SUICIDE AND VIOLENCE TOWARDS OTHERS AMONG THOSE WITH HIGH-RISK BEHAVIOR: FIREARMS ACCESS AND THE INHERENT RISKS[1]

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Background

Half of all suicides and two-thirds of all homicides in the United States involve firearms.[1] Previous analyses of individual-level data have indicated that there is strong evidence that access to firearms is associated with completed suicide while there is moderate evidence that access is associated with homicide victimization.[2] And a history of psychiatric illnesses has been linked with a significantly increased risk of suicide completion (method non-specific).[3] Though some evidence suggests that individuals with a mental illness are significantly more likely to attempt suicide using a firearm than other means,[4] the extent that any restriction of means would have on completed suicide among individuals exhibiting suicidal behaviors is not clear. Some empirical studies of policies aimed at restricting firearm access to high-risk individuals have shown a reduction in suicide,[5] while others have shown mixed results.[6] Nevertheless, mental health background checks for prospective firearm purchasers are not universal and vary widely between countries, states, and even metropolitan areas.

The roles that mental illness and firearm access play on violence perpetration are not yet well understood. However, evidence suggests that mental illness is not a primary influencing factor in most violent acts.[7–10] Mental illness accounts for only about 4% of all violent acts in the US.[9,11] Similarly, in Wales and UK only about 5% of violent offenders have had recent contact with mental health professionals; in these patients, 22% were diagnosed with a personality disorder and 19% with schizophrenia.[12] Recent evidence suggests that convicted murderers with severe mental illness (defined as diagnosed psychotic, schizophrenic, major depression, mania, or bipolar) are less likely to use a firearm than convicted murderers without a severe mental illness.[13] Moreover, most individuals with these severe mental illnesses (e.g., schizophrenia, bipolar) are, in fact, more likely to be victims rather than perpetrators of violence.[7,8,14] And compared with individuals without mental health conditions, individuals with depression or anxiety are no more likely to be violent toward others.[9] A meta-analysis revealed that approximately 6.5% of all homicide offenders had a diagnosis of schizophrenia and that the rates of homicide by schizophrenic offenders and non-schizophrenic offenders are highly correlated—suggesting that schizophrenics are not any more likely to commit homicide.[15] While focusing on individuals with mental health conditions may have a marginal impact on reducing most violent crimes, there is some evidence that suicidal behavior and some mass shootings may not be independent events.[16]

Intimate partner violence (IPV) is an important risk factor for homicide as it often precedes the murder of an intimate partner.[17] In fact, intimate or ex-intimate partners are

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responsible for 40-50% of all murdered women in America,[18] while only about 6% of men killed are killed by an intimate partner.[19] Access to firearms, prior arrests for domestic violence, and poor mental health have all been previously linked with intimate terrorism.[20] In a recent meta-analysis of published individual-level data evaluating the impact of firearm access and homicide victimization, researchers found that females had a higher probability of being a homicide victim than males when comparing firearm access.[2] As evidenced by prior research that suggests that most homicide victims know their assailant,[21,22] domestic violence or interpersonal disputes play an integral part in intimate partner homicides (IPH).

The commission of violent acts of self-harm or harming others is often associated with alcohol and drug abuse. Andreuccetti et al found a higher mean blood alcohol content (BAC) among homicide victims in Brazil who were killed by firearms than among victims killed by other means.[23] And empirical evidence suggests that the strongest risk factors for violent act commission are substance abuse and suicidal behaviors, while the strongest predictor of shooting or stabbing someone else is substance abuse.[24] And among youth, alcohol and drug use has been linked with carrying a weapon and fighting, though alcohol and drug use are not as strongly linked with suicidal behavior.[25]

To better understand the impact of firearm accessibility among individuals at the highest risk of harming themselves or others, a systematic review and meta-analysis was performed. Specifically, studies were evaluated that have estimated the impact of firearm accessibility among people with criminal past on risk of homicide and/or violence perpetration. And, studies were evaluated that have estimated the impact of firearm accessibility among mentally ill patients on risk of suicide.

Methods

Data Sources and Searches

In this review, PubMed, Scopus (including EMBASE), and Web of Science were searched without limitations. In Appendix 1 details of the search terms and study selection details are outlined.

Study Selection

Study Design

Study designs eligible for inclusion were pre- or post-intervention evaluations and observational studies (e.g., cohort and case-control studies) if a comparator was available. Both population-level (e.g., ecological studies) and individual-level data were included in our review, though only individual level-data were meta-analyzed.

Types of Participants

Included study participants were no restricted by age, sex, or country of residence. Participants in individual-level studies of suicide were restricted to those who exhibited suicidal behavior; participants in individual-level studies of homicide were restricted to those with known risk factors for harming others. For the present review, an individual with suicidal behavior is known to have risk factors including previous suicidal attempts, aggressive or impulsive tendencies, depression, mental health problems, or alcohol/drug

dependencies. Further, an individual with known behaviors for harming others includes a prior arrest for violence (e.g., IPV) or previous convictions of violent crimes.

Types of Exposures
In individual-level data, studies needed to assess whether firearms were available for all individuals. Specifically, individual-level studies needed to compare firearm availability (ownership or accessibility) with no availability. Firearm accessibility could be defined as self- or proxy-reported or collected from other sources (e.g. criminal records or background checks). In population-level data, firearm accessibility needed to be assessed before and after a policy initiative restricting access for individuals displaying suicidal behavior or for individuals who are known to have been harmful to others. Or population-level data could have compared populations with different firearm ownership regulations specifically targeting those who are at risk of harming themselves or others.

Types of Outcomes
The primary outcomes of interest were suicide, suicidal behavior, homicide victimization, homicide perpetration, and violent behavior toward others.

Data Extraction and Quality Assessment
Assessment of Risk of Bias
The risk of bias for each study was assessed using the Newcastle-Ottawa Scale.[26] See Table 3 and Appendix 2 for details.

Data Synthesis and Analysis
Though published adjusted estimates were preferentially extracted, the odds ratio (OR) and 95% confidence interval (CI) for all outcomes were calculated when necessary. Data were pooled across included studies with similar design and characteristics to estimate the summary effect size. A subgroup analysis was performed where data were available--types of firearms available were compared and risks of suicide or violence toward others. Lastly, a secondary analysis was performed where data were available--pooled effects were compared between subgroups of studies of individuals displaying and not displaying suicidal behavior or violence toward others. Both fixed- and random-effects models were estimated. In the absence of heterogeneity, using the I^2 statistic, fixed-effects models were employed. R[27] was used for statistical analyses.

Results

Search Results

The initial search across three databases (PubMed, Web of Science, and Scopus) yielded 13,374 references in total (see Figure 1); 4,018 duplicates and 4,196 additional clearly irrelevant references were removed. The remaining 5,160 titles and abstracts were closely reviewed and 165 articles were selected for full-text review. Overall, 8 studies were included in the qualitative analysis while 15 observational studies were included in the meta-analysis. If identified population-level studies were previously reviewed in one of the two reviews, they were excluded.

Individual-level Studies
Eleven of the included studies estimated the odds of suicide with and without firearm access adjusting for suicidal behavior (or providing data stratified by suicidal behavior),[28–38] and 5 studies estimated the odds of homicide with and without firearm access adjusting for homicidal behavior (or providing data stratified by homicidal behavior).[34,39–42] One study reported both suicide and homicide outcomes.[34]

Population-level Studies
Three of the 6 primary studies estimated the effects of different policies on suicide[5,6,43] and 5 estimated the effects of different policies on homicide.[5,43–46] Two studies estimated the effects on both homicide and suicide.[5,43] Of the two reviews of population-level data, the main outcome of one was crime reduction,[47] while the other review evaluated homicide, suicide, and crime outcomes.[48]

Study Characteristics

Demographic Characteristics
Of the 4 studies providing data specifically among those with suicidal behaviors, 3 were among adolescents only[30–32] and one was among middle-aged adults.[33] Of the 9 studies providing estimates of suicide adjusting for suicidal behaviors, 6 were among adults only[28,33–37] and 3 were among adolescents only.[29,30,38] In studies of suicide, cases were more commonly male (mean 81%; range 70-96%) than controls (mean 75%; range 57-92%).[28–35,37]

Of the 3 studies providing data specifically among those with homicidal behaviors, all were among adults only.[40–42] Similarly, of the 3 studies providing estimates of homicide adjusting for homicidal behaviors, all were among adults only.[34,39,40] In Branas et al, 91% of the cases and 92% of the controls were male.[39] Similarly, in Wintemute et al, 94% of both groups (purchasers of assault type handgun or other type of firearm) were males.[41] All the offenders in Rothman et al were male as the offenders to their female partners.[42] And in Kellermann et al, 63% of cases and controls were male;[40] similarly, in Dahlberg et al 63% of the cases were male and 56% of the controls were male.[34]

Firearm Access
Among 8 US-based studies that adjusted for suicidal behaviors, the prevalence of firearm access among suicide cases ranged from 62.7% to 75.4%, while the prevalence ranged from 26.4% to 50.8% among controls (see Table 1). In the single non-US study identified, 23.9% of the suicides and 18.5% of controls had firearm access.[28] In the 4 studies of suicide specifically among individuals displaying suicidal behavior, the prevalence of firearm access ranged from 41.7% to 77% among the suicide cases; the prevalence of firearm access ranged from 17.4% to 56.5% among the controls. Two studies reported the proportion of suicides committed using firearms among individuals with suicidal behavior (54%[31] and 78%[32]).

Among the 5 studies of homicide victimization or violence offending, the prevalence of firearm access among cases varied widely between study designs, objectives, and outcomes (see Table 2). In homicide victimization studies that adjusted for homicidal behaviors, two estimated the proportion of homicides with firearm access (as determined by proxy interviews) to be over 40% (approximately 10% higher than controls in each study),[34,40] whereas the proportion of homicides with firearm access was approximately 9% in a study in which firearm access was determined more specifically as on-person possession at time of the homicide.[39] In a study of IPV threats, nearly 12% of those who had owned a firearm recently made threats, while only 2% who did not own a firearm recently made threats.[42] And among prior violent offenders, 50.8% of assault-type handgun purchasers committed new firearm or violent offenses, while 29.2% of other types of firearms purchasers committed similar offenses.[41]

Suicidal Behavior

All 11 studies interviewed proxies to ascertain firearm accessibility (see Table 1). Ten studies defined suicide as intentional, self-inflicted death by any means, while 1 study[38] defined suicide as death due only to firearms. All suicides were reported using death certificates and/or reported consecutively. Seven of 10 case-control studies used school or community controls,[28,30–33,35,38] 1 study's controls were patients receiving care within a facility,[29] and 2 studies used deaths from other causes.[36,37]

Homicidal Behavior

Two of 5 studies[34,40] interviewed proxies to ascertain firearm accessibility (see Table 2). The proportions of cases with firearm access ranged from 9% to 51% and among the controls 8% and 36% had access to firearms, though firearm access was determined by various means including proxy interviews,[34,40] police records,[39] subject interviews,[42] and background check records.[41] Three of 5 studies defined the outcome as homicide victimization,[34,39,40] the primary outcome of 1 study was new firearm or violence offense,[41] and the primary outcome of another study was IPV threats.[42] All homicides were reported using death certificates and/or reported consecutively in the three studies of homicide.[34,39,40] Intimate partner threats were reported in interviews of offenders,[42] and violent offenses were reported within the Department of Justice criminal records.[41] Both case-control studies used community controls.[39,40]

Control Participant Selection

Suicide studies suffered minimally from selection bias, as all but one had independent validation of cases, good representativeness of cases, and used community controls (see Table 3). Moreover, the risk of selection bias in the two case-control homicide studies was determined to be minimal for similar reasons.

Comparability

All suicide studies had adequate comparability, as all controlled for mental illness (via design or modeling) and controlled for other factors (e.g., age, sex, race, socio-economic

status). Both homicide case-control studies also had adequate comparability as they controlled for prior arrest history and other important confounding factors.

Exposure

All of the included suicide studies are likely somewhat biased in terms of firearm exposure classification. Specifically, 8 of the 10 case control studies were at high risk of exposure bias resulting from inadequate information about (or different) non-response rates between cases and controls and unblinded interviews ascertaining firearms exposure.[29,31–33,35–38] One of the two homicide case-control studies[40] potentially suffered from exposure bias as it utilized unblinded interviews to determine firearms exposure.

Meta-Analysis of Effects of Access to Firearms

Suicide Outcomes

Data were pooled from 9 identified observational studies that assessed the odds of suicide after adjusting for suicidal behavior. Using a random-effects model, a summary OR of 3.14 (95% CI 2.29-4.29) was calculated with substantial heterogeneity (I^2=76%) (see Figure 2). After adjusting for suicidal behavior, all but one study found significantly higher odds of suicide among individuals who had firearm access compared with those who did not.

Data from 4 identified observational studies that assessed the odds of suicide specifically among individuals displaying suicidal behavior were pooled. Using a fixed-effects model, a summary OR of 2.78 (95% CI 1.56-4.95) with no heterogeneity (I^2=0%) (see Figure 3) was calculated. Two of the 4 included studies found significantly higher odds of suicide among individuals displaying suicidal behavior comparing their firearm access.

Firearm Type Subgroup Analyses

The effects of access to specific firearm types and risk of suicide among individuals with suicidal behavior were explored. Three studies provided adequate data for subgroup analyses of firearm types. Suicidal individuals with access to long guns specifically were not more likely to commit suicide than those without access (OR=1.14; 95% CI 0.52-2.51).[31,32] Further, from the available data, suicidal individuals with access to loaded guns were not more likely to commit suicide than those without access (OR=0.98; 95% CI 0.32-2.99).[30,32] However, suicidal individuals with access to handguns were more than 10 times more likely to commit suicide than those without access (OR=10.27; 95% CI 3.41-30.96, I^2=0%).[30–32]

Homicide Outcomes

Data from 3 identified observational studies that assessed the odds of homicide after adjusting for homicidal behavior were pooled. Using a fixed-effects model, a summary OR of 2.41 (95% CI 1.69-3.45) with no heterogeneity (I^2=0%) (see Figure 4) was calculated. After adjusting for homicidal behavior, all studies found significantly higher odds of homicide among individuals who had firearm access compared with those who did not.

One observational study that assessed the odds of homicide specifically among individuals displaying homicidal behavior was identified.[40] The odds of homicide among this population was not significant when comparing firearm access (OR=1.67; 95% CI 0.61-4.58). Additional research, which estimated the risk of violent offending among those who committed a prior violent crime, found the risk to be significantly higher among those who purchased an assault-type handgun compared with other types of firearms (RR=3.00; 95% CI 1.93-4.67).[41]

An additional study estimated the odds of using a firearm to threaten a partner comparing recent firearm ownership (i.e., within 3 years) after adjusting for a number covariates including criminal record, restraining order, and previous jail sentence for IPV.[42] The authors estimated a significantly higher likelihood of threatening a partner among those with recent firearm ownership compared with those without recent ownership (OR=7.8; 95% CI 5.6-11.0).

Secondary Analysis

Lastly, when adequate data were available, pooled estimates of odds of suicide comparing those with and without suicidal behaviors to explore possible differences in risks were compared. Two studies provided data for individuals without suicidal behaviors and the pooled estimate was significantly increased among those with access to firearms (OR=4.35; 95% 1.21-15.57).[30,33] In contrast to the pooled estimate among those individuals with suicidal behaviors (OR=2.78; 95% CI 1.56-4.95), the test for differences between subgroups was not significant (p value = 0.53). Only one study of homicide provided adequate data to estimate the odds of homicide comparing those with and without prior arrest history.[40] Among those without a prior arrest history, the odds of homicide were significantly increased among those with access to firearms compared to those without (OR=1.55; 95 CI 1.00-2.40). The test for differences between estimates for those with a prior arrest history (OR=1.67; 95% CI 0.61-4.58) and those without was not significant (p value = 0.89).

Population-level Studies

Eight studies[5,6,43–48] containing population-level data were identified and an overview of these studies is in Table 4. Of the 8 identified studies, 6 were primary analyses[5,6,43–46] and 2 were reviews of previously published population-level data.[47,48] Three of the primary analysis studies used Federal Bureau Investigation (FBI) data as their source of suicide and violence outcomes[43–45] and three used Centers for Disease Control and Prevention (CDC) data.[5,6,46] Two of the primary analysis studies evaluated IPH outcomes specifically,[44,45] 3 evaluated homicide outcomes,[5,43,46,48] and 3 evaluated suicide outcomes.[5,6,43] All of the primary analysis studies were performed in the US. Each of the studies evaluated firearm restriction policies uniquely. The two reviews evaluated waiting periods and specific acquisition restrictions or background checks on violent

crime, gun crime, homicide, or suicide.[47,48] A general overview of results from population-level studies is given in Table 5.

Acquisition Restrictions or Background Checks

Suicide

In a study that evaluated the effect of firearm restriction on suicide,[6] reduction in suicide among males was significant, but firearm restrictions based on mental health or alcohol/drug problems is not as effective. Specifically, the researchers found that restrictions on firearms possession resulting from a history of mental health problems was only significantly related to a reduction in suicide among males 25-44 and a restrictions due to alcohol abuse was only significantly related to a reduction in suicide among males 65 years old or older. A restriction to firearms possession resulting from a history of drug abuse was not significantly related to suicide among males. In contrast, Sen et al found that background checks at the state-level were associated with fewer suicides.[5] Specifically, the states with background checks that considered mental illness as prohibitory had lower incidence of firearm suicide (IRR=0.96; 95% CI 0.92-0.99), and all suicide (IRR=0.97, 95% CI 0.95-0.99). And Kleck et al found no significant reduction in suicides where there were restrictions on individuals with a mental health history, or drug and alcohol addiction history when compared to areas without these restrictions.[43]

Homicide and Assaults

In a primary analysis using FBI data, researchers evaluated the effect of firearm restriction laws on IPH.[44] The researchers controlled for additional law passage that restricted access to firearms but were not specifically domestic violence-related. They found significantly lower incidence rates of firearm IPHs (IRR=0.91; 95% CI 0.84-0.99) comparing those states with restraining order laws to those without, and significantly lower incidence rates of firearm IPHs among females (IRR=0.90; 95% CI 0.83-0.97). Furthermore, the researchers found no significant effect of domestic violence misdemeanor laws or confiscation laws on any measure of IPH incidence. Similarly, Zeoli et al found that state statutes restricting individuals with restraining orders from accessing firearms are associated with reductions in IPH.[45] In fact, the authors only found that these specific restrictions were impactful and no additional policies restricting access to domestic violence offenders. Ruddell et al found that state background checks have a consistently negative association with firearms homicides across states.[46] Specifically, using various combinations of covariates (i.e., state-level data on race, urbanicity, poverty, violent crime index, suicides, firearm theft rate, firearm density factors), all models yielded significantly reduced homicide rates the more effective the screening mechanisms for state background checks were.[46] And, Sen et al found that background checks at the state-level were associated with fewer homicides.[5] The authors found that states with background checks that considered restraining orders as prohibitory had lower incidence of firearm homicide (IRR=0.87; 95% CI 0.79-0.95) and all homicide (IRR=0.91; 95% CI 0.85-0.98) when compared with states without such restrictions. The greatest effect on homicide incidence was when fugitive status was used as a prohibitory factor in background check laws (firearm homicide: IRR=0.79, 95% CI 0.72-0.88; all homicide: IRR=0.77, 95% CI 0.71-0.84).[5] Kleck et al found mixed effects of firearm

restrictions laws on homicides and aggravated assault.[43] Where criminals were prohibited from possessing firearms, there was no significant reduction in homicides when compared to areas where there was no such prohibition. However, where there was a restriction on criminals possessing firearms the authors noted a significantly reduced gun assault rate. In a review performed by Hahn (2005), the authors identified two studies that evaluated the impact of acquisition restrictions.[48] One population-level study performed in California evaluated the effect of a restrictions on individuals with previous felony convictions and found that among restricted felons, subsequent arrest for violent crime was reduced by almost 20%.[49] An additional study identified evaluating the impact of acquisition restrictions found that there was no significant evidence for a reduction in homicide or suicide among the younger US adults, though there was a noted significant decrease in suicide among older adults (55 years old or older).[50] One population-level study found that restrictions for misdemeanor convictions subsequently reduced the rate of first violent crime arrest by nearly 20%, though not significantly.

Waiting Periods

Suicide

Kleck et al found no significant reduction in suicides where there was a waiting period instituted when compared to areas without these restrictions.[43] Additionally, in Hahn et al the review authors identified 6 studies that evaluated the effects of waiting periods on suicide and again found mixed results. One study found a small increase in total suicide, one found a small decrease in total suicides. An additional study found lower rates of firearm-related suicide among children and adolescents[51] while another found a decrease in firearm-related suicide among adults.[50]

Homicide and Assaults

Similarly, Kleck et al found that in metropolitan areas where a waiting period was instituted, there was no significant decrease in homicide, firearm-related or otherwise.[43] For aggravated assaults, where there was a waiting period instituted, there was no significant reduction. Makarios et al found that the summary effect of waiting periods and background checks have a weak effect on crime reduction (r=-0.078), though if only high-quality studies are considered there are no reductions in crime noted.[47] In turn, the authors conclude that comprehensive community-based law enforcement initiatives are likely best at reducing gun violence. And in Hahn et al, the reviewers identified studies that evaluated the effects of waiting periods on homicide and found mixed results. Three of 6 studies identified had point estimates that showed lower rates of homicide, 2 of 6 studies had point estimates that showed an increase in homicide, and none of the 6 studies had statistically significant findings.

Quality of Evidence

Individual-Level Data

The quality of identified evidence evaluating the effect of firearm access on suicide and harming others among individuals who are known to be at risk for harming themselves or others is highlighted in Table 6. Across all questions, the quality of evidence is determined to be low. For completed suicide, few studies analyzing individual-level data have ever evaluated the impact of firearm accessibility among individuals with mental illness. Further, the available evidence is gathered mostly from case-control studies of adolescents where proxy interviews were used to determine firearm access. For homicide outcomes, even fewer studies have ever used individual-level data to evaluate the impact of firearm accessibility among individuals with prior arrests, a history of violence, or a restraining order. In turn, the evidence identified is affected by serious indirectness, as the comparison groups were not exactly the comparisons of interest (i.e., assault-type handgun vs any other firearm); the small number of studies added to the imprecision of the evidence.

Summary of Findings

Individual-Level Data

There is a strong association between the access to firearms and the likelihood of committing suicide after removing the effects of mental illness. Among individuals with a mental illness history, the effect of having access to firearms is no different than the effect among individuals without a mental illness history. There is a very strong association between suicide completion among those with a mental illness history and access to handguns specifically. The relationship between homicide or assault and firearm access among those highest at risk is mixed. Among those with an arrest history, there is no clear association between homicide and firearm access. However, threatening an intimate partner with a gun is associated with recent firearm ownership after adjusting for criminal record, restraining order, and previous jail sentence for IPV.

Population-Level Data

Overall, studies evaluating the impact firearm restriction or background check laws have on suicide have mixed results. When considering only restrictions to individuals with mental illness history, there are conflicting results or significant effects only found within subgroups of populations. Similarly, restrictions to individuals with drug or alcohol addiction or abuse history are not universally effective across studies. Similarly, studies evaluating the impact restriction to access or background check laws have on homicide or assault also have mixed results. When considering restraining orders as a prohibitory factor in accessing firearms, there is agreement across all studies that these laws can reduce firearm IPH incidence and homicide rates. Furthermore, restrictions to more serious criminals (e.g., fugitive status, felony conviction) appears to reduce violent crime and assault rates, though there are mixed results regarding homicide rates. And the effects access restriction or background checks for less serious crimes (e.g., misdemeanor convictions, domestic violence misdemeanor) have on violent crime or IPH are mixed. Waiting periods may be effective at reducing suicide rates, but only specifically for firearm-related suicides, though this finding was not universal. However, the effect waiting periods have on rates of homicide or assault are mixed from the identified population-level literature, with most indicating no effect.

Discussion

In the present review, studies using individual level data or population-level data to explore the effects of firearm accessibility on suicide and harming others among those exhibiting suicidal and harmful behaviors were identified. In a meta-analysis of individual-level data, among individuals with a mental health history, those who had access to a firearm were nearly 3 times more likely to commit suicide than those without access (pooled OR=2.78; 95% CI 1.56-4.95). However, this increase in odds is no different than what would be seen among individuals without a history of mental illness (pooled OR=4.35; 95% 1.21-15.57) (test for subgroup differences: p value =0.53). Similarly, an analysis of all individual-level studies that adjusted for a history of mental illness or suicidal behavior found consistently elevated odds of suicide when comparing firearm access (pooled OR=3.14; 95% CI 2.29-4.29). This would suggest that mental health status might not really act as an effect modifier to the firearm accessibility and suicide relationship. In fact, Miller et al came to similar conclusions finding that firearms in the home actually levy a risk for suicide that is beyond the baseline risk.[52] As such, the increased risk for suicide among those with access to firearms may be ubiquitous and gives credence to the influence of impulsive suicide.

Our review of studies with population-level data found that restrictions to purchase firearms among individuals with mental health conditions were largely inconsistent[5,43] or marginally effective at reducing suicide rates across a population.[6,48] These findings, similar to results from individual-level data, again seem to support the notion that the bulk of firearm-related suicides are not driven by a mental health condition, but by ready access to a firearm. Waiting periods may have at least a weak impact on suicide,[47,48] however, which can act as a cooling off period for impulsive self-harm behaviors.

The extent that age plays a role in the relationship between firearm access and suicide among individuals with a mental illness is not clear from the identified data. Qualitatively, the risks of suicide as it relates to firearm access among younger individuals with a mental illness appear elevated when compared to older individuals with a mental illness, though this may be reflective of the impulsivity of younger individuals. Among males, Rodriguez Andres et al found the only significant impact of firearm acquisition laws for those with a mental illness was among younger adults (25-44),[6] though another review of population-level data failed to find the same results among young adults.[48] Nearly all studies providing data for individual-level meta-analyses among individuals exhibiting suicidal behavior were conducted among adolescent populations. Only one was conducted in middle-aged and older adults[33] and the point estimate was similar to the estimates from 2 out of 3 adolescent studies.[30,32]

Depression or anxiety disorders may be less likely or less severe in individuals who attempt impulsive suicide and impulsive suicide attempts may be more likely in younger individuals.[53] Because the bulk of the identified individual-level data are among adolescents, the pooled effects seen may actually be skewed toward impulsive violent suicide rather than suicide after proximal planning. In fact, violent methods for

committing suicide have previously been linked with suicide attempts that had little planning or pre-thought.[54]

In subgroup analyses, there was mixed evidence for specific types of firearms or storage practices on subsequent risk of suicide. Specifically, long guns and loaded guns were not associated with a significant increase in suicide, though individuals with access to handguns were much more likely to commit suicide than those without access (OR=10.27; 95% CI 3.41-30.96). This relationship, independent of mental illness status, was also noted by previous research, which found the largest risk for suicide when considering types of firearms was among those with access to handguns only (OR=38.2; 95% CI 20.3-71.9).[34] Though mixed evidence that the type or storage of firearms had a discernable effect on suicide risk in the presence of a psychiatric disorder was found, it may be that the study population already has a lower threshold for attempting to commit suicide; in turn, the type or storage of firearms may not be a critical, additional contributor to their suicide risk. It may also be that the available data were collected from a more urban population as previous research indicates that the presence of a handgun in these populations can increase the risk for suicide after controlling for psychiatric variables.[30,31]

There were mixed results from studies using individual-level data to assess the risk of homicide or other violent outcomes when comparing access to firearms. Studies of homicides and violent crime were too heterogeneous to warrant most meta-analyses. However, a pooled OR of 2.41(95% CI 1.69-3.45) for homicide victimization among individuals who had firearm access compared with those who did not among studies that adjusted for homicidal behavior was estimated. While there is a paucity of individual-level data estimating the effects of firearm accessibility on homicide or violent behavior outcomes among those who exhibited prior homicidal or violent behavior, 1 study estimated the odds of homicide perpetration among this population was not significantly different from those without access to firearms (OR=1.67; 95% CI 0.61-4.58).[40]

Intimate partner violence, restraining orders, and firearm accessibility are not well researched in individual-level data. One study was identified which only somewhat provided insight into this question—the authors estimated a significantly higher likelihood of threatening a partner comparing recent firearm ownership (OR=7.8; 95% CI 5.6-11.0), after adjusting for restraining order, criminal record, and previous jail term for IPV.[42]

Population-level data evaluating the impact of firearm acquisition and waiting periods on violent crime and homicide may provide better insight into understanding the body of evidence. Evidence suggests that acquisition laws are not as effective for all homicides, but laws that are specifically targeting individuals with a restraining order from acquiring new firearms, or even accessing their current firearms, are generally effective in reducing intimate partner homicides.

The policies restricting firearm access for individuals with restraining orders are necessarily varied and may be less effective at preventing IPV or IPH without explicit

changes. Specifically, Vigdor et al found that only laws that prohibit purchase of firearms were effective in reducing IPH, while laws that prohibit possession without prohibition of firearm purchases specifically may not be as effective.[44] The authors conclude that it is possible that more easily enforceable laws, such as purchase laws, may be more effective than laws aimed at firearms removal.

The role firearms play in violent aggression is situational dependent, particularly for stranger homicide.[55] The impact of firearms access on stranger homicide in particular is not clear.[55] In fact, some research suggests armed aggressors are actually less likely to attack and injure victims than aggressors without a firearm,[56] though among incidents where the aggressors attack, the aggressors with a firearm are much more likely to commit homicide.[56]

Implications for Future Research

Background checks may not work if mental illness disqualifications are not broad enough, but the less specific a disqualification the more likely an individual's constitutional rights will be violated. A study of violent crimes committed by individuals with serious mental illnesses, nearly all (96%) did not meet the federal mental health firearm disqualification criteria,[57] though many did have a disqualifying criminal record.[57] Reducing access to firearms for those with a mental illness may not have as much impact on homicide as anticipated.[58] Coupled with the fact that the federal government has previously acknowledged the difficulties with instant background checks because of missing information regarding mental illness, drug addiction, and immigration status,[48] perhaps future research on firearm possession and acquisition and its impact on violence should not focus on mental illness necessarily but rather on an individual's history of violence. In turn, more reliable data (i.e., criminal records) could be used with potentially more impact on violence.

Mental illness is a broad term that encapsulates disparate diagnoses with disparate risks. In the present review, studies of individual-level data considered mental illness as a probable or definite diagnosis of major depression,[30–32] substance abuse,[30–32] conduct disorder,[30–32] and previous suicide attempt,[30] any affective disorder,[31,32] and the presence of any active Axis I disorder[33]. To isolate the potential difference in effects between disorders, future studies should be powered to explicitly compare diagnosis subgroups.

Several study design approaches are possible for better elucidating the relationship between mental illness, firearm access, and suicide risk. For example, using a case-control approach, firearm-related suicides could be compared to non-firearm related suicides to determine whether mental health diagnoses are different between groups. This approach would provide valuable information about the method choice for completed suicide for individuals with various mental illnesses.

Currently, there is a paucity of data examining the effect of firearm access on IPV and IPH among couples with an established restraining order. Furthermore, firearm possession and purchase among individuals who have a history of domestic violence and/or current restraining order varies substantially between states. One approach to

estimate the impact of the different types of policies on IPV or IPH would be to create two cohorts of couples with similar firearm possession prevalence but located in two different areas with disparate policies. Using this approach, individual-level factors such as alcohol or drug abuse, prior convictions, or a history of violence could all be considered in the analysis.

Different approaches to estimating the effect of firearm policies on the risk of violent acts can include being more transparent about types of violent acts (i.e., what constitutes the violent act). While this is typically research question dependent, policy recommendations are best made when the research is of sound quality and directly addressing the policy in question. For example, some researchers suggest using all firearm deaths as the outcome of interest in studies of firearm policies and risk of violence because the heterogeneity of violent acts is reduced to one measure which has an unambiguous interpretation.[59]

Future studies may find it useful to explore different approaches to population-level data. In fact, data for violent outcomes, such as homicide or aggravated assault, are not standardized. Future studies would greatly benefit from thoroughly collected data containing specific details about the perpetrators of the crime, circumstances, weapon type or whether it was legally owned, and perhaps even the location.

Additionally, future research should also consider substitution of method or other unintentional consequences of firearm restriction policies for individuals with a history of mental illness or harming others. Some argue that firearm restriction may disproportionately affect law-abiding citizens as criminals would likely not adhere to any restriction laws.[60] In turn, it is theorized that homicide rates would potentially increase gun levels among in law-abiding citizens (though the extent that homicides are actually prevented by law-abiding citizens is also not well-understood). Additionally, there is some empirical evidence of substitution of method for suicide; stricter firearms access laws may decrease rates of firearm-related suicide while increasing rates of suicide by other means.[61,62] And, because individuals with certain types of mental illness are more vulnerable to violence victimization, it is important for future research to consider the effects firearms laws may have on their ability to legally defend themselves while weighing their inherent risks for self-harm.

Though the evidence suggests that those without mental illness predominantly commit violence, the public's perception and subsequent policies are focused primarily on addressing the restriction of firearms to those with a history of mental illness. To combat misunderstandings of the data and the perception regarding the risk to society mentally ill pose, those at high-risk will have to start with individual counseling,[63] while communities with tighter restrictions should educate their communities about the dangers of mental illness.

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Tables

Table 1: Characteristics of Included Individual-level Studies of Suicide

Study-Year	Population (location)	Firearm-Specific Outcomes	Type of Cases	Type of Controls	Proportion of Cases With Gun Access	Proportion of Controls With Gun Access
Suicide Outcomes Adjusted For Suicidal Behaviors						
Brent- 1991[29]	Adolescents (Pennsylvania)	69% of suicides	Serially reported (proxy interview)	In-patient Adolescent Suicide- Attempters (parental figure interviews)	72.3%	37.0%
Kellermann-1992[35]	Adults (Tennessee, Washington, Ohio)	51-73% of suicides	Serially reported within home (proxy interview)	Community controls (control proxy interviews)	65.0%	41.0%
Brent-1993[30]	Adolescents (Pennsylvania)	70.2% of suicides	Serially reported (proxy interview)	Community controls (parental figure interviews)	75.4%	50.8%
Beautrais-1996[28]	Adults (New Zealand)	13% of suicides	Serially reported (proxy interview)	Community controls	23.9%	18.5%
Shah-2000[38]	Adolescents (Colorado)	Firearm only cases	Death certificate (proxy interviews)	Students at same school (control proxy interviews)	72%	50%
Conwell-2002[33]	Adults over 50 years (New York)	47.7% of suicides	Serially reported (proxy interview)	Community controls (control proxy interviews)	62.7%	41.3%
Kung-2003[36]	Adults (United States)	Any means (unreported %)	Deaths determined to be suicide by death certificate (proxy interviews)	Deaths determined to natural by death certificate (control proxy interviews)	69.47%-Males 56.01%-Females	46.77%-Males 31.99%-Females
Dahlberg-2004[34]	Adults (United States)	68% of suicides	Cohort Defined Using: Mortality Survey data and death certificates (proxy interviews of decedents)		72.4%	32.0%
Kung-2005[37]	Adults (California)	Any means (unreported %)	Deaths determined to be suicide by death certificate (proxy interviews)	Deaths determined to natural by death certificate (control proxy interviews)	64.25%	26.42%
Suicide Outcomes Among Individuals With Suicidal Behaviors						
Brent-1994[31]	Adolescents (Pennsylvania)	54% of suicides	Serially reported (proxy interview)	Community controls (parental figure interviews)	68.9%	56.5%

Bukstein-1993[32]	Adolescents (Pennsylvania)	78% of suicides	Serially reported (proxy interview)	Community controls (parental figure interviews)	77%	50%
Brent-1993[30]	Adolescents (Pennsylvania)	70.2% of suicides[a]	Serially reported (proxy interview)	Community controls (parental figure interviews)	41.7%[b]	17.4%[b]
Conwell-2002[33]	Adults over 50 years (New York)	47.7% of suicides[a]	Serially reported (proxy interview)	Community controls (control proxy interviews)	61.1%	33.3%

a. Among all cases, those with and without suicidal behavior.
b. Crudely back-calculated proportions based on reported odds ratios.

Table 2: Characteristics of Included Individual-Level Studies of Homicide Victimization and Violent Behavior Offending

Study-Year	Population (location)	Firearm-Specific Outcomes	Type of Cases	Type of Controls	Proportion of Cases With Gun Access	Proportion of Controls With Gun Access
Homicide Victimization Outcomes Adjusted for Homicidal Behaviors						
Kellermann-1993[40]	Adults (Tennessee, Washington, Ohio)	49.8% of homicide cases	Serially reported within home (proxy interview)	Community controls (control proxy interviews)	45.4%	35.8%
Dahlberg-2004[34]	Adults (United States)	68% of homicide cases	Cohort defined using mortality survey data and death certificates (proxy interviews of decedents)		41.9%	32.0%
Branas-2009[39]	Adults (Philadelphia)	Firearms only cases	Serially reported	Community controls (participants)	8.8%	7.9%
Among Offenders, New Gun or Violent Offense						
Wintemute-1998[41]	Adults (California)	Any type of violent offense (% not reported)	Cohort defined using California Department of Justice data		50.8%[a,b]	29.2%[a,c]
Among Offenders, IPV Threats						
Rothman-2005[42]	Adults	30.4% of cases	Cohort defined using batterer intervention program enrollment		11.8%[d]	2.1%[e]

a. Among all individuals with a criminal history
b. Among assault-type firearms purchasers
c. Among other types of firearms purchasers
d. Among all individuals who owned a firearm in past 3 years
e. Among all individuals who did not own a firearm in past 3 years

Table 3: Summary of critical appraisal of included case control studies using the Newcastle-Ottawa Quality Assessment Scale for observational studies

Study ID	Selection	Comparability	Exposure

	(maximum 4 points)	(maximum 2 points)	(maximum 3 points)
Suicide outcomes*			
Brent et al[31]	****	**	*
Brent et al[29]	***	**	*
Kellermann et al[35]	****	**	*
Brent et al[30]	****	**	**
Beautrais et al[28]	****	**	**
Bukstein et al[32]	****	**	*
Shah et al[38]	****	**	*
Conwell et al[33]	****	**	*
Kung et al[36]	****	**	*
Kung et al[37]	****	**	*
Homicide Victimization and Violence Offending Outcomes*			
Kellermann et al[40]	****	**	**
Branas et al[39]	***	**	***

*Dahlberg et al[34], Wintemute et al[41], and Rothman et al[42] not shown because scale is different for cohort studies

Table 4: Characteristics of Included Population-Level Studies Evaluating the Impacts of Specific Policies and Legislation on Violence and Suicide

Study-Year	Population (location)	Data Source(s)	Specific Outcomes
General Firearm Restriction Laws			

Vigdor-2006[44]	All US	FBI	Intimate partner homicide
Specific Firearm Restriction Laws			
Zeoli-2010[45]	All US	FBI	Intimate partner homicide
Firearm Restriction Laws Due to Behavior Issues (Mental Health Condition or Drug Dependency)			
Rodriguez Andres-2011[6]	All US	CDC	Suicide
State Background Checks			
Ruddell-2005[46]	All US	CDC	Firearm-related homicide
Specific Types of Background Checks (restraining order or mental illness)			
Sen-2012[5]	All US	CDC	Homicide and suicide
Waiting Periods, Criminal Possession Restriction, Prohibit Possession for Mental Illness			
Kleck-1993[43]	All major US cities	NCHS and FBI	Suicide, homicide, and aggravated assault
Acquisition Restrictions and Waiting Periods			
Hahn-2005[48]	Multiple (Review)	Multiple (Review)	Homicide, aggravated assault, suicide, and violent crime
Waiting Periods and Background Checks			
Makarios-2012[47]	Multiple (Review)	Multiple (Review)	Violent or gun crime

NCHS: National Center for Health Statistics
FBI: Federal Bureau of Investigation
CDC: Centers for Disease Control and Prevention

Table 5: Overview of Results from Population-Level Studies

Study-Year	Policy Type	Direction of the Effect
Firearm Restriction or Background Check Laws: Suicide		

Rodriguez Andres-2011[6]	Mental Health Problems	↓ Among males 25-44 year old
	Alcohol Abuse	↓ Among males 65 years old or older
Sen-2012[5]	Mental Illness Prohibitory	↓ In states with background checks
Kleck-1993[60]	Mental Illness History	←→ Contrasting areas with background checks
	Drug or Alcohol Addiction	←→ Contrasting areas with background checks
Firearm Restriction or Background Check Laws: Homicide or Assault		
Vigdor-2006[44]	Restraining Order Laws	↓ Firearm IPH incidence
	Dom. Violence Misdemeanor	←→ Any measure of IPH incidence
	Confiscation Laws	←→ Any measure of IPH incidence
Zeoli-2010[45]	Restraining Order Laws	↓ Firearm IPH incidence
	Others	←→ Any measure of IPH incidence
Ruddell-2005[46]	State background checks	↓ State-level homicide rates
Sen-2012[5]	Restraining Order Laws	↓ State-level homicide rates
	Fugitive Status Prohibitory	↓ State-level homicide rates
Kleck-1993[60]	Criminals Prohibitory	←→ Homicide rate contrasting areas with laws
	Criminals Prohibitory	↓ Assault rate contrasting areas with laws
Hahn-2005[48]	Felony Conviction [a]	↓ Violent crime rate
	Felony Conviction [a]	←→ Homicide rate among younger US adults
	Misdemeanor Conviction [a]	←→ Rate of first violent crime arrest
Makarios-2012[47]	Background Check [a,b]	←→ Crime rate contrasting areas with laws
Waiting Period Laws: Suicide		
Kleck-1993[60]	Waiting Period	←→ Suicide rate contrasting areas with laws
Hahn-2005[48]	Waiting Period [a]	←→ Total suicide rate
	Waiting Period [a]	↓ Firearm-related suicide among adolescents
	Waiting Period [a]	↓ Firearm-related suicide among adults
Waiting Period Laws: Homicide or Assault		
Kleck-1993[60]	Waiting Period	←→ Homicide rate contrasting areas with laws
	Waiting Period	←→ Assault rate contrasting areas with laws
Hahn-2005[48]	Waiting Period [a]	←→ Homicide rate contrasting areas with laws
Makarios-2012[47]	Waiting Period [a,b]	←→ Crime rate contrasting areas with laws

a. Multiple primary studies contributed to these results within this review

b. Review did not distinguish between background check and waiting period laws

IPH: Intimate partner homicide

↑ Indicates an increase in risk; ↓ Indicates a decrease in risk; ←→ Indicates mixed effects or no difference

Table 6: Quality of Evidence of Studies Evaluating Firearm Accessibility and Its Impact on Violence and Suicide

Factors Affecting Quality of Evidence	Grading of quality of evidence (score)

Suicide (Adjusted for MI)	
Design	All observational studies (-2)[1]
Risk of bias (NOQAS)	Serious (-2)[2]
Directness (generalizability)	No serious indirectness (0)
Inconsistency	No serious inconsistency (0)
Imprecision	No serious imprecision (0)
Publication/reporting bias	Unlikely (0)
Overall Quality Rating	Very Low[3]
Homicide Victimization (Adjusted for prior arrest)	
Design	All observational studies (-2)[1]
Risk of bias (NOQAS)	Serious (-1)[4]
Directness (generalizability)	No serious indirectness (0)
Inconsistency	No serious inconsistency (0)
Imprecision	No serious imprecision (0)
Publication/reporting bias	Unlikely (0)
Overall Quality Rating	Very Low[3]
Suicide (Among individuals with MI history)	
Design	All observational studies (-2)[1]
Risk of bias (NOQAS)	Serious (-2)[5]
Directness (generalizability)	No serious indirectness (0)
Inconsistency	No serious inconsistency (0)
Imprecision	No serious imprecision (0)
Publication/reporting bias	Unlikely (0)
Overall Quality Rating	Very Low[3]
Homicide (Among individuals with prior arrest)	
Design	All observational studies (-2)[1]
Risk of bias (NOQAS)	Serious (-2)[6]
Directness (generalizability)	Serious indirectness (-1) [7]
Inconsistency	No serious inconsistency (0)
Imprecision	Serious imprecision (-1) [8]
Publication/reporting bias	Unlikely (0)
Overall Quality Rating	Very Low[3]

MI: Mental Illness

1. Observational studies, in contrast to RCTs, are automatically considered low quality of evidence by default.
2. Eight of 9 studies had a high risk of exposure bias.
3. The overall quality of evidence rating is assessed by the total of points subtracted for each factor: 0 points, high quality; 1 point, moderate quality; 2 points, low quality; < 2 very low quality.
4. One of 2 case control studies had a moderate risk of exposure bias because firearm access determined using proxy interviews.
5. Four of 4 studies had a high risk of exposure bias.
6. One study had a high risk of exposure bias.
7. Some studies compared assault-type handguns to other types of firearms while other studies compared access and no access for any type of firearm.
8. Few events.

Figures

Figure 1: Study Identification and Selection

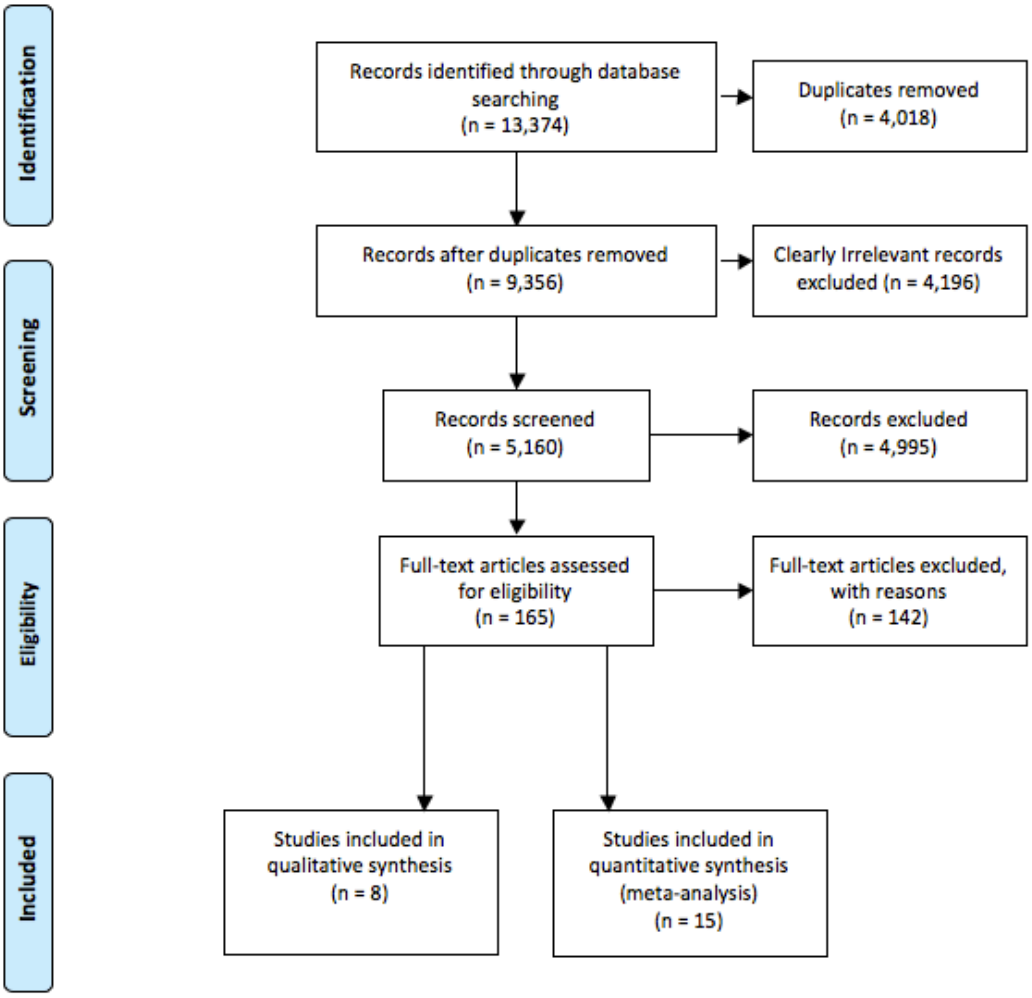


Figure 2: Forest Plot of Identified Studies Estimating the Effect of Firearm Accessibility and Suicide (adjusting for suicidal behavior)

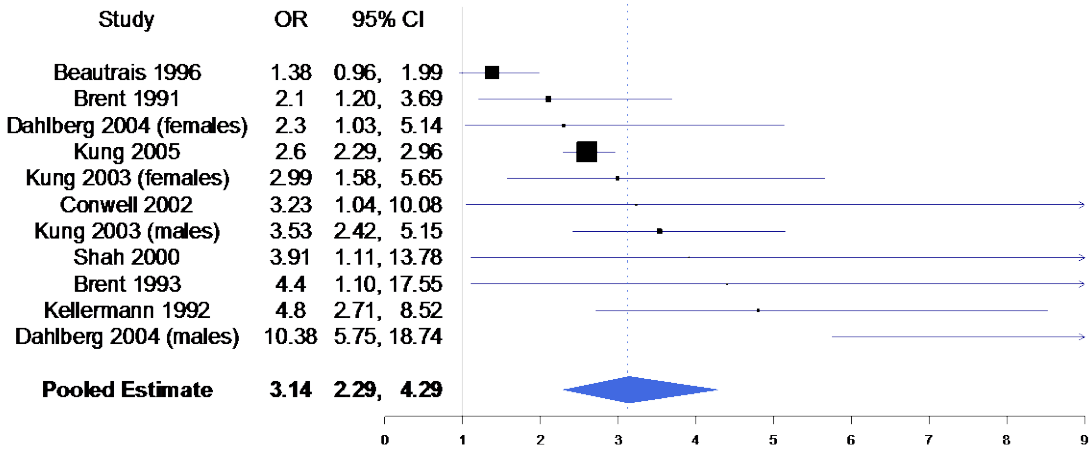


Figure 3: Forest Plot of Identified Studies Estimating the Effect of Firearm Accessibility and Suicide (among individuals displaying suicidal behavior)

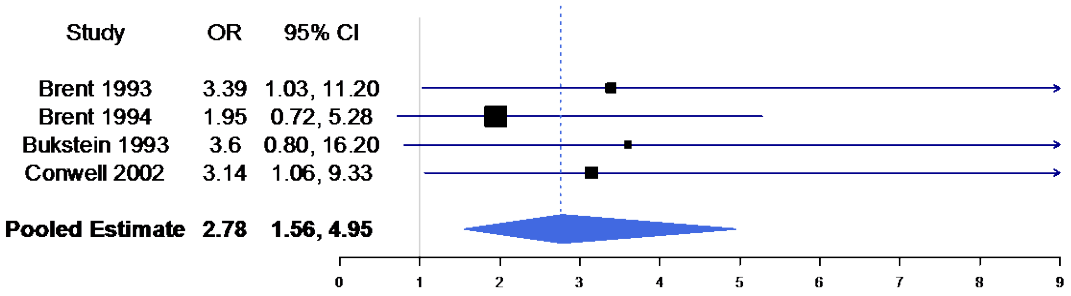
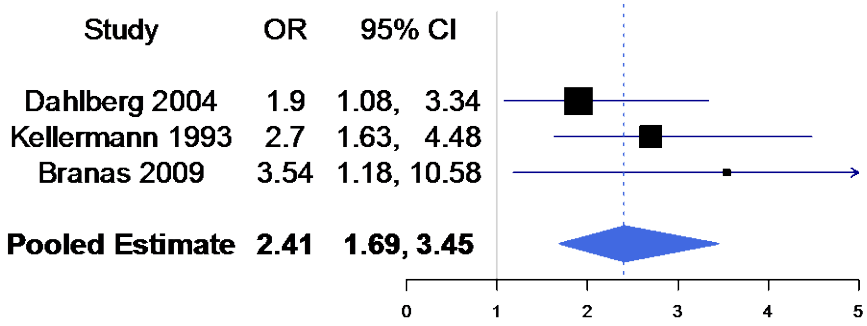


Figure 4: Forest Plot of Identified Studies Estimating the Effect of Firearm Accessibility and Homicide (adjusting for prior arrest or violent domestic abuse history)



APPENDICES

Appendix 1

Search Strategy

The titles and abstracts identified were reviewed in the initial search to assess potential relevance to the topic. After removing irrelevant titles, the remaining selected titles, abstracts, and descriptor terms of the remaining citations were reviewed to identify eligible reports. Full-text articles for all citations identified as potentially eligible were obtained and the relevance of the articles according to the inclusion criteria was determined. Where there was uncertainty regarding a study's eligibility, the full-text article was obtained. Studies were reviewed for relevance based on design, types of participants, and outcome measures.

Core terms of PubMed search strategy, adapted as needed for use in the other databases.

Initial Search date: November 3, 2014

PubMed-Specific Strategy

(Firearm*[tiab] OR Weapon*[tiab] OR Firearms[mh] OR Weapons[mh] OR gun*[tiab] OR handgun*[tiab] OR rifle*[tiab] OR shotgun*[tiab] OR pistol*[tiab] OR shoot*[tiab] OR gunshot[tiab] OR (Gunshot Wounds[mh])) **AND** (murder*[tiab] OR kill*[tiab] OR homicid*[tiab] OR suicid*[tiab])

Other Databases Strategy

(Firearm*OR Weapon* OR gun* OR handgun* OR rifle* OR shotgun* OR pistol* OR shoot* OR gunshot) OR (Wounds AND Gunshot)) **AND** (murder* OR kill* OR homicid* OR suicid*)

initial individual database yields:
PubMed: n=3,356
EMBASE/Scopus: n=3,761
Web of Science: n=6,257

Appendix 2

Detailed Risk of Bias Results Using Newcastle-Ottawa Quality Assessment Scale for observational studies

Homicide Victimization Outcomes	Kellermann[40]	*	*	*	*	*	*			*	*
	Branas[39]	*	*	*	*	*	*				
Suicide Outcomes	Brent[31]	*	*	*	*	*	*			*	
	Kung[36]	*	*	*	*	*	*			*	
	Kung[37]	*	*	*	*	*	*			*	
	Kellermann[35]	*	*	*	*	*	*			*	
	Brent[30]	*	*	*	*	*	*			*	*
	Beautrais [28]	*	*	*	*	*	*			*	*
	Brent[29]	*	*		*	*	*			*	
	Shah[38]	*	*	*	*	*	*			*	

CATEGORY				
			Bukstein[32]	Conwell[33]
Selection Criteria	**Is the case definition adequate?**	Yes, with independent validation	*	*
	Representative-ness of the cases	Consecutive or obviously representative series of cases	*	*
	Selection of controls	Community controls	*	*
	Definition of controls	No history of studied endpoint	*	*
Comparability	**Comparability of cases and controls (design or analysis)**	Study controls for mental illness history	*	*
		Study controls for age or sex	*	*
Exposure	**Ascertainment of exposure**	Secure record		
		Blinded Structured Interviews		
	Same method of ascertainment for cases and controls	Yes	*	*
	Non-Response Rate	Same rate for both groups		