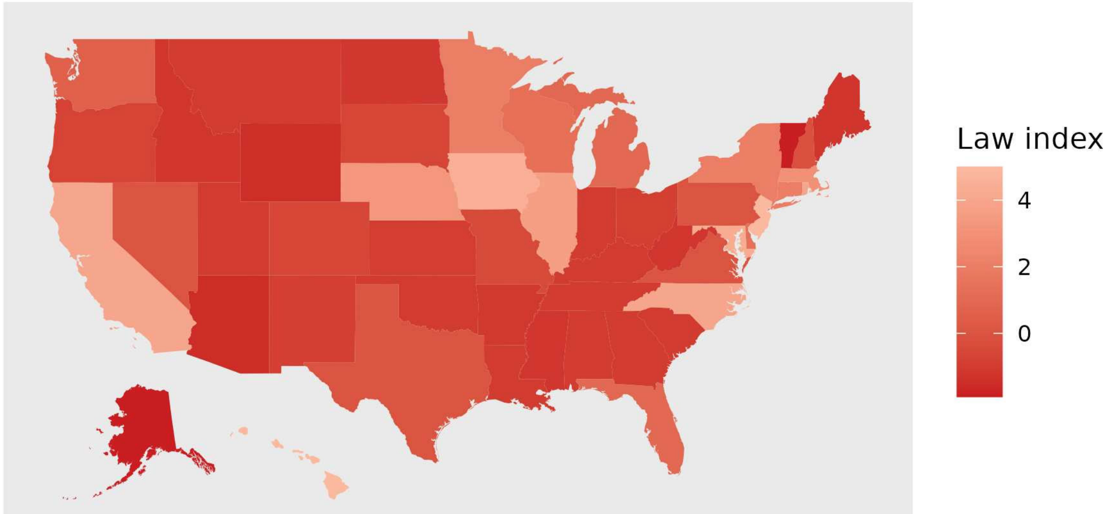

Figure 2 Mean law restrictiveness index score by US state, 2002–2019 (N=50 states).

laws that prohibit government from exercising discretion in the issuance of permits (reverse coded); (6) permitless carry laws which allow concealed carry without a permit (reverse coded); and (7) laws that require a permit and background check to acquire any firearm (see figure 2).

Statistical analysis

We modelled state-level suicide rates from 2002 to 2019, where rates were stratified by veteran status (veteran or matched non-veterans) and by lethal means (firearm or non-firearm) within each 3-year period. We used a Bayesian negative binomial model of state suicide deaths with a population offset. Predictors included: veteran status, lethal means, HFR, firearm law index, state and period effects and several covariates, discussed below. Several interaction terms were included to permit HFR, firearm law index and time to have different associations with suicide risk as a function of veteran status and lethal means (see model description in supplemental materials).

Initial model development began with a complex model that included state and period fixed effects, as well as 21 state-level covariates that captured the demographic, socioeconomic and population health characteristics of each state in each period (Table S1). Because controlling for this large set of interrelated predictors may not provide the most accurate model estimates, the model was simplified whenever that change resulted in improvements in an estimate of out-of-sample prediction error, the leave-one-out crossvalidation information criterion (LOOIC).[23] The final, best-fitting model used random effects for state and period and retained two covariates: percentage of residents who are black and population density. Results from the complex model are included in the supplemental materials. It produced estimates in the same direction and approximate magnitude as the final model, although with wider CIs.

We present results using marginal effects expressed as suicide rates per 100 000 person-years. These effects are derived from the posterior distributions of expected deaths when setting specified predictors to identified values, while maintaining the empirical distribution of other predictors. The reported estimates are the posterior median, and the 95% credible interval (CrI) lower and upper limits are the 2.5th and 97.5th quantiles of the posterior distributions. Because the model includes interactions with time, marginal effects are computed for the most recent period, 2017–2019.

Ethics approval. RAND's Institutional Review Board approved this research on 9 September 2022.

RESULTS

The average suicide rate over the full period was 28.2 per 100 000 population (95% confidence interval (CI): 28.0, 28.4) among veterans and 27.5 (95% CI: 27.4, 27.6) among matched non-veterans (here and throughout this discussion, rates are expressed as deaths per 100 000 population). For both groups, most suicides involved a firearm. For veterans, the overall rate was composed of 19.0 (95% CI: 18.9, 19.2) and 9.2 (95% CI: 9.1, 9.3), for firearm and non-firearm suicides, respectively. For matched non-veterans these rates were 17.6 (95% CI: 17.5, 17.7) and 9.9 (95% CI: 9.9, 10.0).

Among veterans and matched non-veterans there were large differences across US states in suicide rates, with the maximum average state rate being three times greater than the minimum over the study period. The geographical pattern in suicide rates was similar for the veteran and matched non-veteran populations (figure 3), and the correlation in rates across states between the two groups was high (r=0.94), the substantial variance in suicide risk across states is primarily due to the differences in firearm suicide rates. For veterans and non-veterans the SD across states in firearm suicide rates was three times greater than for non-firearm suicides (veterans' SDs=7.3 and 2.1, respectively; non-veterans' SD=7.2 and 2.4). Table 1 provides state suicide rates by veteran status and lethal means (firearm vs non-firearm).

Predicted values from the model of state suicide rates were highly associated with the actual suicide rates, R^2=0.90 suggesting a good model fit. Additional information about model fit and posterior distributions of all parameters is contained in the supplemental materials.

To evaluate the modelled association of HFR with suicide rates, we estimated marginal effects in the 2017–2019 period, comparing predicted suicide rates when setting states to a low (35.3%) versus a high HFR (52.3%) value. These correspond to the 25th and 75% percentiles of state HFR in 2017–2019. Among veterans, the high HFR value was associated with a suicide rate 4.35 per 100 000 (95% CrI: 1.90, 7.14) higher than with a low HFR. For matched non-veterans it was also

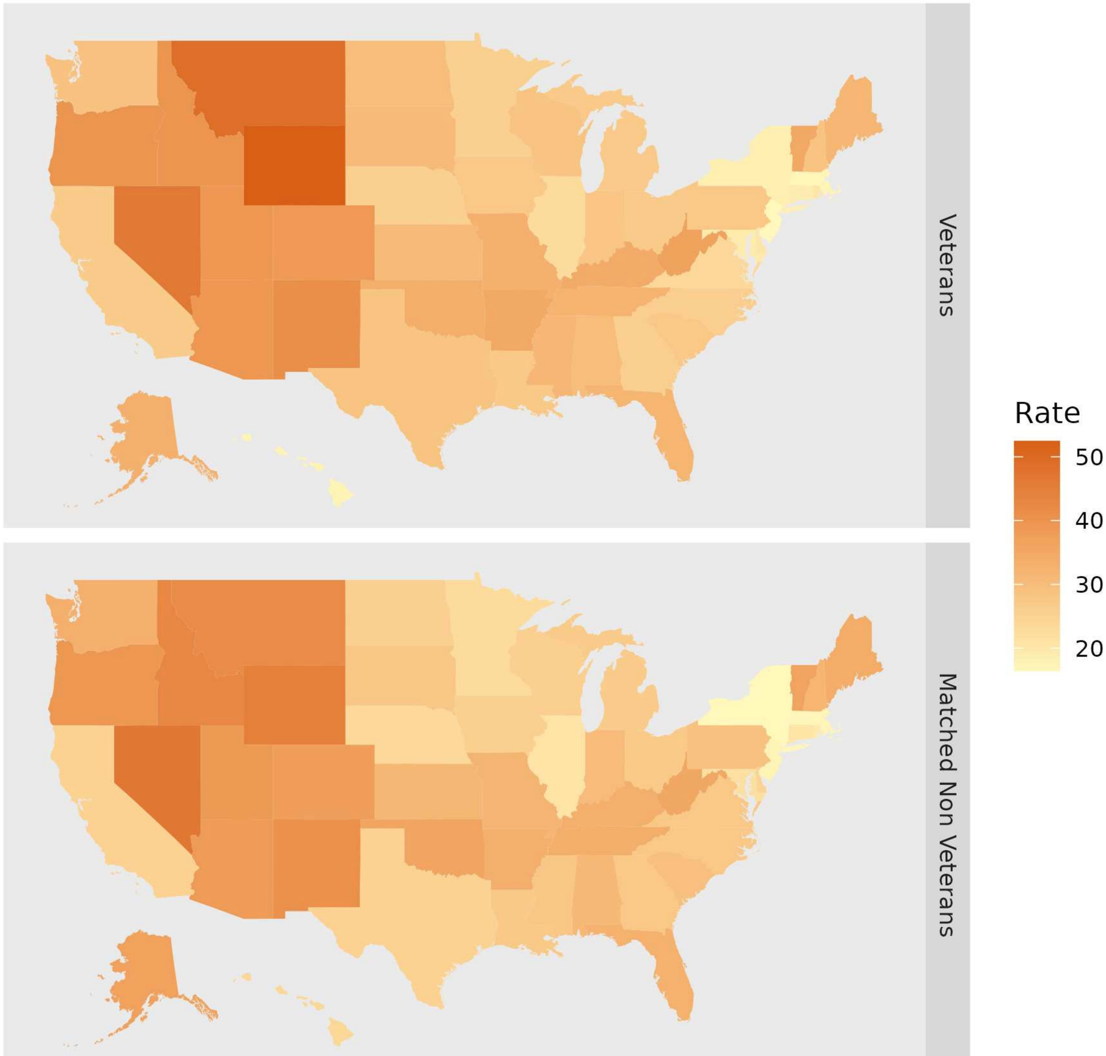

Figure 3 Mean suicide rates by US state and veteran status, 2002–2019 (N=50 states).

associated with higher rates (3.31; 95% CrI: 1.11, 5.77), and there was little evidence that the association of HFR and suicide rates is meaningfully greater among veterans than non-veterans (difference of 1.03; 95% CrI: −0.23, 2.43).

Decomposing the association of HFR and suicide rates into the firearm and non-firearm suicide rates reveals that this positive association is entirely explained by the positive association of HFR with firearm suicides. The association with firearm suicide was positive for veterans (5.85 deaths per 100 000; 95% CrI: 3.92, 8.01) and matched non-veterans (5.77; 95% CrI: 4.06, 7.66). In contrast, the association of HFR with non-firearm suicide rates was negative for veterans (−1.49 95% CrI: −2.18 to –0.73) and non-veterans (−2.46; 95% CrI: −3.05 to –1.78). There was little evidence that the association of HFR and firearm suicide rates differed between veterans and non-veterans (difference of 0.08 deaths per 100 000; 95% CrI: −1.16, 1.37). Although the negative association of HFR with non-firearm suicides was stronger for non-veterans than veterans (difference of 0.96; 95% CrI: 0.47, 1.43), or both groups the HFR's small negative association with non-firearm suicide was fully offset by the large positive association with firearm suicides.

Marginal effects for state firearm law restrictiveness on suicide rates were computed by contrasting 25th and 75th percentile values for state law restrictiveness in 2017–2019, which corresponds to a difference of three laws. Greater law restrictiveness was associated with fewer suicides among both veterans (−2.49 per 100 000; 95% CrI: −4.64 to –0.21), and non-veterans (−3.19; 95% CrI: −5.22 to –1.16). There was little evidence that these two effects differed in strength (difference in estimates: 0.70; 95% CrI: −0.67, 2.03).

The association between firearm law restrictiveness and overall suicide rates was almost entirely attributable to its association with firearm suicides. Expected suicide rates associated with low versus high law restrictiveness were larger for firearm suicides than non-firearm suicides over the two populations (difference of 4.7; 95% CrI: 3.0 to 6.4). Greater law restrictiveness was associated with fewer firearm suicides among both veterans (−2.44 deaths per 100 000; 95% CrI: −4.00 to –0.78), and matched non-veterans (−2.68; 95% CrI: −4.02 to –1.36). In contrast, law restrictiveness was not reliably associated with non-firearm suicide rates for either veterans (−0.06; 95% CrI: −0.87, 0.77) or non-veterans (−0.50; 95% CrI: −1.35, 0.35). There was little evidence that these associations with law restrictiveness differed between veterans and matched non-veterans for either firearm suicide rates (difference of 0.26; 95% CrI: −0.93, 1.40), or non-firearm suicide rates (difference of 0.45; 95% CrI: −0.26, 1.13).

Table 1 Suicide rates per 100 000 population over 2002–2019 by US state, veteran status and method of suicide

	N		Total suicide		Firearm suicide		Non-firearm suicide	
State	**Veteran**	**Non-veteran***	**Veteran**	**Non-veteran***	**Veteran**	**Non-veteran***	**Veteran**	**Non-veteran**
Alabama	1 232 667	2 340 530	30.1 (28.9 to 31.4)	31.1 (30.1 to 32.0)	23.9 (22.8 to 25.1)	24.6 (23.7 to 25.4)	6.2 (5.6 to 6.7)	6.5 (6.1 to 6.9)
Alaska	218 333	400 654	32.9 (29.8 to 36.0)	36.7 (34.3 to 39.2)	25.7 (23.0 to 28.5)	25.7 (23.7 to 27.7)	7.2 (5.7 to 8.6)	11.0 (9.7 to 12.4)
Arizona	1 613 667	2 558 370	39.2 (37.9 to 40.4)	38.3 (37.3 to 39.3)	29.0 (27.9 to 30.0)	26.9 (26.0 to 27.7)	10.2 (9.6 to 10.9)	11.5 (10.9 to 12.0)
Arkansas	750 833	1 378 019	34.9 (33.1 to 36.6)	33.5 (32.2 to 34.7)	25.4 (23.9 to 26.8)	25.9 (24.8 to 27.0)	9.5 (8.6 to 10.4)	7.6 (7.0 to 8.2)
California	6 136 333	16 187 315	26.5 (26.0 to 27.0)	25.0 (24.7 to 25.3)	15.9 (15.5 to 16.3)	13.4 (13.2 to 13.7)	10.6 (10.3 to 10.9)	11.6 (11.3 to 11.8)
Colorado	1 261 667	2 280 441	38.4 (37.0 to 39.8)	37.3 (36.3 to 38.3)	24.9 (23.8 to 26.1)	23.2 (22.4 to 24.0)	13.5 (12.7 to 14.3)	14.1 (13.5 to 14.7)
Connecticut	698 167	1 346 120	18.7 (17.4 to 20.1)	20.6 (19.6 to 21.6)	8.8 (7.9 to 9.7)	9.1 (8.5 to 9.8)	9.9 (9.0 to 10.9)	11.5 (10.7 to 12.2)
Delaware	234 500	394 426	20.6 (18.2 to 23.0)	24.8 (22.8 to 26.9)	12.9 (11.1 to 14.8)	13.9 (12.4 to 15.4)	7.7 (6.2 to 9.1)	10.9 (9.6 to 12.2)
Florida	5 080 333	9 542 776	31.9 (31.2 to 32.5)	32.7 (32.2 to 33.2)	21.8 (21.3 to 22.4)	20.1 (19.7 to 20.4)	10.1 (9.7 to 10.4)	12.6 (12.3 to 12.9)
Georgia	2 223 500	4 910 396	26.0 (25.1 to 26.8)	27.6 (27.0 to 28.2)	19.8 (19.0 to 20.5)	20.3 (19.8 to 20.8)	6.2 (5.8 to 6.6)	7.3 (7.0 to 7.6)
Hawaii	360 833	782 736	17.2 (15.5 to 19.0)	23.8 (22.5 to 25.2)	5.7 (4.7 to 6.7)	5.6 (5.0 to 6.3)	11.5 (10.1 to 13.0)	18.2 (17.0 to 19.4)
Idaho	392 500	646 455	39.7 (37.2 to 42.3)	42.8 (40.8 to 44.9)	30.0 (27.8 to 32.2)	31.9 (30.2 to 33.7)	9.8 (8.5 to 11.0)	10.9 (9.8 to 11.9)
Illinois	2 329 667	5 178 346	22.6 (21.8 to 23.4)	21.0 (20.5 to 21.6)	13.4 (12.8 to 14.0)	10.6 (10.2 to 10.9)	9.2 (8.7 to 9.7)	10.5 (10.1 to 10.8)
Indiana	1 476 000	2 833 829	27.8 (26.7 to 28.9)	30.2 (29.4 to 31.1)	19.3 (18.3 to 20.2)	20.4 (19.7 to 21.1)	8.5 (7.9 to 9.2)	9.8 (9.4 to 10.3)
Iowa	723 167	1 315 099	27.7 (26.1 to 29.2)	25.6 (24.4 to 26.7)	17.0 (15.7 to 18.2)	15.5 (14.6 to 16.4)	10.7 (9.7 to 11.7)	10.1 (9.4 to 10.8)
Kansas	688 167	1 273 271	30.5 (28.9 to 32.2)	31.5 (30.2 to 32.8)	20.6 (19.2 to 22.0)	21.6 (20.5 to 22.6)	10.0 (9.0 to 10.9)	9.9 (9.2 to 10.6)
Kentucky	1 007 833	2 131 903	34.2 (32.7 to 35.7)	33.5 (32.5 to 34.5)	25.5 (24.3 to 26.8)	25.5 (24.6 to 26.4)	8.6 (7.9 to 9.4)	8.0 (7.5 to 8.5)
Louisiana	994 667	2 329 063	27.3 (26.0 to 28.6)	27.2 (26.3 to 28.0)	21.2 (20.1 to 22.4)	20.6 (19.8 to 21.3)	6.0 (5.4 to 6.7)	6.6 (6.2 to 7.0)
Maine	397 833	624 969	31.6 (29.3 to 33.8)	33.9 (32.0 to 35.8)	21.3 (19.4 to 23.1)	22.6 (21.1 to 24.2)	10.3 (9.0 to 11.6)	11.3 (10.2 to 12.3)
Maryland	1 349 500	2 865 598	19.3 (18.4 to 20.3)	21.6 (20.9 to 22.3)	12.3 (11.5 to 13.0)	12.6 (12.1 to 13.1)	7.1 (6.5 to 7.6)	9.0 (8.6 to 9.5)
Massachusetts	1 240 667	2 437 486	17.1 (16.1 to 18.0)	17.2 (16.5 to 17.8)	6.6 (6.0 to 7.2)	5.6 (5.2 to 5.9)	10.5 (9.7 to 11.2)	11.6 (11.0 to 12.1)
Michigan	2 163 500	4 223 368	27.0 (26.1 to 27.9)	26.5 (25.9 to 27.2)	17.8 (17.1 to 18.6)	17.2 (16.7 to 17.7)	9.2 (8.7 to 9.7)	9.3 (9.0 to 9.7)
Minnesota	1 165 833	2 008 987	25.4 (24.2 to 26.6)	22.6 (21.8 to 23.5)	15.2 (14.3 to 16.1)	13.7 (13.0 to 14.4)	10.2 (9.5 to 11.0)	8.9 (8.4 to 9.5)
Mississippi	652 333	1 522 566	31.6 (29.8 to 33.3)	27.7 (26.7 to 28.8)	25.6 (24.0 to 27.2)	22.1 (21.1 to 23.0)	6.0 (5.2 to 6.7)	5.7 (5.2 to 6.2)
Missouri	1 522 167	2 530 426	33.2 (32.0 to 34.4)	31.9 (31.0 to 32.8)	24.0 (23.0 to 25.0)	22.8 (22.1 to 23.6)	9.2 (8.6 to 9.9)	9.1 (8.6 to 9.6)
Montana	300 333	466 980	48.9 (45.7 to 52.2)	41.8 (39.4 to 44.2)	36.6 (33.8 to 39.4)	30.0 (28.0 to 32.0)	12.4 (10.8 to 14.0)	11.8 (10.5 to 13.0)
Nebraska	442 500	762 408	25.4 (23.5 to 27.3)	23.3 (21.9 to 24.7)	17.4 (15.8 to 19.0)	15.1 (14.0 to 16.3)	8.0 (6.9 to 9.1)	8.2 (7.4 to 9.1)
Nevada	696 167	1 164 937	46.3 (44.2 to 48.4)	46.5 (44.9 to 48.1)	31.0 (29.3 to 32.7)	31.0 (29.7 to 32.3)	15.3 (14.1 to 16.5)	15.5 (14.6 to 16.4)
New Hampshire	355 833	533 053	28.4 (26.2 to 30.7)	31.8 (29.9 to 33.8)	18.3 (16.5 to 20.1)	18.7 (17.2 to 20.2)	10.2 (8.8 to 11.5)	13.2 (11.9 to 14.4)
New Jersey	1 416 667	3 169 054	16.4 (15.6 to 17.3)	17.3 (16.7 to 17.9)	8.0 (7.4 to 8.6)	6.6 (6.3 to 7.0)	8.4 (7.8 to 9.1)	10.6 (10.1 to 11.1)
New Mexico	519 333	924 103	41.1 (38.9 to 43.4)	40.9 (39.2 to 42.5)	28.8 (26.9 to 30.7)	28.0 (26.7 to 29.4)	12.4 (11.1 to 13.6)	12.8 (11.9 to 13.7)
New York	2 988 833	8 186 276	18.3 (17.7 to 18.9)	16.4 (16.1 to 16.8)	9.7 (9.2 to 10.1)	6.4 (6.2 to 6.7)	8.6 (8.2 to 9.0)	10.0 (9.7 to 10.3)
North Carolina	2 301 500	4 877 939	25.9 (25.1 to 26.8)	27.6 (27.0 to 28.2)	18.7 (18.0 to 19.4)	19.8 (19.2 to 20.3)	7.2 (6.7 to 7.6)	7.8 (7.5 to 8.2)
North Dakota	178 000	386 620	30.1 (26.9 to 33.4)	25.7 (23.7 to 27.8)	20.3 (17.6 to 23.0)	16.7 (15.1 to 18.4)	9.8 (8.0 to 11.7)	9.0 (7.8 to 10.2)
Ohio	2 773 667	5 089 117	26.8 (26.0 to 27.6)	27.1 (26.5 to 27.7)	18.0 (17.3 to 18.6)	17.5 (17.1 to 18.0)	8.8 (8.4 to 9.3)	9.6 (9.2 to 9.9)
Oklahoma	997 833	1 689 913	33.6 (32.1 to 35.0)	35.8 (34.6 to 37.0)	24.3 (23.1 to 25.6)	26.2 (25.2 to 27.2)	9.3 (8.5 to 10.0)	9.6 (9.0 to 10.2)
Oregon	1 021 833	1 615 474	39.6 (38.0 to 41.2)	39.1 (37.8 to 40.3)	27.7 (26.3 to 29.0)	26.2 (25.2 to 27.3)	11.9 (11.1 to 12.8)	12.9 (12.1 to 13.6)
Pennsylvania	2 992 667	4 887 119	27.5 (26.7 to 28.3)	28.7 (28.0 to 29.3)	18.2 (17.6 to 18.8)	18.4 (17.9 to 18.9)	9.3 (8.9 to 9.7)	10.2 (9.8 to 10.6)
Rhode Island	230 500	407 748	20.6 (18.2 to 23.0)	19.1 (17.4 to 20.9)	9.0 (7.5 to 10.6)	5.9 (5.0 to 6.9)	11.6 (9.8 to 13.4)	13.2 (11.8 to 14.6)
South Carolina	1 237 000	2 245 273	27.6 (26.4 to 28.8)	29.4 (28.5 to 30.3)	20.4 (19.4 to 21.5)	22.0 (21.2 to 22.8)	7.2 (6.5 to 7.8)	7.4 (6.9 to 7.8)
South Dakota	223 667	393 370	30.6 (27.7 to 33.6)	27.7 (25.6 to 29.8)	20.0 (17.6 to 22.4)	18.6 (16.9 to 20.4)	10.6 (8.8 to 12.3)	9.1 (7.9 to 10.3)
Tennessee	1 529 000	3 135 056	32.3 (31.1 to 33.5)	33.7 (32.9 to 34.5)	24.1 (23.1 to 25.1)	25.4 (24.7 to 26.1)	8.2 (7.6 to 8.8)	8.3 (7.9 to 8.7)
Texas	5 022 667	11 919 450	28.4 (27.8 to 29.0)	24.9 (24.6 to 25.3)	20.7 (20.2 to 21.2)	17.4 (17.1 to 17.7)	7.8 (7.4 to 8.1)	7.5 (7.3 to 7.8)
Utah	446 833	872 824	39.3 (36.9 to 41.7)	38.6 (36.9 to 40.3)	26.1 (24.2 to 28.0)	25.8 (24.4 to 27.2)	13.2 (11.8 to 14.6)	12.8 (11.8 to 13.7)
Vermont	145 667	289 160	35.0 (31.1 to 38.9)	36.1 (33.3 to 39.0)	23.5 (20.2 to 26.7)	25.3 (22.9 to 27.7)	11.6 (9.3 to 13.8)	10.8 (9.3 to 12.4)
Virginia	2 301 167	4 454 124	23.3 (22.5 to 24.1)	27.4 (26.8 to 28.0)	16.3 (15.6 to 17.0)	18.8 (18.2 to 19.3)	7.0 (6.6 to 7.5)	8.6 (8.3 to 9.0)
Washington	1 850 000	3 021 506	28.6 (27.6 to 29.6)	33.3 (32.5 to 34.1)	18.2 (17.4 to 19.0)	21.0 (20.3 to 21.7)	10.4 (9.8 to 11.0)	12.3 (11.8 to 12.8)
West Virginia	494 500	883 590	36.4 (34.3 to 38.6)	35.2 (33.6 to 36.8)	29.0 (27.0 to 30.9)	27.8 (26.3 to 29.2)	7.5 (6.5 to 8.5)	7.5 (6.7 to 8.2)
Wisconsin	1 289 833	2 392 773	28.4 (27.3 to 29.6)	25.7 (24.9 to 26.5)	17.7 (16.8 to 18.7)	15.6 (15.0 to 16.3)	10.7 (10.0 to 11.5)	10.1 (9.6 to 10.6)
Wyoming	146 167	277 438	52.5 (47.7 to 57.2)	44.7 (41.5 to 47.9)	40.0 (35.8 to 44.2)	34.2 (31.4 to 37.0)	12.4 (10.1 to 14.8)	10.5 (9.0 to 12.1)

Note: 95% CIs are in parenthesis. Population sizes (N) are average populations across the 3-year intervals.
*Non-veterans are weighted to match to the veteran population on age and gender and are not representative of the broader state populations. Non-veteran N is the effective sample size of the weighted non-veteran population.

DISCUSSION

Veteran suicide rates, particularly their firearm suicide rates, vary dramatically across states. This state variation in risk was associated with HFR and with the restrictiveness of state firearm laws. The association of both state characteristics with suicide rates was highly specific to the subset of suicides completed with a firearm. The effect size for the association between suicide rates and HFR is substantial. With a 17% point increase in HFR, the expected veteran suicide rate shifts 14% (inter-quartile range (IRR)=1.14; 95% CrI: 1.06, 1.22), which corresponds to 870 more veteran deaths nationally in 2021.[1]

These state firearm characteristics had similar associations with suicide risk for veterans and matched non-veterans, although the positive association between HFR and non-firearm suicides was slightly larger for non-veterans than veterans. These similarities occur despite veterans having a unique relationship to firearms that differs from their non-veteran neighbours, due to their extensive firearm training, military experience and higher average rates of firearm ownership.[3]

Our estimates are correlational, and we do not interpret them as causal effect estimates. This reflects the fact that most interstate variation in gun ownership and firearm laws predates the beginning of the available VA suicide data. Thus, the data do not support a stronger analytical approach that might identify causal effects. Restricting the analysis so that modelled effects are identified solely through the limited changes in state firearm ownership and in firearm policies during the study period yields imprecise effect estimates (Tables S4-S5).

There are, however, four reasons why the current results should be seen as supportive of theories that hypothesise a causal link between the state firearm environment and suicide risk: (1) The estimates controlled for a range of state characteristics thought to be confounds for firearm environment variables (The estimated effects of state firearm ownership and firearm law restrictiveness are from the same model where each controls for the effect of the other. These constructs are plausibly mutually endogenous, which would make the modelled effects conservative estimates of the underlying causal effects for one or both variables.) as well as state random intercepts which can capture differences in risk between states caused by state characteristics that are not explicitly included in the model. (2) Associations were found prospectively within a longitudinal model that covers an 18-year period. (3) The associations of the state firearm environment variables were highly specific to firearm suicide rates; to the extent that the reported associations represent some omitted confounding variable, that variable must have sharply differentiated effects on firearm and non-firearm suicide rates—without itself being a state firearm characteristic. And (4) some of the estimated associations are large. For these association to be fully explained by omitted confounds requires that the current model failed to capture some especially strong predictors of firearm suicide risk that vary dramatically across states.

Finally, the results of this study are consistent with other research suggesting that firearm ownership and state-level policies affect suicide risk. For instance, other research shows that the suicide risk increases substantially in the period shortly after an individual purchases a firearm,[2] and is substantially higher than for similar individuals who did not purchase firearms.[24] Thus, while one should not interpret our results as suggesting that a shift in HFR from 35% to 52% has the causal effect of increasing veteran firearm suicides by 5.8 per 100 000, our findings are consistent with the theory that state firearm policies and firearm ownership affect suicide risk.

In addition to the limitations inherent in interpreting associations in observational data, the data themselves present limitations. The VA does not share microdata on veteran suicide. As such, our construction of a matched comparison sample of non-veterans required estimating how many veteran decedents to remove from the general population suicide totals within the cells of a five-way table of decedent characteristics based on the publicly released three-way tables of veteran suicide decedents (see supplemental materials). Despite this imprecision, the matched comparison sample appeared to have suicide risk that was highly comparable to veterans' risks. While the counts of veteran suicides we used are the most complete and carefully constructed data available, they are known to undercount suicides among veterans who separated from the military prior to 1974.[20] This is likely to result in a slight underestimate of veteran suicide rates for the oldest cohort of veterans, particularly in the earlier periods of this study.

CONCLUSIONS

One of the five priority goals for reducing military and veteran suicide announced by the White House was addressing upstream risk and protective factors, such as economic well-being, access to community resources and educational and vocational opportunities all of which have been linked to suicide risk.[25] This study identifies two candidate social determinants of suicide that have strong associations with suicide risk among veterans and non-veterans, and which states have considerable control over: the restrictiveness of state firearm policies and state firearm ownership rates. These factors can help identify groups of veterans who are at unusually high risk for suicide to better target existing prevention programmes or resources. In addition, the results suggest that changes to state firearm laws and policies should be investigated as a possibly cost-effective primary prevention strategy for reducing suicide rates among veterans and non-veterans.

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Supplemental Materials:

The association of veteran suicide risk with state-level firearm ownership rates and firearm laws in the United States.

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Methods

Nonveteran comparison sample. Data on suicide rates in the total population comes from CDC Wonder.(1) To construct the matched comparison sample of nonveterans veteran decedents were first removed from the full population suicide totals. This was done for each cell (N=3600) of a five-way table defined by the combination of six time periods, fifty states, two genders, three age groups (25-44, 45-64, and 65 and older), and two methods of suicide (firearm, nonfirearm).

For privacy reasons, the VA will not provide exact counts of veteran suicides for the individual cells of this data table. However, we can closely approximate those counts using data that is publicly available. Specifically, the VA has publicly released (via their annual report, or via https://www.mentalhealth.va.gov/suicide_prevention/data.asp), or have provided directly to RAND, tables that represent the key margins of the full table of interest. These include the following three-way tables of suicide counts: time period by state by sex, time period by method by sex, time period by state by method, and time period by method by age. We estimated the suicide counts in the cells of the full five-way table of interest ensuring that all such three-way tables were reproduced. Specifically, the individual cells of the table were imputed so that they summed to the corresponding cell values in each of the available three-way tables but were otherwise assumed to be independent. For example, the number of female suicide decedents between the ages of 18 and 45 in period 1 in Alabama who used a firearm is not available in any provided table. However, we know (a) the number of female decedents in Alabama in period 1, (b) the number of decedents age 18-45 in period 1 in Alabama, (c) the number of firearm decedents in Alabama in period 1, (d) the association between sex and the likelihood of using a firearm in suicide in period 1 across all states. One can then estimate female firearm suicide decedents in period 1 in Alabama that is consistent with those three pieces of information.

Although cell values in the 5-way table are imputed in this way, imprecision in these imputations are likely to have minimal effects for the overall analysis. This table determines the number of veteran decedents who are subtracted from the total population suicide decedents so that we can create a nonveteran suicide rate. However, the proportion of all suicide decedents in the general population who are veterans is just 17 percent over the study period, and so the final suicide rate among nonveterans is expected to be relatively insensitive to exactly how the veterans' deaths are allocated – the suicide rate for age and gender matched nonveterans is always going to be very close to the suicide rate for the age and gender matched total population regardless of how we allocate the veteran suicide decedents. In addition, we know our allocation is approximately correct because it reproduces all three-way contingency tables discussed above. Finally, these estimated counts only affect suicide rate estimates for the matched nonveteran comparison group. The suicide rates for the veterans in our analyses do not depend in any way on the estimated cell counts in this table because the primary analysis is not stratified by age and gender (only time by state and by method, which is a table provided by the VA); the allocation only affects suicide rates of the matched nonveteran group.

Once estimated counts of veterans' suicides of each type are subtracted from the population total suicides to create a count of nonveteran suicides, we also subtract the total veteran population sizes (provided by the VA using the VETPOP model) from the population sizes provided in CDC wonder to get a nonveteran population estimate so that nonveteran suicide rates can be computed.

We then use balancing weights to match the population age and sex distribution of the nonveteran to the distribution of veterans within each state and time period. This indirect standardization allows for comparisons of suicide rates among veterans and a demographically similar nonveteran comparison group. Weights are only applied to the nonveteran group in the analysis. Weighting is done using six strata defined by the two genders by three age groups within each state and period. The older-male weighting stratum is the one in which veterans are most overrepresented relative to the general population. It is treated as the reference group for the development of initial balancing weights. The weights for all strata within a state and time period are calculated as

$$w_i = v_i/k_i$$

Where for each weighting stratum *i* (young males; young females; middle aged males; middle aged females, older females), v_i is the ratio of the veteran population size in stratum *i* relative to the population size of veterans in the reference stratum (older male), and k_i the ratio of the nonveteran population size in stratum *i* relative to the population size of nonveterans in the reference stratum.

We create weighted nonveteran suicide rates for both firearm and nonfirearm suicide within each period and state. However, our primary analysis considers the population sizes on which each rate was computed in estimating the uncertainty of model-based estimates. This quantity depends on the scale used for the weights, even though the nonveteran suicide rates themselves do not depend on the scale used for the weights., Our final weights are scaled so that the sum of the nonveteran population across the weighting strata equals the effective sample size of the weighted suicide rate estimate. This was done using Kish's formula for effective sample size.(2)

Statistical model. We used a Bayesian negative binomial model of state suicide deaths, *D*, at time *t* and in state *s*, as a function of a logged population offset (*P*), an intercept (*a*), random effects for each state (*s*) and three-year period (*t*), fixed effects for firearm method (*F*), veteran status (*V*), household firearm ownership (*H*), the firearm law index (*I*), and the standardized demographic and economic covariates (***X***), see Table S1.

The model allows for a range of interactions to account for the possibility that the two state firearm characteristics of interest have different associations with suicide risk as a function of veteran status and firearm vs nonfirearm methods. For each firearm characteristic we include this three-way interaction as well as both two-way interactions. In addition to these planned interactions, during model development we identified several other interactions whose inclusions improved model fit as assessed with LOOIC.(3) These interactions suggest that suicide rates have been increasing faster over time for veterans than for the matched nonveterans, and that this increase was larger for firearm than nonfirearm suicides. These exploratory interactions were fit by allowing one interaction between veteran status and a linear function of time (T), and a second interaction that allows that linear time interaction to differ for firearm suicides. As such, the final model is described by:

$$D_{st} \sim Negative\ Binomial(\gamma_{st}, \varphi)$$

$$\log(\gamma_{st}) = \log(P) + \alpha + \boldsymbol{\lambda}_s + \boldsymbol{\gamma}_t + \alpha F_{st} + \beta V_{st} + \delta H_{st} + \boldsymbol{\omega X}_{st} + \rho V_{st}F_{st} + \zeta T_{st}V_{st} + \eta H_{st}F_{st} + \psi H_{st}V_{st} + \theta I_{st}F_{st} + \pi I_{st}F_{st} + \varrho I_{st}V_{st} + \Delta I_{st}V_{st}F_{st} + \partial H_{st}V_{st}F_{st} + \tau T_{st}V_{st}F_{st}$$

$$\boldsymbol{\lambda}_s \sim Normal(0, \epsilon\ )$$

$$\boldsymbol{\gamma}_t \sim Normal(0, \vartheta)$$

$$\epsilon \sim Cauchy(0,1)$$

$$\vartheta \sim Cauchy(0,1)$$

$$1/\varphi \sim Exponential(3).$$

Priors for all parameters were weakly informative. For most coefficients they were normal(0,1), with the exception of the intercept, normal(2,2), the two random effect standard deviations, ϵ and ϑ and the overdispersion parameter, φ .

Measurement error in HFR. Although all predictors in the model are measured with error, in the case of HFR, which are model-based estimates of household firearm ownership, we have information about measurement error. We have opted not to adjust model coefficients for measurement error because 1) the omission of measurement error information is conservative: disattenuating for measurement error would increase the magnitude of modeled associations between HFR and suicide risks; 2) such an adjustment could only be made for HFR even though we have no indication that this variable has more error than other predictors, which may result in greater underestimation of the effect sizes for those predictors (4), and 3) the estimated measurement error in HFR is a small fraction of the variance of this measure. The standard deviation in our 3-year HFR estimates across states and years is 13.5 percentage points. The average standard error of those modelled estimates is 1.8 percentage points. This implies that less than 2% of the variance in the HFR measure is measurement error. That is, the variance of the measure (.135^2) divided by the estimated error variance (.018^2) is just .017.

Supplemental Results

Model fit. As part of model development, we explored more and less complex models and selected the final model as the one that minimized cross-validated error of prediction as assessed with LOOIC.(3) The final model used random effects for states and periods as well as two covariates (Percent of residents who were Black and Population Density), and had a LOOIC of 11413.9. In comparison, the more complex model with fixed state effects and 21 covariates had LOOIC of 11444.3. see Table S.2 for a comparison of marginal effects between the final and saturated models. The model was well-estimated using rstan 2.32.2. All pareto k diagnostics were less than 0.5, indicating good model fit.(4) Rhat values were all less than 1.01, with no divergent transitions across 4000 post-warmup iterations indicating good model convergence. The effective sample size for all model parameters was greater than 700, indicating adequate tail densities for estimating credible intervals. The effective number of parameters in the final model was 68.7, which is less than the nominal number of modeled parameters (75), due to the hierarchical structure of the state and time effects. Given that the model was estimated on 1200 data points, 68.7 effective parameters pose minimal threat of model overfit.

Model coefficients. Table S3 provides a description of the posterior distributions of all model parameters. The article is focused primarily on the marginal effects of state gun ownership rates and firearm law restrictiveness, however estimated parameters for the percentage of the state population that is Black and the state's population density – the two covariates to remain in the model after pruning – are shown in the table, as are individual state and period effects. Both the proportion of residents who are Black, and population density are negatively associated with state suicide rates, conditional on the other predictors in the model.

State random effects also suggest that some states have substantially higher or lower rates of suicide among veterans and matched nonveterans after accounting for other model covariates. Specifically, Arizona, California, Colorado, Florida, Maryland, Nevada, New Mexico, Oregon, Utah and Wyoming are all associated with higher conditional risk of suicide, while Alaska, Hawaii, Massachusetts, Minnesota, Nebraska, New York, North Dakota, South Dakota, and Texas are associated with lower conditional suicide risk.

Model results restricting law effect identification to changes over the period. The associations of suicide with state law restrictiveness reported in the paper identify law associations using both changes to law restrictiveness during the period and differences between state law restrictiveness that predate the period of study. To examine these associations in a way that is insensitive to pre-existing differences in state laws, we reran the model using state law restrictiveness scores for each period that are differenced with state law restrictiveness scores in the first period. Thus, in the first period, each state has a state law restrictiveness of zero, and subsequent restrictiveness scores represent changes in law restrictiveness from the initial period. Tables S4 and S5 highlight key law associations under the model presented in the paper vs the model excluding preexisting state law differences. In general, associations between more restrictive gun laws and veteran suicides have similar point estimates, but the estimates are far more uncertain for both veterans and nonveterans. The standard errors of the estimates are frequently more than twice as large for those that restrict identifying variation to solely the changes in state laws within the study period. Table S5 contains estimates for the effect of HFR on suicide excluding the pre-period differences in firearm ownership rates from the identifying variation. Similar to the estimates of the law effects, this estimation approach results in a sufficiently high level of uncertainty that it is not clear what should be concluded from the estimates. Our view is that the available veteran suicide data, which begins in 2001, do not support effect estimates for these variables that exclude pre-period differences between states from the identification. This is because the changes in state firearm laws and state levels of firearm ownership since 2001 are small relative to the difference between states in 2001. In addition, we believe it is useful to document that states with high firearm ownership and permissive firearm laws in 2001 have unusually high risk for firearm suicide almost 20 years later.

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Supplemental Tables

Table S1. State characteristics included as covariates with sources

State Characteristic	Source
Demographics	
Percent Black	US Census Bureau
Percent Hispanic	US Census Bureau
Percent Age 15-29	US Census Bureau
Percent foreign born	CPS ASEC
Percent divorced, separated, or widowed	CPS ASEC
Percent urban households	CPS ASEC
Population density	US Census Bureau
Socioeconomic conditions	
Poverty Rate	US Census Bureau
Unemployment rate	U.S. Department of Labor, BLS
Decile income share	World Inequality Database(5)
Average income (inflation adjusted)	Bureau of Economic Analysis
Percent without a high-school diploma	CPS ASEC
GOP control	National Conference of State Legislatures(6)
Unemployment insurance replacement rates	US Dept. of Labor(7)
Population Health	
Health insurance coverage rate	US Census Bureau
Physician population rate	CPS ASEC
Therapist and psychologist pop. rate	CPS ASEC
Current smoker population rate	BRFSS
Per capita alcohol consumption	Slater and Alpert (2023)(8)
Adequate sleep population rate	BRFSS
Physically active population rate	BRFSS

Notes: CPS ASEC (Current Population Survey, March Annual Social and Economic Supplement) values calculated using IPUMS data (Ruggles et. al., 2023).(9) *Decile income share* is proportion of state's personal income associated with the top 10 percent of the income distribution. *GOP control* is the proportion of legislative veto points (typically house, senate, governor) controlled by Republicans using data from the National Conference of State Legislatures. In Nebraska's nonpartisan legislature, GOP control is determined by a majority of unicameral members with Republican affiliations. *Unemployment insurance replacement rate* is an estimate of the proportion of individuals' expected salary provided through state unemployment insurance. *Physician population rate* is the proportion of the population with an occupation of physician or surgeon. *Therapist and psychologist population rate* is the proportion of the population with an occupation of psychologist or "therapist, other", which excludes physical therapists and occupational therapists, but includes psychotherapists and other mental health providers.

Table S2. Marginal effects of HFR and law restrictiveness on suicide risk per 100,000 for a complex model and the best-fitting model; United States, 2017-2019.

Effect	Veterans Median (95% CI)	Matched Civilians Median (95% CI)	Difference Median (95% CI)
Initial, complex model (time and state fixed effects with 21 covariates)			
High - Low HFR			
for All Suicide	5.15 (1.69, 9.21)	4.02 (0.94, 7.50)	1.15 (-0.24, 2.67)
for Firearm Suicide	6.43 (3.82, 9.51)	6.26 (3.95, 9.00)	0.17 (-1.10, 1.55)
for Nonfirearm Suicide	-1.28 (-2.24, -0.20)	-2.27 (-3.11, -1.37)	0.98 (0.46, 1.50)
Restrictive - Permissive Law			
for All Suicide	-1.16 (-4.63, 2.13)	-1.99 (-5.15, 0.96)	0.81 (-0.59, 2.20)
for Firearm Suicide	-1.51 (-3.93, 0.76)	-1.94 (-3.95, -0.03)	0.41 (-0.82, 1.64)
for Nonfirearm Suicide	0.37 (-0.86, 1.48)	-0.03 (-1.33, 1.13)	0.42 (-0.32, 1.13)
Final model (time and state random effects with 2 covariates)			
High - Low HFR			
for All Suicide	4.35 (1.90, 7.14)	3.31 (1.11, 5.77)	1.03 (-0.23, 2.43)
for Firearm Suicide	5.85 (3.92, 8.01)	5.77 (4.06, 7.66)	0.08 (-1.16, 1.37)
for Nonfirearm Suicide	-1.49 (-2.18, -0.73)	-2.46 (-3.05, -1.78)	0.96 (0.47, 1.43)
Restrictive - Permissive Law			
for All Suicide	-2.49 (-4.64, -0.21)	-3.19 (-5.22, -1.16)	0.70 (-0.67, 2.03)
for Firearm Suicide	-2.44 (-4.00, -0.78)	-2.68 (-4.02, -1.36)	0.26 (-0.93, 1.40)
for Nonfirearm Suicide	-0.06 (-0.87, 0.77)	-0.50 (-1.35, 0.35)	0.45 (-0.26, 1.13)

Note: Effects are the posterior median marginal effects expressed as suicide rates per 100,000, along with 95% credible intervals. *High-low HFR* is the difference in expected suicide rates associated between high and low state HFR defined by the 75^{th} and 25^{th} percentiles of HFR in 2017-2019. *Restrictive-permissive law* is the difference in expected suicide rates between restrictive and permissive state firearm laws, defined by the 75^{th} and 25^{th} percentiles of state law restrictiveness score in 2017-2019. Difference column reflects the difference in marginal effects between veteran and matched nonveteran populations.

Table S3: Quantiles of the posterior distribution of final model parameters.

Model parameter	2.5%	10%	Median	90%	97.5%
Intercept	2.21	2.24	2.28	2.32	2.35
Firearm Method	0.61	0.62	0.64	0.66	0.66
Veteran	-0.17	-0.15	-0.12	-0.09	-0.08
Veteran x Firearm	0.03	0.05	0.09	0.12	0.14
Veteran x Linear time	0.01	0.02	0.03	0.03	0.04
Veteran x Linear time x Firearm	-0.01	0.00	0.01	0.02	0.02
HFR	-0.27	-0.25	-0.21	-0.17	-0.15
HFR* x Firearm	0.40	0.41	0.44	0.46	0.48
HFR* x Veteran	0.05	0.06	0.09	0.12	0.13
HFR* x Veteran x Firearm	-0.17	-0.16	-0.12	-0.08	-0.06
Law index*	-0.08	-0.06	-0.03	0.00	0.02
Law index* x Firearm	-0.10	-0.09	-0.07	-0.04	-0.03
Law index* x Veteran	-0.02	0.00	0.03	0.05	0.07
Law index* x Veteran x Firearm	-0.06	-0.04	0.00	0.04	0.05
Percent black*	-0.09	-0.08	-0.05	-0.03	-0.01
Population density*	-0.16	-0.14	-0.10	-0.06	-0.04
Alabama	-1.12	-0.84	-0.36	0.10	0.37
Alaska	-1.87	-1.61	-1.10	-0.61	-0.34
Arizona	0.35	0.55	0.95	1.36	1.58
Arkansas	-0.57	-0.35	0.04	0.42	0.62
California	0.06	0.31	0.76	1.23	1.50
Colorado	0.67	0.85	1.24	1.66	1.90
Connecticut	-1.07	-0.79	-0.26	0.28	0.56
Delaware	-0.44	-0.19	0.33	0.82	1.09
Florida	1.46	1.70	2.13	2.58	2.82
Georgia	-1.00	-0.70	-0.20	0.31	0.59
Hawaii	-1.94	-1.60	-1.00	-0.38	-0.04
Idaho	-0.24	-0.03	0.40	0.84	1.06
Illinois	-0.96	-0.73	-0.31	0.11	0.33
Indiana	-0.71	-0.49	-0.13	0.26	0.45
Iowa	-1.18	-0.87	-0.31	0.27	0.55
Kansas	-1.16	-0.94	-0.53	-0.15	0.07
Kentucky	-0.67	-0.44	-0.06	0.33	0.56
Louisiana	-1.54	-1.22	-0.65	-0.10	0.19
Maine	-1.03	-0.81	-0.38	0.04	0.25
Maryland	0.08	0.34	0.89	1.47	1.76
Massachusetts	-2.04	-1.73	-1.11	-0.50	-0.19
Michigan	-0.47	-0.29	0.04	0.37	0.57
Minnesota	-1.93	-1.70	-1.24	-0.83	-0.60
Mississippi	-1.40	-1.07	-0.41	0.22	0.57
Missouri	-0.39	-0.20	0.15	0.51	0.70
Montana	-0.14	0.14	0.67	1.21	1.50
Nebraska	-2.35	-2.04	-1.47	-0.93	-0.64
Nevada	1.94	2.20	2.73	3.30	3.62

Model parameter	2.5%	10%	Median	90%	97.5%
New Hampshire	-0.61	-0.38	0.05	0.51	0.73
New Jersey	-0.91	-0.59	0.04	0.70	1.04
New Mexico	0.46	0.69	1.15	1.63	1.91
New York	-2.31	-2.04	-1.51	-1.03	-0.78
North Carolina	-0.01	0.24	0.75	1.30	1.59
North Dakota	-2.98	-2.67	-2.10	-1.57	-1.30
Ohio	-0.64	-0.42	-0.04	0.36	0.57
Oklahoma	-0.56	-0.34	0.03	0.40	0.61
Oregon	0.44	0.67	1.05	1.47	1.70
Pennsylvania	-0.22	-0.01	0.37	0.75	0.96
Rhode Island	-0.70	-0.37	0.29	0.98	1.30
South Carolina	-0.77	-0.51	-0.03	0.44	0.70
South Dakota	-2.49	-2.19	-1.66	-1.15	-0.93
Tennessee	-0.10	0.08	0.46	0.84	1.04
Texas	-1.46	-1.25	-0.89	-0.53	-0.33
Utah	0.28	0.50	0.95	1.40	1.66
Vermont	-0.66	-0.40	0.10	0.60	0.86
Virginia	-0.95	-0.75	-0.37	0.00	0.18
Washington	-0.13	0.05	0.40	0.76	0.96
West Virginia	-1.23	-0.95	-0.47	0.02	0.26
Wisconsin	-0.99	-0.78	-0.40	-0.03	0.19
Wyoming	0.08	0.33	0.86	1.40	1.72
2002-2004	-1.54	-1.18	-0.51	0.09	0.39
2005-2007	-2.27	-1.86	-1.05	-0.38	-0.06
2008-2010	-1.31	-0.98	-0.35	0.24	0.57
2011-2013	-0.80	-0.47	0.11	0.70	1.02
2014-2016	-0.21	0.12	0.77	1.49	1.95
2017-2019	-0.01	0.35	1.05	1.83	2.28
Inverse of dispersion parameter	0.02	0.02	0.02	0.02	0.02
Std. Dev. of state random effects	0.11	0.12	0.13	0.16	0.17
Std. Dev. of time random effects	0.03	0.04	0.06	0.10	0.14

Note: * indicates a continuous state characteristics where the coefficients represent the effect associated with one SD change in the predictor, all other predictors are dichotomous 0,1. All coefficients are on a log Incident Risk Ratio scale.

Table S4: Comparison of marginal effects for state law restrictiveness when pre-existing differences in state law restrictiveness are vs are not used to estimate these associations, United States, 2017-2019.

Contrast (greater vs less law restrictiveness)	**With pre-existing state differences in law restrictiveness**	**Without pre-existing state differences in law restrictiveness**
Total veteran suicides	-2.49 (-4.64, -0.21)	-2.68 (-8.12, 2.60)
Total nonveteran suicides	-3.19 (-5.22, -1.16)	1.60 (-3.35, 6.38)
Veteran firearm suicides	-2.44 (-4.00, -0.78)	-3.26 (-7.53, 1.33)
Nonveteran firearm suicides	-2.68 (-4.02, -1.36)	-0.52 (-4.48, 3.32)

Note: Effects are the posterior median marginal effects expressed as suicide rates per 100,000, along with 95% credible intervals. *With pre-existing state law differences* estimates are from our primary model which identifies effects with both across-time and across-state differences in laws. *Without pre-existing state law differences* estimates are from a model where effects are indicated only by changes in state laws within the study period.

Table S5: Comparison of marginal effects for HFR when pre-existing differences in state law restrictiveness are vs are not used to estimate these associations, United States, 2017-2019.

Contrast (Higher vs lower HFR)	**With pre-existing state differences in law restrictiveness**	**Without pre-existing state differences in law restrictiveness**
Total veteran suicides	5.15 (1.69, 9.21)	1.54 (-4.30, 8.02)
Total nonveteran suicides	4.02 (0.94, 7.50)	4.96 (-0.57, 10.70)
Veteran firearm suicides	6.43 (3.82, 9.51)	2.78 (-2.07, 8.46)
Nonveteran firearm suicides	6.26 (3.95, 9.00)	4.86 (0.48, 9.81)

Note: Effects are the posterior median marginal effects expressed as suicide rates per 100,000, along with 95% credible intervals. *With pre-existing state law differences* estimates are from our primary model which identifies effects with both across-time and across-state differences in laws. *Without pre-existing state law differences* estimates are from a model where effects are indicated only by changes in state laws within the study period.