

Epidemiological analysis of fatal and non-fatal firearm injuries occurring in gun establishments in the United States, 2015–2022

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ABSTRACT

Background Firearm-related injury represents a significant public health problem in the USA. Firearm purchasing has risen nationwide and there has been increased efforts to deploy injury prevention initiatives within gun establishments. However, firearm-related risks and harms that may occur inside these high-exposure settings are not well characterized.

Methods This secondary analysis leveraged Gun Violence Archive data to quantify firearm injury prevalence rates within different types of gun establishments from 1 January 2015 to 31 December 2022. Data were restricted to incidents that occurred in gun ranges, gun shops, and public and private ranges. The following incident characteristics were available in the individual-level data: date, location, injury count, fatality count, victim demographics (age, sex), shooting intent (suicide/self-inflicted, assault/homicide, unintentional, undetermined) and establishment type.

Results Over 7 years, 445 non-fatal and 183 fatal shooting events occurred across 576 unique establishments. Non-fatal, unintentional injuries predominated in stand-alone firing ranges whereas fatal, self-inflicted injuries concentrated in retail shops with accompanying firing ranges. Firearm-related assaults were prevalent among stand-alone retail shops.

Conclusion Overall, this secondary analysis underscores that the prevalence of firearm injury in gun establishments across the USA is low, and these settings should continue to be studied as important contexts for intervention. Interweaving public health interventions into gun establishments presents an opportunity to potentially reduce associated harms to consumers interacting within these environments.

INTRODUCTION

The USA has experienced a recent surge in gun purchasing and evidence suggests that purchaser demographics are transforming. For instance, between March and mid-July 2020, approximately 34% of firearm purchasers were first-time purchasers.¹ These 'surge purchasers' were more likely to be female, Black and Hispanic/Latinx.² This increase in first-time firearm ownership coincides with a concerted effort by injury preventionists to develop and deploy firearm safety interventions within gun establishments—an approach that has garnered widespread stakeholder support.^{3–6} Although increasing attention is paid to these settings for primary prevention (ie, social marketing campaigns, temporary storage programs), it is unclear whether more downstream approaches are also needed to address injuries that may occur on the

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The USA witnessed a firearm purchasing surge in 2020 suggesting increased foot traffic in gun establishments where firearms are sold, purchased, traded and used. Concurrently, firearm injury prevention efforts such as temporary gun storage programs are increasingly being implemented within these environments. However, to date, no research has quantified the risk of firearm injury within these places even as they gain priority as settings for injury prevention.

WHAT THIS STUDY ADDS

⇒ This study offers novel evidence that firearm injuries in gun establishments are relatively rare and declining over the study period. The most common types of injuries were non-fatal, unintentional firearm injuries followed by fatal, self-inflicted firearm injuries. Firearm-related assaults disproportionately occurred in retail shop environments compared with establishments operating solely as a firing range.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ While firearm injuries were relatively uncommon, the results indicate retail and range-based prevention efforts should incorporate emergency response trainings such as Stop the Bleed and Mental Health First Aid to account for injuries that may be occurring on-site. More broadly, the low prevalence of firearm-related harm across gun establishments reinforces the potential of these place-based initiatives to mitigate the larger firearm injury epidemic.

premises of these high-exposure environments. Therefore, the objective of this study is to characterise the epidemiology of fatal and non-fatal firearm injuries that occur within gun establishments in the United States (US).

METHODS

Data sources

Data on firearm injuries within US gun establishments were obtained from the Gun Violence Archive (GVA).⁷ The GVA compiles gun violence



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incidents daily from law enforcement, media, government and commercial sources. According to the GVA methodology, trained coders manually review incidents identified through scanning online sources and enter detailed incident information on 120 different contextual attributes.⁷ The GVA has been used to study other firearm injury contexts, including officer-involved shootings,⁸ mass shootings,⁹ and pre-COVID-19 and post-COVID-19 pandemic comparisons.¹⁰ Data were restricted to incidents in gun ranges, gun shops, and public and private ranges as the intended environments for community-based programs. Military and police ranges and gun shows were excluded. The following individual-level incident characteristics were available: date, location, injury count, fatality count, victim demographics (age, sex), shooting intent (suicide/self-inflicted, assault/homicide, unintentional, undetermined) and establishment type. When the establishment type was unavailable, the original source was consulted. Data from 1 January 2015 to 31 December 2022 were used.

Data on the number of federal firearm licences (FFLs) were obtained from the US Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF). The ATF differentiates between FFL types—in this analysis, only dealers and pawnbrokers were included. ATF publicly reports data on active FFLs in the USA annually with data available until 2020; thus, rates were modelled from 2015 to 2020.

Patient and public involvement

This was a secondary data analysis that used publicly available data. No human subjects were directly involved in the research.

Data analysis

Descriptive statistics (ie, frequencies and percentages) summarised gun establishment shooting incidents characteristics. χ^2 tests assessed bivariate associations between fatality and shooting intent across establishment types. Temporal trends in the rates of fatal and non-fatal injuries were plotted. The number of FFLs was the denominator in rate calculations. A post hoc analysis using GVA data compared fatal and non-fatal firearm injury rates in gun establishments to bars/clubs, K-12 schools and colleges/universities. All analyses were performed in Excel and Stata V.15.¹¹

RESULTS

Between 2015 and 2022, 445 non-fatal and 183 fatal shooting events were recorded across 576 unique gun establishments. For non-fatal injuries, 399 (89.7%) were unintentional, 21 (4.7%)

assault-related and 17 (3.8%) self-harm, with 8 (1.8%) unknown intent. Most non-fatal victims were adults 18 years or older (91.9%) and male (78.7%); 23 victims were youth (5.2%). For fatal injuries, many incidents were suicides (52.5%), followed by unintentional deaths (25.1%) and homicides (15.3%), with 13 incidents (7.1%) of unknown intent. Most victims sustaining firearm-related fatalities were adults (90.7%) and male (79.8%).

Non-fatal unintentional firearm injuries frequently occurred, with the majority taking place in privately operated firing ranges (n=109) and retail shops with firing ranges (n=69) (figure 1). Additionally, suicides were prevalent in retail shops with firing ranges (n=65). Although relatively rare compared with other intents, fatal and non-fatal firearm-related assaults were more likely to occur in shops with retail stores (ie, shop only, shop with firing range) compared with stand-alone firing ranges (ie, privately and publicly operated ranges). Significant differences existed between fatal and non-fatal shootings ($\chi^2=22.98$, $p<0.001$) and shooting intent ($\chi^2=83.22$, $p<0.001$) by firearm environment type.

Trends in firearm injury rate in FFL establishments per 100 000

Longitudinal trends in non-fatal and fatal firearm injury rates in licensed firearm establishments from 2015 to 2020 are illustrated in figure 2. The non-fatal firearm injury rate substantially decreased from 104.08 per 100 000 persons in 2015 to 54.44 per 100 000 in 2020. The non-fatal injury rate peaked at 106.72 per 100 000 in 2016 and reached its nadir of 57.44 per 100 000 in 2020. In contrast, the fatal firearm injury rate remained relatively stable, from 32.87 per 100 000 in 2015 to 30.23 per 100 000 in 2020. The fatal injury rate peaked in 2016 at 42.41 per 100 000 while the lowest rate occurred in 2018 at 22.64 per 100 000. The post hoc analysis revealed that fatal and non-fatal firearm injury rates in gun establishments were relatively low, comparable to K-12 schools, but lower than rates observed in bars/clubs and colleges/universities (online supplemental table 1, online supplemental figure 3).

DISCUSSION

This analysis aimed to gauge the burden and nature of firearm-related injuries occurring in US gun establishments. This is the first study to our knowledge to characterise injury risk within these locales. Overall, firearm injuries in gun establishments are relatively rare and declining with about 600 fatal and non-fatal firearm injury incidents documented over a seven-year period. In comparison, between 2015 and 2022, the GVA reported 388 866 total firearm injuries.

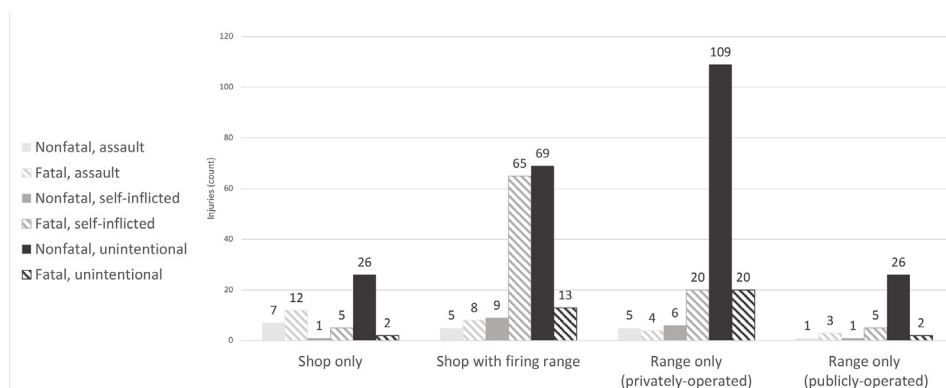


Figure 1 Fatal and non-fatal firearm injury count by shooting intent by gun establishment type in USA (N=424), 2015–2022.

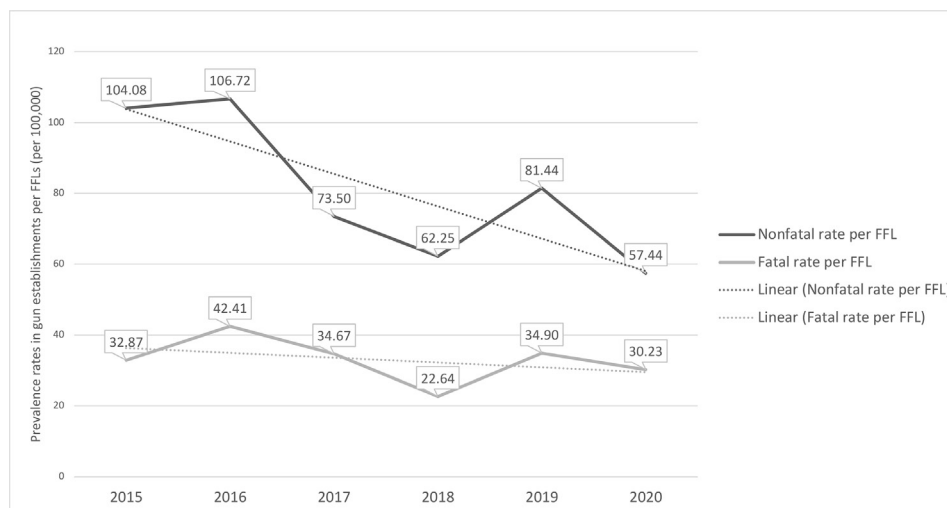


Figure 2 Fatal and non-fatal firearm injury prevalence rates per FFLs (per 100 000) in the USA, 2015–2020. FFL, federal firearm licence.

Though relatively rare, it is notable that gun establishments are not completely devoid of firearm injury risk. Unintentional shootings accounted for most non-fatal injuries, which may reflect risks surrounding firearm handling, target practice, and other routine activities that occur in gun establishments. The finding that gun ranges had more unintentional injuries compared with gun retail shops may relate to the larger volume of individuals using ranges for practice and recreation while interactions occurring in stand-alone shops may relate to purchasing or information seeking behaviors. In addition, the relatively higher count of firearm suicides within gun shops and shooting ranges is concerning given preliminary research indicating limited suicide prevention information and resource dissemination in these settings. For instance, in Texas, suicide prevention information and material dissemination are uncommon in the firearm retail and range environment.¹² Additionally, the high frequency of self-inflicted injuries in gun shops with ranges raises questions about whether the immediate on-site access to firearms could increase suicide risk. Research is needed to contextualise this finding and explore if combined shop-range establishments confer differential firearm suicide risk compared with other environments. Overall, these results highlight gun shops with ranges as potential venues for suicide prevention programming and harm reduction efforts. Finally, an unsurprising yet interesting finding was the higher report of assault-related shootings occurring in retail stores compared with firing ranges.

While results provide a foundational characterization of firearm injuries within US gun establishments, these findings raise questions surrounding whether these injuries occur more in gun establishments compared with other contextualised settings. This place-based risk comparison warrants future research. However, identifying appropriate comparison environments poses challenges without established evidentiary guidance.^{13 14} For instance, researchers considered comparing gun establishments to ‘gun-free zones’, but inconsistencies exist in how governments designate such zones across jurisdictions. Additionally, a growing body of literature compares mass shooting injuries between hypothesised ‘gun-free’ and ‘gun-allowing’ environments. Some studies have suggested that fewer injuries occur in gun-free establishments whereas others have found null effects.^{13 15}

Some limitations should be noted. While the sensitivity and positive predictive value of GVA data are satisfactory

for conducting epidemiological analyses, concerns have been raised around potential systematic bias in the individual-level information reported.¹⁵ Although the GVA includes other data sources, most incidents were connected to media sources. Past research indicates that the media may under-report firearm-related assault incidents by up to 50%, suggesting potential underestimation. Further, as Gobaud *et al* described, the media often reports on firearm homicides, specifically those involving women, children and white victims. This limits the generalisability of the present findings and may introduce information bias related to an imprecise measurement of firearm-related injury as a whole.¹⁶ It is likely that these biases held for unintentional injuries. Subsequent investigations should replicate these analyses using more reliable, representative and validated data sources. However, identifying suitable alternative data sources remains challenging as, to our knowledge, this is one of the only firearm injury data sources to provide this type of contextual detail. Finally, the prevalence measures estimated in this study use the count of locations as the denominator (ie, gun shops, bars/clubs) instead of population sizes (ie, number of people) within those locations, as accurately estimating the population sizes across these diverse location types is challenging.

In summary, gun establishments likely represent opportune settings for firearm injury prevention. Upstream interventions, including point-of-sale safety counselling¹⁷ and social marketing campaigns,¹⁸ should be considered along with integrating more responsive, evidence-based interventions like Stop the Bleed and Mental Health First Aid training.^{19 20} Overall, this analysis underscores that the prevalence of firearm injury in US gun establishments is low, and these settings should continue to be studied as important intervention contexts.

Contributors MHG and SM posed the research questions and MHG, SM, and KJ conceptualized the study design. MHG, LM and AB were all involved in data collection and data analysis. SM and KJ were involved in the supervision and mentorship of the research team. All authors contributed to the report writing and provided edits, feedback, and proofreading. Grammarly and Claude AI were used solely to edit and proofread original text generated by the authors during the manuscript drafting process. However, the final report was ultimately reviewed, edited, and proofread by the study’s authors. AI tools and programs were not used in the actual conduct of the research.

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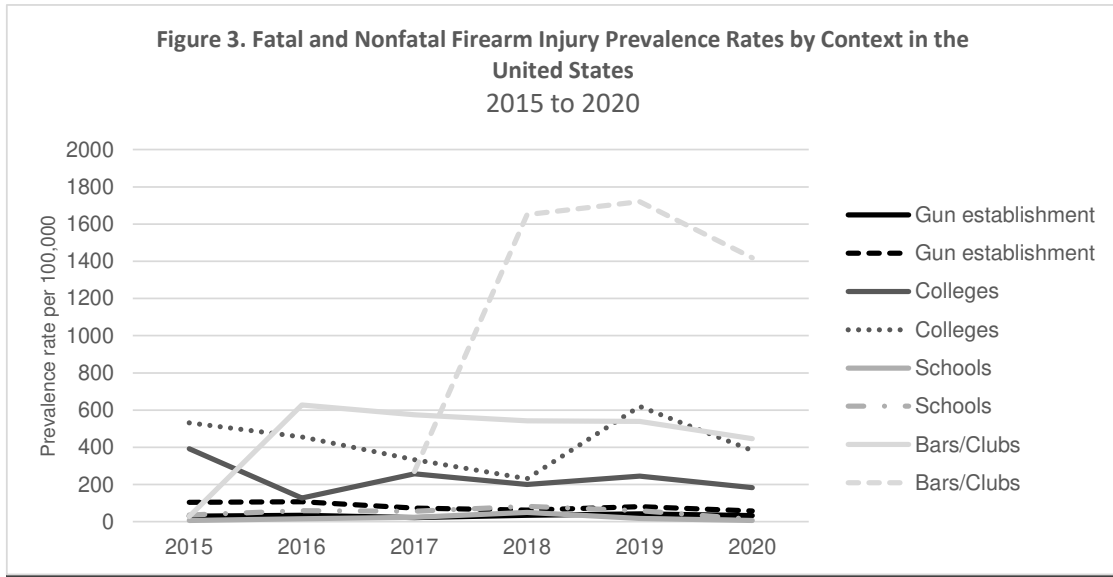
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Table 1. Estimates for prevalence rates of fatal and nonfatal context-dependent firearm injuries in the United States, 2015 to 2020.						
	2015	2016	2017	2018	2019	2020
Gun establishments						
Fatal shootings in gun establishments	24	31	25	16	24	20
Number of FFLs in USA ^a	73020	73088	72113	70680	68759	66161
Prevalence rate (fatal rate X 100,000)	32.867707	42.414623	34.667813	22.637238	34.904522	30.229289
Nonfatal shootings in gun establishments	76	78	53	44	56	38
Number of FFLs in USA ^a	73020	73088	72113	70680	68759	66161
Prevalence rate (nonfatal rate X 100,000)	104.081074	106.720665	73.4957636	62.2524052	81.4438837	57.4356494
Elementary and secondary schools						
Fatal shootings in K-12 schools	6	16	23	50	17	7
Number of K-12 schools in USA ^b	98176	98277	98158	98469	98755	98469
Prevalence rate (fatal rate X 100,000)	6.111473	16.280513	23.431610	50.777402	17.214318	7.108836
Nonfatal shootings in K-12 schools	36	58	55	82	59	12
Number of K-12 schools in USA ^b	98176	98277	98158	98469	98755	98469
Prevalence rate (nonfatal rate X 100,000)	36.6688396	59.0168605	56.0321115	83.2749393	59.7438104	12.1865765
Colleges (postsecondary institutions)						
Fatal shootings in postsecondary institutions	28	9	17	13	15	11
Number of postsecondary institutions in USA ^c	7151	7021	6606	6502	6138	5999
Prevalence rate (fatal rate X 100,000)	391.55363	128.18687	257.34181	199.93848	244.37928	183.36389
Nonfatal shootings in postsecondary institutions	38	32	22	15	38	23
Number of postsecondary institutions in USA ^c	7151	7021	6606	6502	6138	5999
Prevalence rate (nonfatal rate X 100,000)	531.394211	455.775531	333.030578	230.698247	619.094167	383.397233
Bars, pubs, and nightclubs						
Fatal shootings in bars and clubs	19	404	371	350	363	298
Number of bars and clubs in USA ^d	65204	64337	64461	64563	67336	66715
Prevalence rate (fatal rate X 100,000)	29.13932	627.94349	575.54180	542.10616	539.08756	446.67616
Nonfatal shootings in bars and clubs	0	0	174	1066	1158	946
Number of bars and clubs in USA ^d	65204	64337	64461	64563	67336	66715
Prevalence rate (nonfatal rate X 100,000)	NULL	NULL	269.930656	1651.10048	1719.73387	1417.97197
Footnote: a = Number of FFLs in the denominator included only type 1 and type 2 FFLs; b = Number of K-12 schools in the USA only include public institutions; K-12 school data was pulled from the National Center on Educational Statistics; c = Number of postsecondary institutions included Title IV institutions; data on postsecondary institutions was pulled from the National Center on Educational Statistics; d = Data on bars and clubs was pulled from IBISWorld.						



Footnote: Total number of gun establishments (FFLs) ranged from 66,161 (2020) to 73,088 (2016); Total number of K-12 schools ranged from 98,158 (2017) to 98,755 (2019); Total number of postsecondary institutions ranged from 5,999 (2020) to 7,151 (2015); Total number of bars, pubs, and nightclubs ranged from 64,337 (2016) to 67,336 (2019).