



A systematic review of the causes and prevention strategies in reducing gun violence in the United States

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ABSTRACT

Background: Approximately 100 lives are lost each day as a result of gun violence in the United States (US) with civilian mass shootings increasing annually. The gun violence rate in the US is almost 20 times higher than other comparable developed countries and has the most gun ownership per capita of any nation in the world. Understanding the causes and risk factors are paramount in understanding gun violence and reducing its incidence.

Methods: A literature search of all published articles relating to gun violence and mass shootings in the US was conducted using the Medline and PMC databases. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines were used in conducting this study. Rayyan statistical software was utilized for analysis. Statistical significant was defined as $p < .05$.

Results: Of the initial 2304 eligible manuscripts identified, 22 fulfilled our selection criteria. A variety of common causal and contributory factors were identified including but not limited to mental illness, suicidal ideation, intimate partner violence, socioeconomic status, community distress, family life, childhood trauma, current or previous substance abuse, and firearm access.

Conclusion: Gun violence is pervasive and multi-factorial. Interventions aimed at reducing gun violence should be targeted towards the most common risk factors cited in the literature such as access, violent behavioral tendencies due to past exposure or substance abuse, and mental illness including suicidal ideation.

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1. Background

The United States (US) is amidst a gun violence epidemic, with mass shootings becoming increasingly common [1]. Gun related incidents place the American people at imminent danger, with firearm related death 10 times more likely for those in the US than in any other high income country [1]. Astonishingly, out of all the firearm deaths in the 23 highest income countries, approximately 80% occur in the US [1]. In addition to causing upwards of 33,000 mortalities and 79,000 non-fatal injuries per annum, gun-related injuries cost the US \$229 billion per year, posing a tremendous economic burden on the US healthcare system [2,3].

While perpetrators of gun violence have varying motives, understanding the fundamental risk factors which motivate more and more individuals each day to use guns for violence is crucial to understanding gun violence as well as reducing its incidence. Firearm violence is associated with a variety of risk factors beginning as early as the adolescent years (ages 7 ½ to 20) and includes individual, family, school, peer,

community, psychosocial, socioeconomic, and sociocultural risk factors. Besides physical danger, gun violence incidents result in lasting negative mental health conditions for millions of Americans, such as fear, anxiety, depression and feelings of helplessness [4].

Contemporary research on gun violence was hindered by the Dickey Amendment of 1996, which prohibited Centers for Disease Control (CDC) funding from supporting gun violence research pertaining to injury prevention and control. This was extended to National Institute of Health (NIH) funding in 2012, effectively ceasing any federal funding supporting gun related injury and prevention research [5].

It has been suggested that the connection between mental illness and gun violence is complex and multifaceted [6]. In fact, little evidence exists that supports the notion that individuals diagnosed with mental illness are more likely to commit gun crimes [6].

Current and up to date research about gun violence injury prevention is very limited. While the risk factors associated with gun violence are numerous, the root causes of gun violence can be simplified using the following equation:

Access to firearms + violent or aggressive behavioral tendencies or risk factors + psychiatric disease or mental illness causing a defect of reason and impaired judgment = gun-related injuries.

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The purpose of this systematic review is not to provide an exhaustive list of risk factors but rather to systematically shed light on the fundamental elements, as previously stated, in an attempt to guide policymakers to create interventions which will reduce gun violence injury morbidity and mortality.

2. Methods

2.1. Data sources and search strategy

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines were used in conducting this study. Studies were identified by searching the Medline and PMC databases. The reference lists of eligible articles were also searched for additional references. We created searches including but not limited to terms and phrases such as “gun violence in the United States,” “mass shootings in the United States,” and “risk factors in gun violence.” Studies from Medline and PubMed Central from inception through December 2019 were included. Rayyan software was used for categorization of studies. Statistical significance was defined as $p < .05$.

2.2. Study selection and eligibility criteria

Studies were included if they assessed risk factors for gun violence in one of three categories: 1) access to firearms, 2) violent and aggressive behavior, or 3) psychiatric and mental illness. Specifically, articles about firearm access focused on gun laws, background checks, gun ownership, and gun carrying. For articles relating to violent behavior, we focused on exposure to childhood trauma, exposure to violent video games, bullying, gang involvement, childhood neglect and abuse, socioeconomic, intimate partner violence, and substance abuse disorders. For disease states or mental illness which have the potential to impair judgment, conditions such as bipolar disorder, schizophrenia, suicidal ideation, and impulsiveness, were included. Other inclusion criteria include studies conducted in US or majority US populations and studies which were published in the English language. Mass shooting events were not differentiated from other incidents of gun violence due to the limited number of studies exclusively studying mass shootings. Finally, all studies were included regardless of the type of firearm used. Differences among different gun types were not analyzed.

2.3. Data collection process

Three reviewers (CS, DJ, and AE) conducted the primary literature search, screened all articles, and extracted data from full-text articles. The following data was extracted: citation, year, location, patient population, age, socio-economic factors, mass shootings, gun violence; funding, policies, substance abuse, and family and childhood trauma. Questions regarding inclusion or exclusion were addressed by four authors (CS, DJ, MM and AE) and all differences were resolved with unanimity.

3. Results

A total of 2304 results remained following which 846 duplicates were removed (Fig. 1). Titles and abstracts were screened for inclusion which left 100 articles for full-text eligibility screen. After full-text screening, 22 articles were eligible for inclusion (Table 1) [7–26,28,29]. Our search yielded articles ranging from 1876 to 2019. Reviews, cross-sectional studies, retrospective studies, and observational studies were included.

3.1. Access to firearms

Results from a survey ranked a ban on assault weapons as one of the most effective measures to prevent mass shootings and also revealed that 67% of the US population would support such a ban [27].

Studies examining the association between gun permissiveness and mass shooting frequency found that mass shooting frequency actually increased in the US [27]. However, this increase is not representative of the trend across all states [26]. Using a cross-sectional design, researchers found that state gun laws favoring gun use was associated with significantly higher rates of mass shootings—11.5% increase for states with gun laws ten times more permissive than other states (95% confidence interval [CI] 4.2% to 19.3%, $p = .002$). Moreover, a 10% increase in state gun ownership was associated with a 35.1% higher rate of mass shooting incidents (95% CI 12.7% to 62.7%, $p = .001$) [26].

In 2012, open carry gun laws were banned in California, significantly lowering the incidence of firearm-related fatalities and non-fatal hospitalizations ($p < .001$) even after controlling for baseline state gun laws. Following this, 3.7% fewer deaths occurred in the post-ban period and there was a reduction of 1285 non-fatal firearm related hospital visits during that time [28]. Fig. 2 and 3 illustrate gun permissiveness and gun-related deaths, respectively, to show this association of laws and fatalities [29]. The association between firearm legislation and firearm-related fatalities has also been studied before. In a cross-sectional study, Fleeger et al. found that states with high legislative strength scores had lower overall firearm fatality rates than states in the lowest quartile (absolute rate difference 6.64 deaths/100,000/y; age-adjusted incident rate ratio 0.58; 95% CI 0.37–0.92) [29].

Another study found that youth with access to firearms were significantly more likely to be physically aggressive (odds ratio [OR] 2.7) and more likely to be future perpetrators of violence (OR 2.6) [8]. Risk factors associated with gun carrying have also been studied. Students who carried guns to schools had victim rates that were 589% higher for an at school attack, 552% higher for attack outside school supervision, 576% attempts to force sex at school, and 216% higher for rape [18]. Gun carrying students were 17 times more likely to abuse drugs like crack cocaine. Interestingly, these students reported less education on violence prevention and fighting and felt more of an obligation to fight and use violence under a wider variety of conditions [18]. In individuals abusing drugs, risk factors in addition to gun access were also identified [24]. For example, older adolescent age (adjusted odds ratio [AOR] 1.58, 95% CI 1.30–1.94), African American race (AOR 1.34, 95% CI 1.11–1.61), and male gender (AOR 1.99, 95% CI 1.66–2.37) were associated with increased gun-related behavior. Other factors such as alcohol abuse (AOR 1.75, 95% CI 1.37–2.27), marijuana use (AOR 1.93, 95% CI 1.58–2.36), sexual activity (AOR 1.64, 95% CI 1.32–2.02), prior gun injury (AOR 1.80, 95% CI 1.32–2.46), and engagement in serious physical violence (AOR 1.37, 95% CI 1.13–1.66) were associated with increased access to firearms [24].

3.2. Experiences or behavior which increase violent or aggressive tendencies

Prior gun injury and engagement in serious physical violence, or group fighting have previously been identified as predictors of gun access. Specifically, gun access was 80%, 37%, and 200% more likely for individuals with prior gun injury, engagement in serious physical violence, and group fighting, respectively ($p < .05$) [24].

Further, Wamser-Nanney et al. concluded that childhood domestic violence (DV) and community violence (CV) were both associated with increased gun violence risk. Both DV and CV were linked with a slight increase in gun ownership (OR 2.77, $p = .07$ and OR 2.86, $p = .09$, respectively). DV was associated with an increased risk for violent crime arrest (OR 12.8, $p < .001$) and gun arrests (OR 7.75, $p = .02$). Community violence exposure was associated with an increased risk

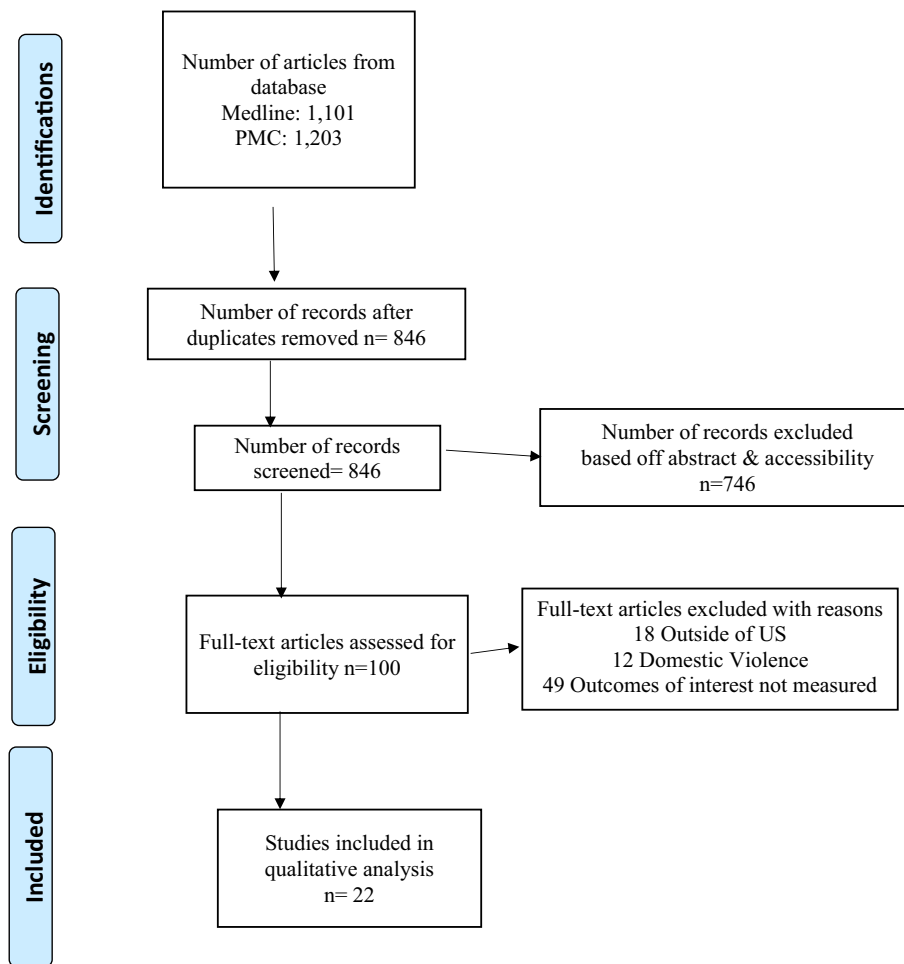


Fig. 1. PRISMA flow diagram of studies included in the systematic review.

for violent arrest (OR 3.66, $p = .06$) but unrelated to gun arrests (OR 1.40, $p = .59$) [15].

Children reporting higher rates of bullying victimization had increased odds of access to a loaded gun without adult permission [22]. Among several risk factors for violence, Ilie et al. concluded that the odds ratio for adolescents (ages 11–20) physically hurting someone on school grounds was 68% higher for students who reported elevated psychological distress compared to those who did not, underscoring the importance of instituting measures to curb school bullying [9]. These feelings of rejection then evolved into fantasies of violence and revenge and eventually lead to firearm homicide events.

When children do not have access to positive resources (i.e. health, nutritional, educational, recreational, or financial), have poor social relationships with others, or feel unsafe in their environment the likelihood of involvement in behaviors like gun violence increases. Aggressive adolescents (ages 7½ to 20) who live in neighborhoods with high levels of community violence, drug trafficking, or gang presence are more exposed to violence and have more opportunities to be part of this behavior [19]. Similarly, one study found that young adults with a high violence index had a 1.74-fold increased likelihood for gun carrying (95% CI 1.70–1.78); the violence index was created from using a survey that assessed the participants perceived threat level [20].

Many studies also found a positive association between substance abuse with violence and gun related behaviors [7,10,12,23–25]. Drugs and alcohol trigger violent behaviors. A study regarding risk factors to gun access revealed that adolescents (ages 14–18) who reported binge drinking were more likely to report access to guns [23]. Behavioral

predictors such as a history of binge drinking and illicit drug were 75% more likely to be associated with keeping a firearm in the home in one longitudinal study (95% CI 1.14–2.68 and 95% CI 1.12–2.76, respectively) [7]. Other researchers suggested that the prevalence of gun carrying is greater among adolescents (ages 13–18) with drug use disorders (adjusted-prevalence ratio [APR] 1.91, 95% CI 1.05–3.45) compared to adolescents without such disorders [10]. Additionally, there was a significant association found between violent behavior and threats made towards others with a gun among individuals suffering from substance abuse disorders (AOR 2.27%, 95% CI 1.62–3.20) and impulse control disorders (AOR 2.67, 95% CI 1.95–3.66) [12].

Alcohol and marijuana use were 75% and 93% more likely to be predictors of gun access, respectively ($p < .05$) [23]. In Latinos, drug use was associated with twice the odds of weapon involvement compared to non-Hispanic white adolescents (7th to 12th graders) ($p < .05$) [25].

3.3. Psychiatric disease or mental illness causing a defect of reason

When evaluating psychiatric disorders and their association with gun-carrying, researchers found that adolescents aged 13–18 with a conduct disorder (APR 1.88, 95% CI 1.38–2.57), drug use disorders (APR 1.91, 95% CI 1.05–3.45), and specific phobias (APR 1.54, 95% CI 1.07–2.22) compared with adolescents (middle school age) without these disorders. The study estimates that 1.1% (95% CI 0.77–1.48) of adolescents with a disorder associated with self- or other-directed violence also carry guns. However, a vast majority of adolescents with mental health disorder did not report gun-carrying [10]. Antisocial

Table 1
Studies evaluating risk factors to gun violence.

Study location	Study design	Database	Year	Independent variable	Dependent variable	Population	Results
Ladapo et al. [8]	Longitudinal Study	Healthy Passages	2004–2011	Mental illness and substance use	Firearm Acquisition	Fifth grade-students	History of depression (aOR 1.36, 95% CI 1.04–1.77), binge drinking (aOR 1.75, 95% CI 1.14–2.68), and illicit drug use (aOR 1.75, 95% CI 1.12–2.76) were associated with a higher likelihood of keeping a firearm in the home
Sigel et al. [9]	Cross-sectional	Communities That Care & Denver Youth Survey	2012–2013	Youth with violence involvement, behavioral, or mental health factors	Access to firearms	10–17 year old & parents for each	Physically aggressive (odds ratio [OR] 2.7), risk for future violence perpetration (OR 2.6), using alcohol (OR 2.0), having internalizing symptoms (OR 1.9), peer problems (OR 1.9), and older age (OR 1.26) predicted youth's possible access to firearms. Marijuana use (OR 9.9), parental gun ownership (OR 6.5), and reported delinquency (OR 8.3) predicted youth's firearm possession.
Ilie et al. [10]	Cross-sectional	Centre for Addiction and Mental Health's 2013 Ontario Student Drug Use and Health Survey	2013	History of TBI, gender, psychological distress, alcohol, and drug use	Illegal possession of weapons and assault on school property	7 th –12 th grade students (11–20-year old's)	Youth who reported carrying a weapon, who were engaged in a physical fight and those who assaulted peers on school property during last year had statistically significantly higher odds of reporting a history of TBIs, being male, in first years of high-school, scored positive for elevated psychological distress, and were current regular alcohol (weapon possession only) and cannabis users.
Kagawa et al. [11]	Cross-Sectional	National Comorbidity Survey-Adolescents Supplement	2001–2004	Presence of psychiatric and substance use disorders	Gun-carrying	13–18-year-old adolescents	The prevalence of gun carrying was greater among adolescents with conduct disorder (adjusted prevalence ratio [APR] = 1.88, 95% CI 1.38, 2.57), drug use disorders (APR = 1.91, 95% CI 1.05, 3.45), and specific phobias (APR = 1.54, 95% CI 1.07, 2.22) compared with adolescents without these disorders.
Loeber et al. [12]	Longitudinal follow-up	Developmental Trends Study	1987–1999	Violence, property offenses, and drug charges in adulthood	Gun-carrying	7–12-year old until they all reached 19 years old	Gun carrying was significantly (incident rate ratio, 3.93%; 95% confidence interval, 1.60–9.60) associated with CD. Conduct disorder, maternal psychopathy, victimization, and parental monitoring increased the risk of gun carrying by a factor of 8. Adult crime was best predicted by gun carrying, CD, and parental monitoring. Gun carrying predicted drug charges, but not violence or property offenses.
Study location	Study design	Database	Year	Independent variable	Outcome Measure	Population	Results
Casiano et al. [13]	Retrospective Review	National Comorbidity Index	2001–2004	Mood, anxiety, impulse control, and substance use disorder	Violent behavior (threatening with a gun or other weapon)	All ages	A significant association was found between threats made against others with a gun and both substance use disorders (adjusted odds ratio [AOR] 2.27; 95% confidence interval [CI] 1.62–3.20) and impulse control disorders (AOR 2.67; 95% CI 1.95–3.66). Threats made against others with any other type of weapon were significantly associated with any anxiety (AOR 1.76; 95% CI 1.34–2.31), substance (AOR 2.63; 95% CI 1.87–3.71), or impulse control disorder (AOR 2.49; 95% CI 1.96–3.18). Of the disorders studied, social phobia, specific phobia, and impulse control disorders seemed to have their onset before the act of threatening others with weapons.
Steadman et al. [14]	Retrospective Review	McArthur Violence Risk Assessment	Non-specified	Discharge from psychiatric hospital	Prevalence of violence		Of the 951 persons available for at least one follow-up, 262 (28%) committed at least one act of violence. A total of 608 violent acts were committed by these 262 patients. Of the 608 violent acts, 178 (29%) were categorized as “weapon threat/weapon use.” In 67 (37%) of these incidents, the weapon was a gun; in 73 (41%) incidents, the weapon was a knife; in 19 (11%) incidents, the weapon—for example, a bat—was categorized as “other”; and in 19 (11%) incidents, the data were not known. The average time from discharge to an act of gun violence was 119 days.

Baumann et al. [15]	Pittsburgh, PA	Longitudinal study	MacArthur Risk Assessment	1992–1994	Interpersonal violence and/or suicidality in individuals with mental health illness	Firearm access	18–40 years old	In the context of firearm access, patients were no more likely to perpetrate violence (OR = 0.588; 95% CI = 0.196–1.764) but were significantly more likely to report suicidality (OR = 4.690; 95% CI = 1.147–19.172).
Wamser-Nanney et al. [16]	Louisiana	Prospective Cohort	Hospital Registry		Childhood domestic violence and community violence	Gun violence involvement or gun ownership, gun carrying, gun arrests, impulsivity, perceptions regarding violence	Individuals hospitalized for gun injury	Childhood DV and CV exposure were both associated with increased gun violence involvement as well as numerous gun violence risk factors. Effect sizes were generally medium to large (M d = .53).
McNabb et al. [17]	New Orleans, Louisiana	Case-control study	Jefferson Parish Questionnaire	1992–1993	Family stability/structure History of victim or witness of violence Perception of school safety Drug use Familiarity with guns	Gun-carrying	Jefferson Parish public school youth < 19 years of age	Case subjects were significantly more likely than non-gun-carrying control subjects to report adult-male unemployment among households with adult males, foreseeing a likely chance to get shot in school, having seen a shooting, using marijuana, watching television > 6 hours per day, and being African American.
Webster et al. [18]	Washington D.C	Cross-sectional	Public school questionnaire	1991	First and second-hand exposure to violence Delinquent activities Beliefs about the acceptability of hitting someone under certain conditions Beliefs about the acceptability of shooting someone under certain conditions Perceived peer support of violence Aggressive behavior patterns The belief that having a weapon can provide effective protection against an attack.	Weapon-carrying	7th and 8th grade students	Having been arrested was the single best predictor of having carried a gun for males (Table 7). The odds of having carried a gun were considerably elevated among males reporting the most aggressive behavior patterns (i.e., being more likely than classmates to participate in and to initiate fights). Believing that shooting someone is justifiable under certain circumstances and perceiving peer acceptance of violence were also positively associated with gun carrying.
Kingery et al. [19]	Central Texas	Cross-sectional	High school questionnaire	1994	Fear/Anger Rates of victimization Drug use Violence prevention education	Handgun access in school	8 th and 10 th grade students	Most students reported they carried a gun out of fear or anger. Those who carried a gun at school had extremely elevated rates of repeated victimization of several types during the previous year: 589% higher for attack at school, 552% higher for attack outside school supervision, 576% higher for attempts to force sex at school, and 216% higher for rape. They also were more likely to enter dangerous situations repeatedly, were 17 times more likely to have used crack cocaine, had less instruction on preventing violence, less knowledge about means of avoiding fighting, and felt an obligation to fight under a wider variety of situations.
Schuster et al. [20]	Birmingham, Alabama; Houston; and Los Angeles County	Cross-sectional	Healthy Passages	Non-specified	Racial/ethnic disparity	Gun violence	5 th grade students and their parents	The rate of witnessing a threat or injury with a gun was 15% higher among black children than among white children before adjustment, but full adjustment reduced this disparity to 8%, a reduction of 7 percentage points.

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Table 1 (continued)

	Study location	Study design	Database	Year	Independent variable	Outcome Measure	Population	Results
Beardslee et al. [21]	Pittsburgh, PA	Longitudinal study	Multi-informant assessments	Non-specified	Childhood socioeconomic disadvantage	Adolescent gun violence	7–20 years old	Childhood socioeconomic disadvantage was associated with adolescent gun violence, and some of this effect was mediated through peer delinquency and conduct problems. Specifically, childhood socioeconomic disadvantage was associated with greater affiliation with delinquent peers in early childhood, and early peer delinquency promoted a greater increase in conduct problems across childhood, and these conduct problems, in turn, led to an increased risk for adolescent gun violence
Kemal et al. [22]	Chicago, IL New York, NY Los Angeles, CA	Longitudinal study	Youth Risk Behavior (YRBS)	2007, 2009, 2011, 2013	Perceived threat level	Gun-carrying	9th–12th graders	Multivariable Poisson regression estimates showed increased likelihood for gun carrying among males (IRR 1.41, CI 1.27–1.58), among non-Hispanic Blacks (IRR 1.26, CI 1.07–1.48), and among those who reported a higher violence index. Each additional violence index count increase was associated with 1.74 times (CI 1.70–1.78) increased likelihood for gun carrying.
Simkes et al. [25]	National	Cross-sectional	2011 and 2013 School Crime Supplement to the National Crime Victimization Survey	2011 and 2013	School-based bullying	Access to a loaded gun without adult permission	Elementary and Middle School students	Of 10,704 participants, 4.2% (95% CI: 3.8%–4.6%) reported gun access. Compared with nonbullied students, those who reported traditional bullying (PR = 2.2; 95% CI: 1.7–2.4), cyberbullying (PR = 2.8; 95% CI: 1.6–4.9), and both (PR = 5.9; 95% CI: 4.6–7.7) were more likely to also report gun access.
Loh et al. [26]	Flint, Michigan	Cross-sectional	Hospital computerized survey	2004–2008	Demographics Sexual activity Substance use Violent behavior	Gun access	14–18-year-old adolescents in ED	Binge drinking (AOR: 1.75; 95% CI: 1.37–2.27), marijuana use (AOR: 1.93; 95% CI: 1.58–2.36), sexual activity (AOR: 1.64; 95% CI: 1.32–2.02), prior injury by a gun (AOR: 1.80; 95% CI: 1.32–2.46), serious physical violence (AOR: 1.37; 95% CI: 1.13–1.66) and group fighting (AOR: 2.07; 95% CI: 1.68–2.56) also predicted access
Chen et al. [28]	National	Systematic Review	N/A	Non-specified	Alcohol and substance use	Firearm access/violence	Non-specified	Some studies indicated a positive association between the frequency of substance use and the odds of engaging in gun-related behaviors. Overall, the results suggest a need to consider substance use in research and prevention programs for gun-related violence.
Shetgiri et al. [29]	National	Longitudinal study	The National Longitudinal Study of Adolescent to Adult Health	1994–1996	Emotional distress Substance use Violence exposure Peer delinquency	Weapon involvement	7th–12th grade students	Emotional distress and substance use were risk factors for all groups. Violence exposure and peer delinquency were risk factors for whites and African Americans. Gun availability in the home was associated with weapon involvement for African Americans only. High educational aspirations were protective for African Americans and Latinos, but higher family connectedness was protective for Latinos only.
Cabrera et al. [5]	National	Cross-Sectional	Mass Shootings in America	1990–2015	Income inequality	Mass Shootings	United States counties	Our results suggest that while inequality and income alone are both predictors of mass shootings, their impacts on mass shootings are stronger when combined via interaction. Specifically, the results indicate areas with the highest number of mass shootings are those that combine both high levels of inequality and high levels of income.
Metzl et al. [7]	Non-specified	Literature Review	Non-specified	Non-specified	Mental illness	Gun violence	United States	Connections between mental illness and gun violence are less causal and more complex than current US public opinion and legislative action allow.

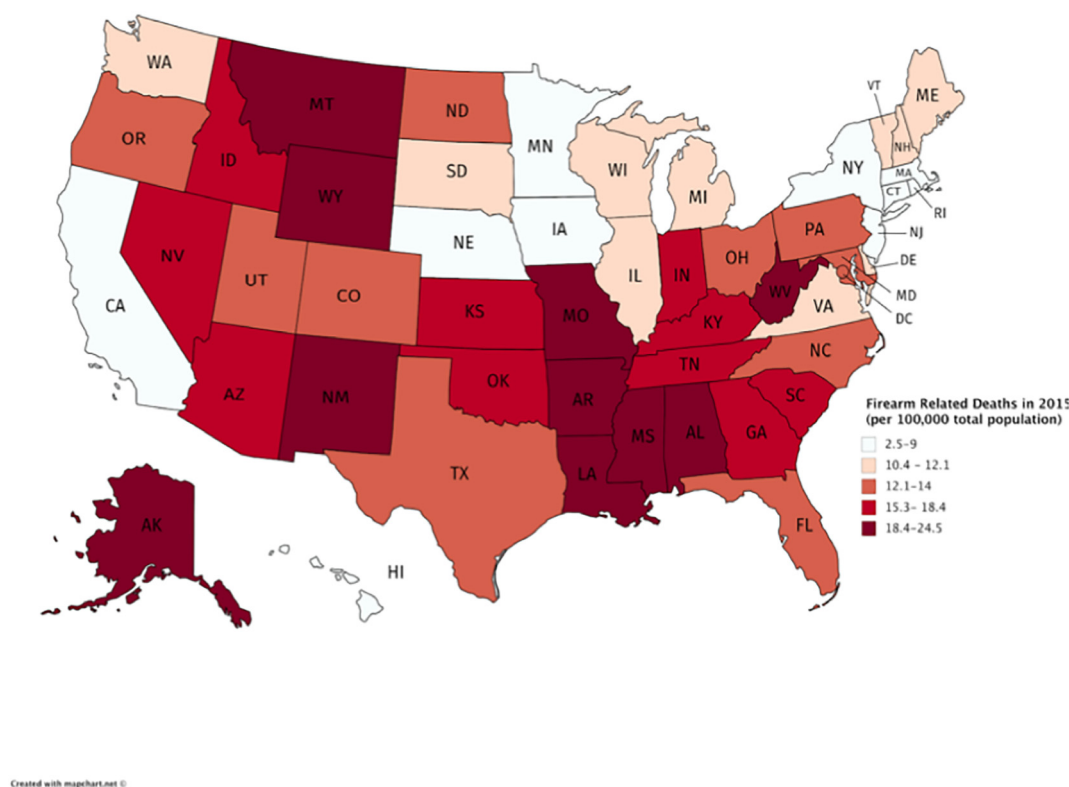


Fig. 2. States in US with the highest and lowest death rates from gun violence in 2015*. *Centers for Disease Control and Prevention, National Center for Health Statistics. Firearm Mortality by State. https://www.cdc.gov/nchs/pressroom/sosmap/firearm_mortality/firearm.htm

behavior, in one study, was associated with gun ownership in young adolescents [21]. History of depression was 36% more likely to be associated with a likelihood of keeping a firearm in the house. (95% CI 1.04–1.77) [23]. In other studies, gun-carrying has been associated with conduct disorder but not with depression, oppositional defiant disorder, or attention deficit hyperactive disorder [11].

One study examining the predictors of firearm related behaviors among Latino, African American, and Caucasian adolescents (7th to 12th grade) found that emotional distress was associated with a higher odds of weapon involvement across racial and ethnic groups (AOR 1.5, 95% CI 1.2–1.9) [25].

Furthermore, a study revealed that psychiatric patients were not more likely to perpetrate violence (OR 0.588, 95% CI 0.196–1.764) but were significantly more likely to report suicidality (OR 4.690, 95% CI 1.147–19.172), suggesting that firearms create a significant risk factor for suicide, but not violence among psychiatric individuals [14]. Interestingly, in a separate study, a higher likelihood of keeping a firearm in the home was associated with a history of depression (AOR 1.36, 95% CI 1.04–1.77) [23]. Together, these results suggest that individuals with a confirmed psychiatric disorder should continue to be assessed on suicidality and firearms in the home.

Most importantly, it should be recognized that there is limited evidence that suggests mental illness is the major cause of gun violence [6,14]. One study using the MacArthur Violence Risk Assessment found that patients with mental illness were not more likely to perpetrate violence with firearm access (OR 0.588, 95% CI 0.196–1.764). However, they were significantly more likely to report suicidality (OR 4.690, 95% CI 1.147–19.172) [14].

4. Discussion

The studies included in this review suggest possible contributors to gun violence. First, physically aggressive behavior, substance use, fear,

and a history of bullying are associated with increased access to firearms. Second, conduct disorder, substance use, impulse control disorders, childhood domestic violence, socioeconomic disadvantage, and community violence were all associated with higher odds of being involved in gun violence. Finally, a history of depression, phobias, and emotional distress were associated with increased gun use. These results suggest that there is no one risk factor for gun violence but rather several risk factors are intricately and intimately connected, together acting to create a pathway towards gun-related injury.

Reducing the incidence of firearm related injury and death is a goal that is crucial to public health and a problem that researchers and physicians are eager to solve. Based on the previous studies, the following suggestions may help reduce firearm related injury and death.

Three studies suggest that firearm access is positively associated with gun violence [26,28,29]. For instance; states with more restrictive gun laws have less firearm-related fatalities. However, it is worth noting that these studies do not establish cause-effect relationships. In fact, California has seen an increase in gun sales despite strengthened gun laws since 2012. Additionally, increased gun purchases were made in the months following mass shooting events [30]. Nevertheless, despite increased numbers of gun sales, California is one of the states with the lowest firearm-related injuries. While these findings should be interpreted with caution, they warrant further research.

In addition to restrictive state gun laws, other preventative strategies can be implemented. For example, criminal background checks performed at the time of gun purchase, by gun dealers, at gun shows, private sales, and transfers between individuals may be beneficial. The current laws only require background checks from retail firearm sellers, or Federal Firearms License holders, thus purchases from private sellers are left unchecked [31]. It is estimated that 40% of firearm transfers (i.e., 6.6 million firearms) are sold or transferred annually with no background checks [31]. In 2017, of the 25 million people who underwent a background check in order to purchase a firearm, 103,985 were

prohibited from making a purchase. Criminal background checks may thus serve as an effective way of getting firearms out of the hands of the wrong people who may cause risk to themselves or others [31]. Recognizing that gun ownership is a right, screening processes including background checks may help reduce the incidence of gun violence aside from stricter gun laws. There is evidence that universal background check laws are associated with a reduction in overall homicides, specifically by 15% [8]. In contrast, however, other studies have found no such association between background checks and gun violence. A study conducted in California found no change in firearm homicide or suicide in the ten years after California's 1991 implementation of strict background checks [32]. Another study in 2018 found an association in two states (differences = 0.7 firearm homicides and 0.5 firearm suicides per 100,000 residents in Indiana and 0.4 firearm homicides and 0.3 firearm suicides per 100,000 residents in Tennessee). They measured age-adjusted firearm homicides and suicides in 1981 to 2008 and 1994–2008 in Indiana and Tennessee, respectively and compared them to control groups by using the synthetic control method [10].

There should be better screening, improved access, and treatment for substance use and mental health disorders. This includes appropriate follow-up. This can reduce the risk for self-harm and interpersonal violence. This is especially true for adolescents who are at higher risk due to their impulsive behavior [27]. Those who receive sufficient treatment for their mental health or substance abuse are less likely to commit violent acts [27]. Early recognition of mental health and social alienation should be identified by teachers, counselors, physicians, or families and be recommended to mental health professionals [31]. The issue of mental illness as a major factor in gun violence is complex and conflicting. Undoubtedly, there is a role that mental illness plays in certain cases of gun violence. However, this is an oversimplification that acts of gun violence, specifically mass shootings, are secondary to a psychiatric disorder. The literature is limited, many of the articles studied combined variables such as gun-carrying and mental disorders.

Further research ought to be done on the incidence of individuals with a diagnosed mental illness committing acts of gun violence.

The traditional approach to controlling violence has been the criminal justice system, however due to the increasing rates of violent injury and death in the US, additional approaches should be produced. A more inclusive public health approach has been proposed as a way to reduce gun violence [33]. There are three public health concepts that can be used to shape programs to prevent firearm violence. Prevention is preferable to treatment, it is more effective to change the environment than to change individual behavior, and that it is necessary to direct multiple strategies aimed at multiple different risk factors to solve the issue. The public health approach shifts the focus of solving the gun violence issue from reacting to violence to preventing it and treating its causes [33]. It is important to evaluate all of the risk factors of gun violence, which include poverty, poor housing conditions, weak family structure, poor schools, anger, poor impulse control, and substance abuse [24,25]. For instance, constant witnessing of violence in the home or in the community allows for psychological desensitization and observational learning of aggression and violence, which is a key mechanism for the development of violent behavior [15]. The public health model has four steps. The first step is to define the problem, then identify the associated risk factors and causes of the problem, to develop interventions and test their efficacy, and lastly to implement specific programs or interventions in the community and test prevention effectiveness [33].

A national tracking system would be helpful in collecting information on firearm related injury and death to study trends or patterns. For instance, the Fatal Accident Reporting System (FARS) has been helpful in classifying pattern of motor vehicle related morbidity and mortality and has thus been used to evaluate seatbelt laws and identify trends after speed limit changes [33]. A similar program could be used to create policies to lower firearm violence. This firearm injury tracking system must include specific information like the details of the event, the location, demographic information, sociographic information, the relationship between attacker and victim, whether drugs were involved, or if

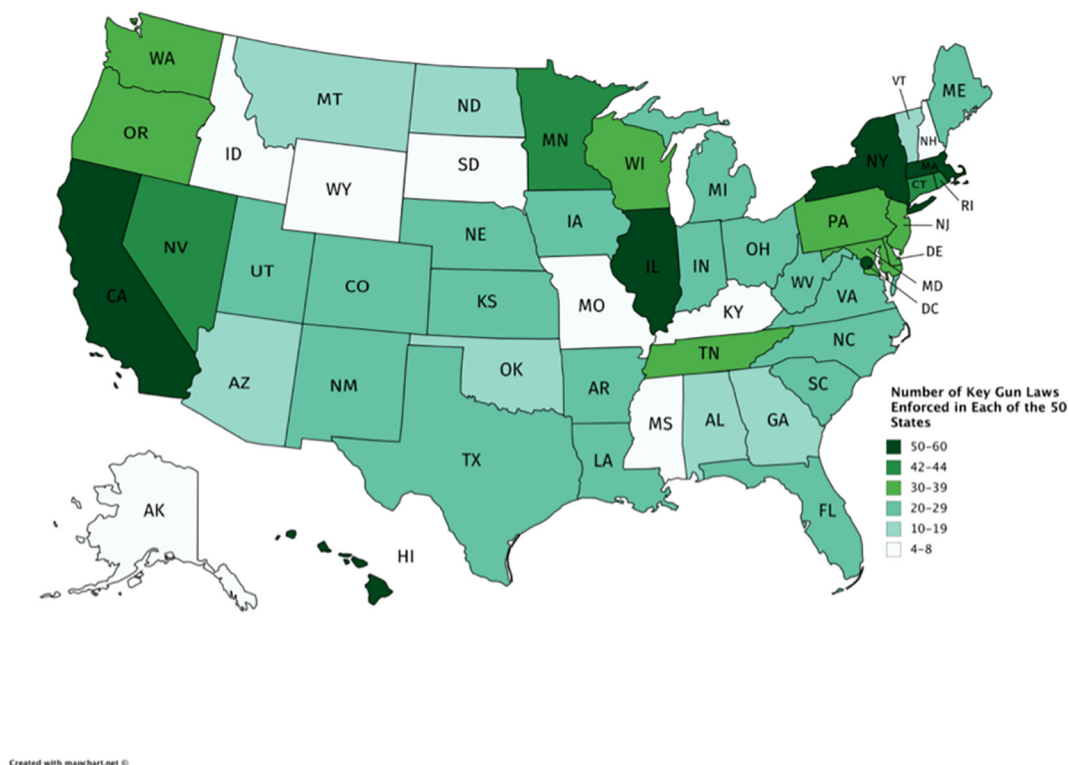


Fig. 3. State gun laws permissiveness during 2015. *. Gun Violence Statistics. Giffords Law Center to Prevent Gun Violence. <https://lawcenter.giffords.org/facts/gun-violence-statistics/>. Accessed November 4, 2019.

the offender was impaired by emotional or mental problems [33]. This detailed information will allow for informed gun policy decisions and the determination of circumstantial risk factors. The identification of demographic, behavioral, and environmental risk factors will help to determine why a certain group is at higher risk for gun injury and then to develop appropriate intervention [33].

In February 2019, 44 different medical and injury prevention associations gathered to discuss areas of intervention and reduction of gun violence [33,34]. The organizations discussed topics such as epidemiology and areas for intervention to reduce the gun violence epidemic through a public health approach. All organizations agreed that federal research funding was lacking and needs to be provided at the level of burden that the violence has caused [33,34]. Publications and the number of active individuals researching the topic of firearm injuries has decreased. To reduce gun violence there needs to be collaboration between hospitals, physicians, government, firearm owners and their families, and populations at-risk.

Current state and federal mandates curtail a physician's freedom and rights by preventing them from discussing a patient's firearm ownership [35]. However, these conversations should be encouraged since mitigating health risks are a natural part of a patient physician relationship. There are currently organizations working on strategies that engage firearm owners in devising scientifically and culturally appropriate patient counseling that physicians can apply broadly [35]. This will help use a public health approach to lower the incidence for firearm injury and death in the US. Doctors are able to intervene with patients who are at risk of injury themselves are others in the privacy of an examination room. Doctors can also provide information, answer questions, and advise patients about firearms relevant to their health or promote health and safety. Physicians provide guidance on how to prevent injuries every day, firearm safety is no different. Physicians must be able to document these conversations on medical record as with discussions of other behaviors that can impact patient health [34,35].

Our study has several limitations. First, the limited number of studies and their reduced similarities in outcomes did not allow for a meta-analysis. Furthermore, in using our broad classifications we may have overlooked some risk factors. Additionally, some factors are inextricably linked to each other (e.g., intimate partner violence and gun violence; suicide and gun violence) and therefore one can only assume correlation, not causation. Lastly, when assessing the risk factors, we did not make distinctions among type of firearm used due to insufficient data. There may be potential differences in the risk factors associated with each gun type (handguns vs. long guns). Of note, this may be also be a limitation when considering the risk factors of gun violence in different types of firearm-related injuries (suicide, mass shootings, vs. overall violence with guns).

From an etiological view, research on gun violence suggests that it is often caused by a complex interaction of biological, social, demographic, and psychological factors. Focusing on the main overarching umbrella factors can allow policymakers to create targeted interventions. The gun violence epidemic is a public health concern of paramount importance; it is critical that meaningful research on the risk factors for gun violence continues, as it may be an important target for prevention efforts.

5. Conclusion

The current gun violence epidemic has a profound impact on individuals and society as a whole. Guns cause an alarmingly high incidence of morbidity and mortality, pose a tremendous economic burden on the US healthcare system, and affect all individuals even remotely involved. The etiology of gun violence is multifactorial and contains numerous contributory factors. The most common risk factors cited in the literature can be classified broadly under access to and owning or carrying a firearm, violent behavior tendencies due to past exposure or substance

abuse, and mental illnesses which impair judgment. This does not necessarily equate to one single risk factor contributing to a gun violence event. Instead, these risk factors collectively play an integral role in the decision to commit violent crimes with guns.

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Declaration of Competing Interest

None.

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