Title: Association of mental disorders with firearm suicides: a systematic review with meta-analyses of observational studies in the United States

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Abstract

Background: In the United States, 61% of all suicide cases may involve firearms, and some evidence suggests that mental health may play a role. We performed the first systematic review and meta-analysis to investigate: (i) whether mental disorders are associated with suicide by firearm, and (ii) whether the risk of using a firearm compared with alternative means is associated with higher levels of suicide in individuals with a mental disorder. *Methods and findings*: We searched twelve databases from inception (the earliest paper included is from 2000) to the 24th of May 2020. We retrieved 22 observational studies conducted in the United States. Random-effects meta-analysis showed individuals who had a diagnosis of a mental disorder had lower odds (odds ratios (OR)= 0.50, 95% CI: 0.36 to 0.69; I^2=100 (95% CI: 87 to 100%) of dying by suicide with a firearm than those who did not have a diagnosis of a mental disorder. Subgroup analysis showed that women without a mental disorder had higher odds of using a firearm than women with a mental disorder, however, the number of studies included were small (n=5). Secondary analysis showed that decedents who had a mental health diagnosis resulted in lower odds of dying by suicide by using firearms than using other means. *Limitations:* Risk of bias revealed a heterogeneous and poor definition of mental health as well as lack of control for potential demographic confounding factors. In the meta-analysis, studies were combined in the same analytic sample as 77% of these studies did not specify the type of mental health diagnosis. *Conclusion*: While at face value our results suggest that having a mental disorder may not be consistently associated with the odds of dying by suicide using a firearm, the presence of substantial heterogeneity and high risk of bias precludes any conclusions.

Highlights

- More than half of all suicides are committed using a firearm in the United States.
- The association between mental health and the risk of firearm-related suicide has not been previously explored.
- Meta-analyses showed that mental health disorder was not associated with greater odds of committing suicide using a firearm.
- Risk of bias revealed a heterogeneous and poor definition of mental health as well as lack of control for potential demographic confounding factors.

Keywords: *mental health, depression, suicide, firearms, systematic review, meta-analysis*

1. Introduction

Suicide is a major cause of preventable deaths worldwide (Naghavi, 2019), and it refers to a deliberate act against oneself with the intention or expectation of dying (Andriessen, 2006; Gulati et al., 2013). In the United States (US), suicide rates have risen 33% since 1999, increasing from 10.5 to 14 suicides per 100,000 people (Hedegaard, 2018), with almost 45,000 people dying by suicide in 2016 (Stone et al., 2018). Overall, suicide is the 10th leading cause of death in the US (Vigil et al., 2019) and the societal cost burden for suicidal behavior reaches around $70 billion per year based on lifetime medical costs and lost productivity (CDC, 2019; Corso et al., 2007; Shepard et al., 2016).

The underlying mechanisms of suicide have been extensively researched (Chesney et al., 2014; O'Connor and Nock, 2014; Shepard et al., 2016). The evidence suggests that a combination of biopsychosocial factors contribute to its completion (O'Connor and Nock, 2014). Some genetic predispositions, for example, to depressive symptoms (Maciejewski et al., 2017) may contribute to suicidal behavior traits (e.g. suicidal thoughts, plans, and attempts) independently of the genetic heritage of the psychiatric disorders (Voracek and Loibl, 2007). Psychosocial stressors, such as sexual assault or combat-related trauma, feature in major theories of suicide (Liu and Miller, 2014). Recently, a review found consistent association between stress (e.g., acute life events, chronic difficulties, trauma), and suicidal ideation and behavior in adolescents and adults (Liu and Miller, 2014; Stewart et al., 2019). Behaviors such as excessive alcohol or drug use may also place an individual at a higher risk of suicide (Branas et al., 2016b; Wilcox et al., 2004) because aggression and impulsivity increase the risk for suicidal behavior among persons with alcohol and substance abuse (Sher,

2005). Presence of a mental disorder (O'Connor and Nock, 2014), particularly a mood, psychotic, or personality disorder is also linked with increased risk of suicide (Chesney et al., 2014; Too et al., 2019). However, while mental disorders are associated with greater suicide risk, not all individuals with a diagnosis of a mental disorder will engage in suicidal behavior (Joiner et al., 2017) and not all individuals who died by suicide carried a diagnosis of a mental disorder prior to suicide (Haw and Hawton, 2015).

The mode of suicide is also a relevant factor to consider when investigating the link between mental disorder and suicide (Kaplan et al., 2012). Certain suicide methods such as firearms carry greater lethality than other methods, including hanging, suffocation, and poisoning (Hawton et al., 2013; Hor and Taylor, 2010; Verrocchio et al., 2016). In the US, firearms are used more frequently than these other methods (ASFP, 2017; Boggs et al., 2018; Stone et al., 2018) and are used more often for suicidal behaviors than for homicides each year (Lewiecki and Miller, 2013). Some individuals might purposely use firearms because of the greater lethality (Shenassa et al., 2003). Some studies found link between mental disorders, including post-traumatic stress disorder (PTSD) or schizophrenia and increased risk of firearm-related suicide (Desai et al., 2008; Price et al., 2009; Shah et al., 2000a; Shields et al., 2007). However, other studies have not documented such relationships (Boggs et al., 2018; Brent et al., 1991; Callanan and Davis, 2012; Choi et al., 2017a; Choi et al., 2017b; Choi et al., 2018; Kaplan et al., 2012; Kaplan et al., 2009; Stone et al., 2018; Trigylidas et al., 2016). For example, individuals with a mental disorder such as depression or bipolar disorder had lower odds of dying using firearms than other means (Choi et al., 2018). Understanding the role that firearms may play in suicidal behavior among individuals with a diagnosis of a mental disorder may be useful in regulating access to firearms in this population (Boggs et al., 2018).

Previous systematic reviews showed that alcohol abuse, fewer restrictions on firearm control , and direct access to firearms increase the firearm-suicide risk (Anglemyer, 2014; Branas et

al., 2016b; Hahn et al., 2005). However, these reviews did not specifically assess whether mental disorders are associated with the use of firearm in suicidal behaviors (Anglemyer, 2014; Branas et al., 2016b; Hahn et al., 2005), and to our knowledge, there is no systematic review addressing this question. Since presence of mental disorders is associated with a greater risk of death by suicide using any means (Balázs, 2006; Bostwick and Pankratz, 2000; Gradus et al., 2010; Tondo et al., 2003), we assessed whether the presence of any mental disorder was associated with an increased risk of death by suicide specifically using a firearm. Therefore, our primary objectives were to systematically review and synthesize evidence from primary observational studies (i) assessing whether any mental health condition is associated with an increase the risk of firearm-related suicide and (ii) whether the risk of using a firearm compared with other means is associated with higher levels of suicide in individuals with a mental disorder.

2. Methods

2.1 Protocol and Registration

This systematic review accords with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Liberati et al., 2009) (S1 Appendix), and it is part of a more extensive systematic review registered a priori (PROSPERO, CRD42019117896).

2.2 Eligibility criteria

This article focuses on exploring whether mental disorders are a precipitating factor for firearm-related suicide. In this systematic review, eligible studies had to be conducted in the US with firearm-related suicide (completed) as the outcome. Suicide is defined as "death caused by self-directed injurious behavior with any intent to die as a result of the behavior" (O'Connor, 2013) and firearm defines as "a lethal barreled weapon of any description from

which any shot, bullet or another missile can be discharged" (CPS, 2019). Studies had to include any mental disorder as the exposure with male and/or female decedents of any age. We included any type of observational studies (cross-sectional, case-control, and cohort studies) and grey literature. We excluded editorials, letters, books, book chapters, opinion papers, blogs, case studies, reviews including systematic reviews and meta-analyses, and randomized-controlled trials. We excluded articles in languages other than English. We excluded studies involving suicides within war/military conflicts for two reasons: 1) War and military conflicts usually occurs outside the US and 2) There is a mental health screening process before troop deployment (Hyams, 2006), and therefore, if a soldier develops a mental disorder in this scenario, it would probably be related to being deployed to a war/military conflict (Russell and Russell, 2019). This would not be representative of the US general population. We also excluded studies including air, pellet, or nail guns as by definition, they are non-firearm and they are usually unregulated under the Federal firearms law. Air, pellet, or nail guns are also less controversial compared with firearms because they are legal in the US and the majority of European countries. We did not add a publication date limit to the search.

2.3 Information source

A search strategy was developed with the help of a reference librarian (S.O'D). It was implemented to search the following electronic databases: MEDLINE (Covidence Systematic Review) (48), PsycINFO EBSCOhost, Embase (Covidence Systematic Review), Scopus, Criminal Justice abstract EBSCOhost, Global Health (Covidence Systematic Review), SocIndex, Academic Search Complete, Political Science Complete, Social Policy and Practice, OpenGrey. The initial search was done in December 2018. A second search was completed on the 24th of May 2020. The search strategy is presented in S2 Appendix.

2.4 Study selection

Studies were uploaded to the Covidence software (Covidence Systematic Review, 2014). The selection process was followed by the inclusion and exclusion criteria stated in the initial protocol (S3 Appendix). Title and abstract as well as full-text screening were performed independently by pairs of two reviewers (A. Z. A., S. B., S. P. H., N. B., D.S.) according to the eligibility criteria. Conflicts were discussed and resolved by two researchers. When consensus could not be reached; a third independent author was consulted.

2.5 Data collection process

Information from the studies was extracted using a customized data extraction form. We collected data on study design, decedents' information, and demographics (sample size, age, sex), the type of mental disorder (we divided diagnosis into two groups: mood or non-mood disorders), and the method of diagnosing decedents (e.g., interviews with family and friends). We also collected information on the type of firearm and study results (number of cases, percentage, mean, standard deviation, odds ratio (OR), Pearson's correlation (*r)*, confidence intervals, and *p*-values).

2.6 Risk of bias in individual studies

We used the critical appraisal tool from the Joanna Briggs Institute (JBI) for cross-sectional studies (Joanna Briggs Institute, 2017b) and case-control studies (Joanna Briggs Institute, 2017a) to assess the risk of bias at the study level. The tools were applied by two authors (A. Z. A., D. S.).

2.7 Synthesis of results

All analyses were performed using the 'meta' and 'metafor' packages of the statistical software R (v.3.6.3). Studies did not provide individual decedent data; therefore, summary

level data were extracted and then transformed onto the log-odds scale using Comprehensive Meta-Analysis software V3 (Borenstein, 2013). The pooled log OR was then estimated and back-transformed to obtain the OR and its corresponding 95% confidence interval (Hahn et al., 2005). The studies were pooled using random-effects meta-analyses with the Hartung-Knapp-Sidik-Jonkman adjustment (IntHout et al., 2014; Langan et al., 2019). To perform the meta-analyses, we included the proportions of the decedents who died by suicide with firearms in each group (i.e., decedents with a diagnosis of any mental disorders vs. decedents without a diagnosis of any mental health disorder). We also included the proportions of decedents with any mental disorder who died by suicide using a firearm vs other means. We excluded studies that had not explicitly provided a diagnosis of any mental disorder. Still, we applied an indicator for the presence of any mental disorder, such as decedents being on medications for mental disorders or using mental health services.

We assessed heterogeneity using the $\chi 2$ test on Cochrane's *Q*-statistic, I^2 and its 95% CI, tau, and τ^2 (Borenstein, 2020). A statistically significant *Q*-statistic and a non-zero τ^2 value indicated non-trivial between-study heterogeneity (Higgins et al., 2003). We also calculated 95% prediction intervals (PI) around the pooled estimate, which provides information about how much the effect sizes vary across different settings (IntHout et al., 2016). The PIs were calculated for meta-analyses with at least 10 studies (Borenstein, 2020). We investigated small-study effects with Egger's test and by generating funnel plots for meta-analyses with at least ten studies (Lau et al., 2006). We explored the impact that imputing missing studies might have on the pooled estimate by performing Duval and Tweedie's trim and fill test (Duval and Tweedie, 2000).

The primary meta-analysis included studies comparing decedents with and without a diagnosis of any mental disorder on the risk of dying by suicide using any firearm. To explore heterogeneity, we then preformed two subgroup meta-analysis; (i) comparing studies

that included decedents with different mental disorders (bipolar disorders, schizophrenia, post-traumatic stress disorder) to studies that included decedents with depression, and studies comparing men with different mental disorders to men without a diagnosis of any mental disorders vs. studies comparing women with different mental disorders to women without a diagnosis of any mental disorders. We couldn´t complete a meta-regression as covariate data was limited and poorly reported. We performed sensitivity analysis, excluding case-control design studies and those with an overall low risk of bias.

3. Results

3.1 Study Selection

The searches revealed 10,887 articles. After reviewing the two-stage screening, 22 studies were included in a systematic review, and 14 (64%) of which were included in the meta-analysis (see PRISMA flow chart in Figure 1).

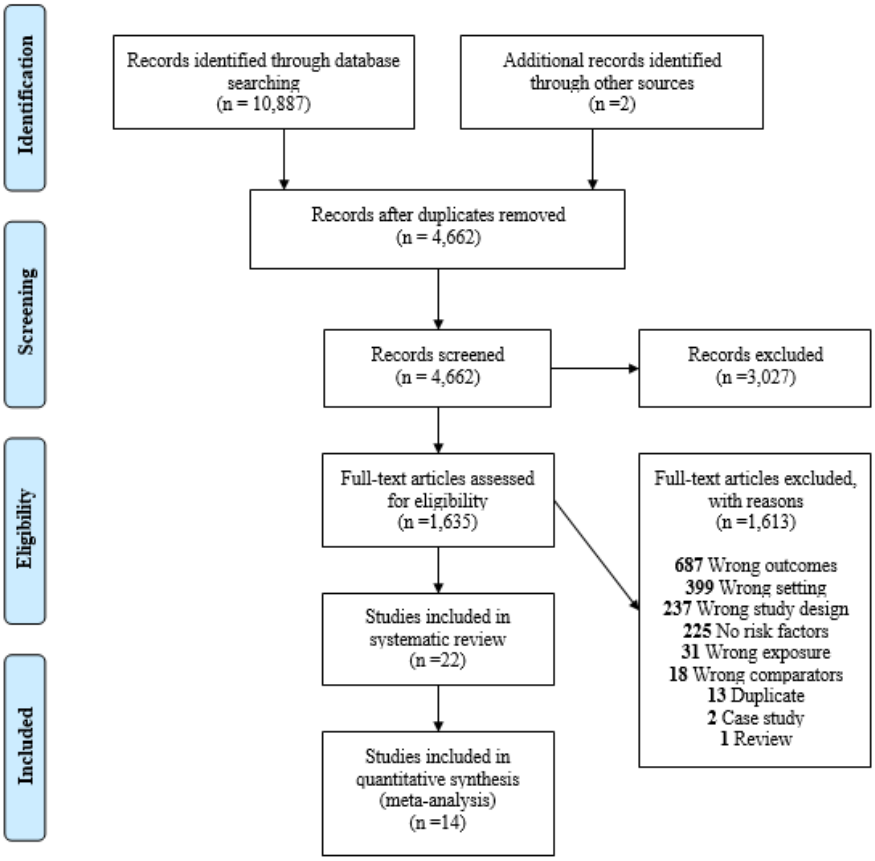

Figure 1. Flow Diagram of Study Selection

3.2 Study characteristics

From the 22 eligible studies, there were 19 (86%) cross-sectional designs and 3 (14%) case-control primary studies. The study with the biggest sample size had 41,244 decedents (Kalesan et al., 2018a) and the study with the smallest sample contained 50 decedents (Weinberger et al., 2000). From all the studies there were three (14%) which did not provide the total sample size (Hemenway and Miller, 2002; Kaplan et al., 2012; Price et al., 2009). The median sample size across studies was 17,254 decedents (interquartile range: 22,792).

The mean age of decedents by a firearm was 40.53 (SD: 18; range 15-63) years. Four (18%) of the studies (Callanan and Davis, 2012; Shields et al., 2007; Simonetti et al., 2020; Weinberger et al., 2000) provided the mean age of all suicide victims including those who used a firearm as well as those who used other methods. Eleven (50%) studies (Choi et al., 2017b; Desai et al., 2008; Hemenway and Miller, 2002; Joe et al., 2007; Kalesan et al., 2018a; Kaplan et al., 2012; Kaplan et al., 2009; Schmutte and Wilkinson, 2020; Schnitzer et al., 2019; Stone et al., 2018; Trigylidas et al., 2016) provided the age range and three (14%) studies (Boggs et al., 2017; Price et al., 2009; Streib et al., 2007) did not provide any information about decedents' ages. Seventeen (77%) of the studies (Boggs et al., 2018; Boggs et al., 2017; Choi et al., 2017a; Choi et al., 2017b; Desai et al., 2008; Joe et al., 2007; Kalesan et al., 2018a; Kaplan et al., 2009; Schmutte and Wilkinson, 2020; Schnitzer et al., 2019; Shah et al., 2000b; Shields et al., 2007; Simonetti et al., 2020; Stone et al., 2018; Streib et al., 2007; Trigylidas et al., 2016; Weinberger et al., 2000) included men and women, two (9%) studies included men decedents only (Kaplan et al., 2012; Shah et al., 2000b), and one (5%) study included only women decedents (Choi et al., 2018). Only five (23%) studies reported the type of firearm used for the suicide (Callanan and Davis, 2012; Choi et al., 2017a; Shah et al., 2000b; Streib et al., 2007; Weinberger et al., 2000). A description of the type of firearm used

is shown in Table 3 and Table 4; definitions of each firearm type are included in S4 Appendix.

3.2.1 Exposure

In this systematic review, the term "exposure" refers to the precipitating/risk factor studied throughout this paper, mental disorders. Nine studies (41%) investigated psychological mood base disorders such as major depression, dysthymia, bipolar disorder and bipolar depression (Boggs et al., 2018; Callanan and Davis, 2012; Choi et al., 2017a; Desai et al., 2008; Hemenway and Miller, 2002; Joe et al., 2007; Kalesan et al., 2018a; Kaplan et al., 2009; Weinberger et al., 2000) (S5 Appendix). Psychological non-mood disorders such as paranoia, drug-induced psychosis, schizophrenia, PTSD, dual diagnosis and dementia were investigated in seven studies (32%) (Boggs et al., 2018; Callanan and Davis, 2012; Choi et al., 2018; Desai et al., 2008; Shah et al., 2000b; Shields et al., 2007; Weinberger et al., 2000) (S5 Appendix). There were also seventeen (77%) studies which include mental disorders as an exposure but did not specify the specific type of mental illness that decedents had been diagnosed (Boggs et al., 2018; Boggs et al., 2017; Callanan and Davis, 2012; Choi et al., 2017a; Choi et al., 2017b ; Choi et al., 2018; Kaplan et al., 2012; Kaplan et al., 2009; Price et al., 2009; Schmutte and Wilkinson, 2020; Schnitzer et al., 2019; Shah et al., 2000b; Simonetti et al., 2020; Stone et al., 2018; Streib et al., 2007; Trigylidas et al., 2016; Weinberger et al., 2000).

3.3 Risk of bias within the studies

Three major sources of bias were found within the cross-sectional studies (Table 1). The first one was how the victims' mental disorder diagnosis were measured in the studies (Boggs et al., 2017; Callanan and Davis, 2012; Choi et al., 2017a; Choi et al., 2017b; Choi et al., 2018; Desai et al., 2008; Hemenway and Miller, 2002; Joe et al., 2007; Kaplan et al., 2012; Kaplan

et al., 2009; Schmutte and Wilkinson, 2020; Schnitzer et al., 2019; Shields et al., 2007; Stone et al., 2018; Streib et al., 2007; Weinberger et al., 2000). There are three commonly established systems for classifying mental disorders: International classification of diseases (International Advisory Group for the Revision of Icd-10 Mental and), Diagnostic and Statistical Manual of Mental Disorders (DSM-5) and the National Institute of Mental Health's Research domain criteria (RDoC) (Clark et al., 2017). From the studies which did not measure the exposure appropriately, nine of them did not follow any of these classifications described (Callanan and Davis, 2012; Choi et al., 2017a; Choi et al., 2017b; Choi et al., 2018; Hemenway and Miller, 2002; Joe et al., 2007; Kaplan et al., 2012; Schmutte and Wilkinson, 2020; Streib et al., 2007) and eight of them measured the exposure using the information provided by the victims´ family members during interviews or from US NVDRS (National Violent Death Reporting System) where the mental health variables are based on reports from family/friends (Callanan and Davis, 2012; Choi et al., 2017a; Choi et al., 2017b; Choi et al., 2018; Joe et al., 2007; Kaplan et al., 2012; Schmutte and Wilkinson, 2020; Streib et al., 2007).

There were eight studies that did not report clearly how they measured the exposure (Boggs et al., 2017; Callanan and Davis, 2012; Desai et al., 2008; Kaplan et al., 2009; Schnitzer et al., 2019; Shields et al., 2007; Stone et al., 2018; Weinberger et al., 2000). Studies also did not identify the confounding factors (i.e., baseline characteristics, prognostic factors, or concomitant exposures). They also did not explain the strategies applied to deal with confounders (Boggs et al., 2017; Price et al., 2009; Shields et al., 2007; Weinberger et al., 2000). There were six studies that did not define the inclusion criteria with adequate detail (Price et al., 2009; Shields et al., 2007; Simonetti et al., 2020; Stone et al., 2018; Streib et al., 2007; Weinberger et al., 2000). Of the three case-control studies (Table 2), none reported the exposure measured in a standard, valid, and reliable way as they did not provide enough

information to understand what classification they used in their studies to measure the exposure (Boggs et al., 2018; Kalesan et al., 2018a; Shah et al., 2000b). Two of the three case-control studies measured the exposure based on the information provided by family members (Boggs et al., 2018; Shah et al., 2000b).

Table 1. Risk of Bias Table: Joanne Briggs Checklist. Cross-sectional Studies

Study	Were the criteria for inclusion in the sample clearly defined?	Were the study subjects and the setting described in detail?	Was the exposure measured in a valid and reliable way?	Were objective, standard criteria used for measurement of the condition?	Were confounding factors identified?	Were strategies to deal with confounding factors stated?	Were the outcomes measured in a valid and reliable way?	Was appropriate statistical analysis used?
Boggs 2017	✓	X	UNCLEAR	N/A	X	X	UNCLEAR	✓
Callanan 2012	✓	✓	UNCLEAR	N/A	✓	✓	✓	✓
Choi 2018	✓	✓	X	N/A	✓	✓	✓	✓
Choi 2017a	✓	✓	X	N/A	✓	✓	✓	✓
Choi 2017b	✓	✓	X	N/A	✓	✓	✓	✓
Desa 2008	✓	✓	UNCLEAR	N/A	✓	✓	✓	✓
Hemenway 2002	✓	✓	X	N/A	✓	✓	✓	✓
Joe 2007	✓	✓	X		✓	✓	✓	✓
Kaplan 2012	✓	✓	X	N/A	✓	✓	✓	✓
Kaplan 2009	✓	✓	UNCLEAR	N/A	✓	✓	✓	✓
Price 2009	X	X	✓	N/A	X	X	UNCLEAR	UNCLEAR
Schmutte 2020	✓	✓	X	N/A	✓	✓	✓	✓
Schnitzer, 2019	✓	✓	UNCLEAR	N/A	✓	✓	✓	✓
Simonetti, 2020	UNCLEAR	✓	✓	N/A	✓	✓	✓	✓
Streib 2007	UNCLEAR	✓	X	N/A	✓	✓	✓	X
Stone, 2018	UNCLEAR	✓	UNCLEAR	N/A	✓	✓	✓	✓
Trigylidas 2016	✓	✓	✓	N/A	✓	✓	✓	✓
Weinberger, 2000	UNCLEAR	✓	UNCLEAR	N/A	UNCLEAR	X	✓	X

✓: question's answer is yes
✗: question's answer is no
N/A: not applicable

Table 2. Risk of Bias Table: Joanne Briggs Checklist. Case Control Studies

Study	Were the groups comparable other than the presence of disease in cases or the absence of disease in controls?	Were cases and controls matched appropriately?	Were the same criteria used for identification of cases and controls?	Was exposure measured in a standard, valid and reliable way?	Was exposure measured in the same way for cases and controls?	Were confounding factors identified?	Were strategies to deal with confounding factors stated?	Were outcomes assessed in a standard, valid and reliable way for cases and controls?	Was the exposure period of interest long enough to be meaningful?	Was appropriate statistical analysis used?
Boggs 2018	✓	X	✓	UNCLEAR	UNCLEAR	✓	✓	✓	N/A	✓
Kalesan 2018	✓	X	✓	X	UNCLEAR	✓	✓	✓	N/A	✓
Shah 2000	✓	✓	✓	UNCLEAR	✓	✓	✓	✓	N/A	✓

✓: question's answer is yes
✗: question's answer is no
N/A: not applicable

3.5 Data synthesis

Comparison of mental disorders vs non-mental disorders on suicide by firearm

In 14 studies (100,299 decedents) involving 18 comparisons (Figure 2), having, as opposed to not having, a diagnosis of a mental disorder was significantly associated with lower odds of dying by suicide using a firearm mental disorder (OR: 0.50, 95% CI: 0.36 to 0.69; 95% PI: 0.12 to 1.99, I^2=100% (95% CI: 87 to 100)). Studies in this meta-analysis were seen to have varied effect sizes with estimate of small between-study variance ($\tau^2 = 0.41$; $\chi^2(21) = 3{,}998$; $p < .0001$). Sensitivity analysis removing the two case-control studies (Boggs et al., 2017; Kalesan et al., 2018a) did not alter the pooled effect (OR: 0.49, 0.34 to 0.70; [PI: 0.11, 2.10], I^2 =100% (84 to 100)).

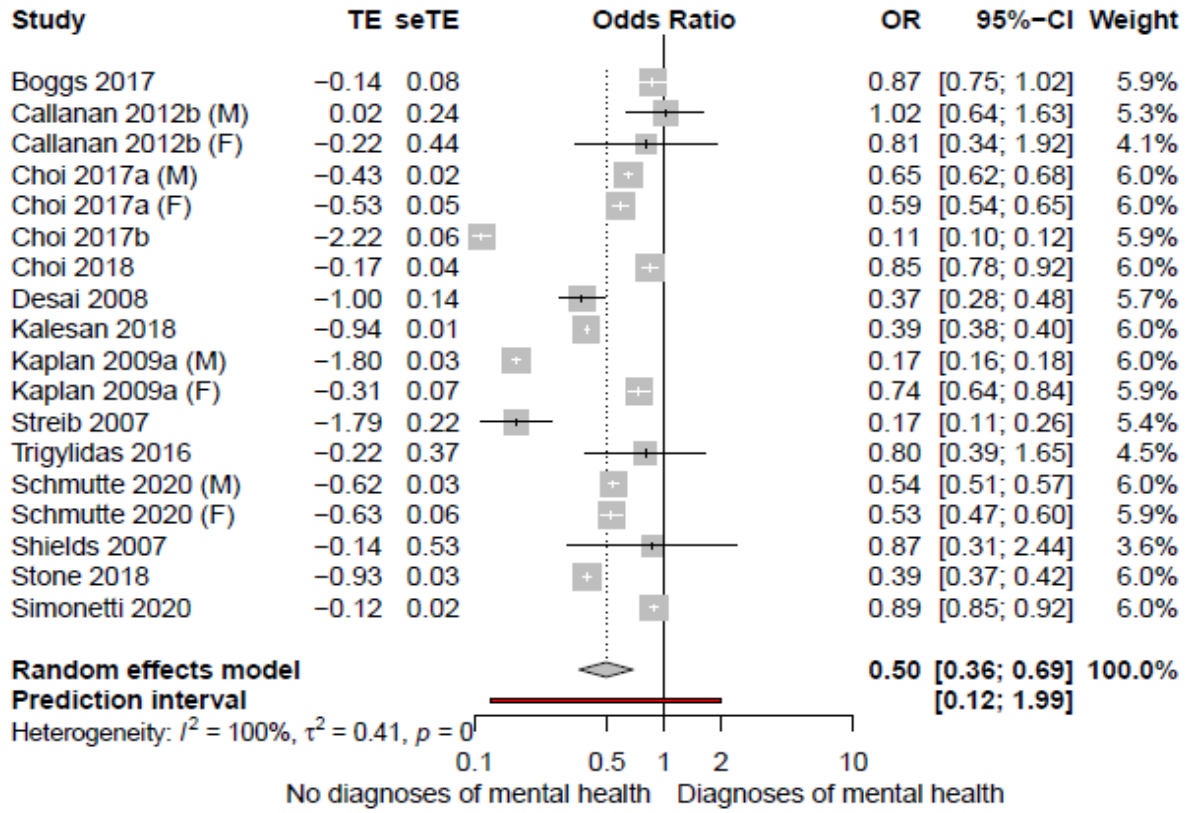

Figure 2. Forest Plot Meta-Analysis Comparing Cross-sectional Studies and One Case-control Study that Included Decedents without a Diagnosis of Mental Disorders to Decedents with a Diagnosis of any Mental Disorders on the Odds of Dying by Suicide by Firearm. Error Bars Represent 95% CI. ***(M): Men population; (F): Women population***

The subgroup meta-analysis comparing studies including decedents with any mental disorder to studies including decedents with a diagnosis of depression is presented in Figure 3. We included eleven studies (involving 14 comparisons, 100,299 decedents), ten of them cross-sectional and one case-control study. The information extracted from the case-control study is only from one of the groups (controls), which included decedents who died by firearm suicide, this way, we are using the data as if the study would be a cross-sectional study. In this subgroup analysis, there were significantly lower odds for suicide with a firearm in decedents with a diagnosis of any mental disorder compared with decedents without a diagnosis of any mental disorder (OR: 0.48, 95% CI: 0.32 to 0.72; I^2 =100%). In the five studies (7 comparisons) that included decedents with depression, those with a diagnosis of depression showed a statistically significant decreased in odds for death by suicide with a

firearm than those without a diagnosis of depression (OR: 0.52, 95% CI: 0.38 to 0.70, I^2 =100% (95 to 100)).

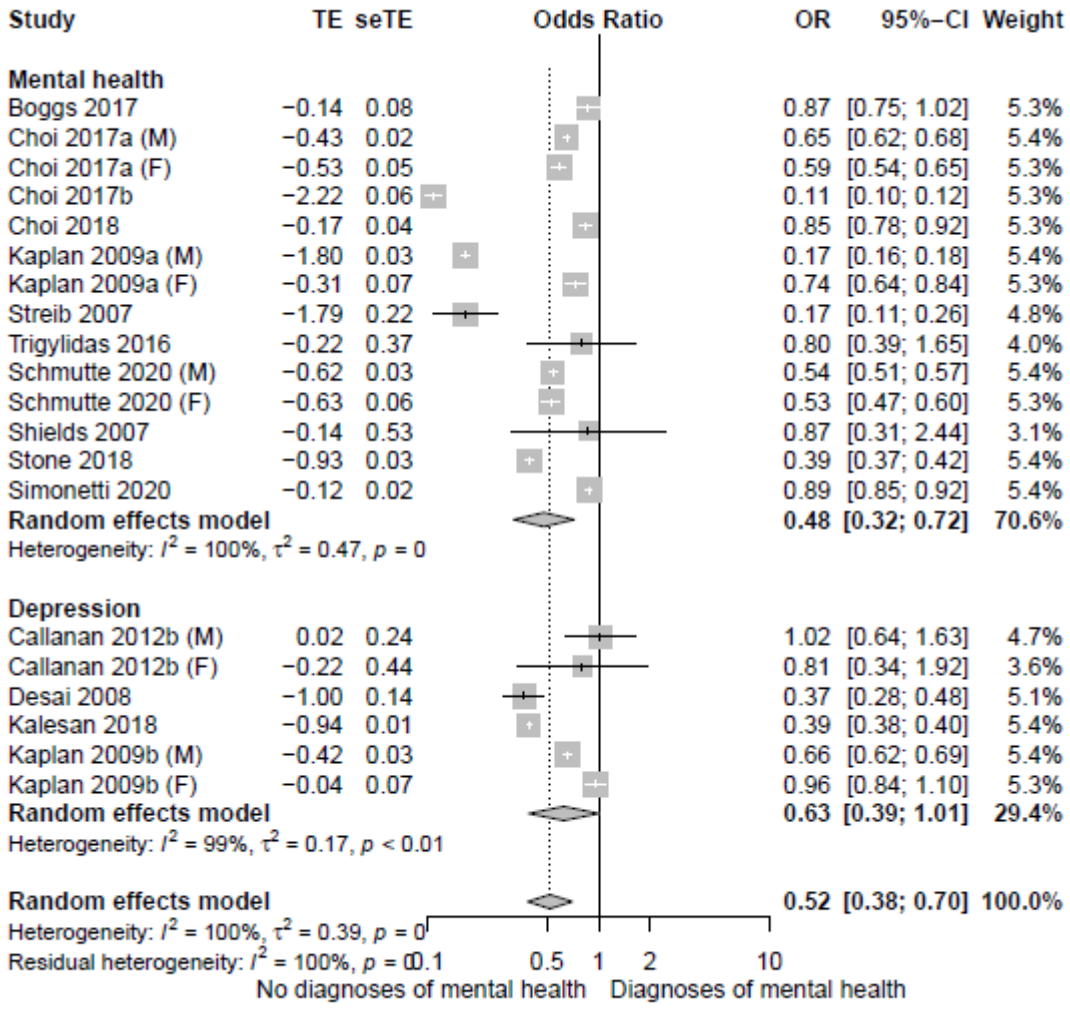

Figure 3. Forest Plot Showing a Subgroup Analysis Comparing Studies that Included Decedents with any Mental Disorders vs Non-mental Disorders on Suicide by Firearm and Decedents with a Diagnosis of Mental Disorder other than Depression vs those with Depression. Subgroup Analysis; M: Men population; F: Women population

The subgroup analysis with the five studies comparing men to women with, as opposed to without, a diagnosis of any mental disorder on the odds of dying by suicide with a firearm is provided in Figure 4. The results showed that studies including men with a diagnosis of any mental disorder did not have significantly lower odds of dying by suicide with a firearm than men without a diagnosis of any mental disorder (OR: 0.48, 95% CI: 0.20 to 1.12, I^2 = 100%). Women with a diagnosis of any mental disorder had a significantly lower odds of dying by

suicide with a firearm than women without a diagnosis of any mental disorder (OR: 0.62, 95% CI: 0.51 to 0.75, I^2=71% (26 to 89)).

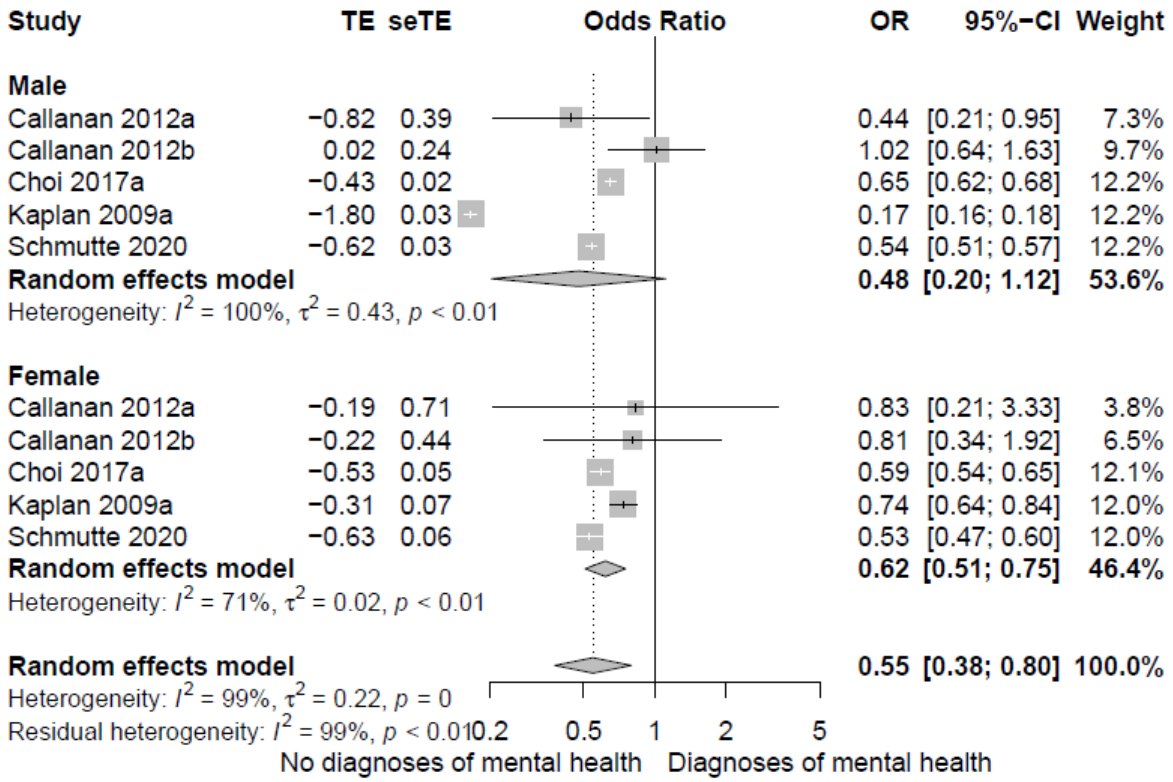

Figure 4. Forest Plot Showing a Subgroup Analysis Comparing Studies including Men vs. Women with or without a Diagnosis of Mental Disorder on suicide.

Comparison of suicide death due to firearms access against those with no access to firearms in decedents with a mental disorder

Decedents in six studies with a diagnosis of a mental disorder had on average significantly lower odds of dying by suicide by using a firearm than any other method (OR: 0.52, 95% CI: 0.30 to 0.91; [PI: 0.12 to 2.69]; I^2 = 99% (98.7 to 99.2), Figure 5). Studies in this meta-analysis did not share a common effect size and the true effect likely varied (τ^2 = 0.36; χ^2 (7) = 1108, p < 0.001).

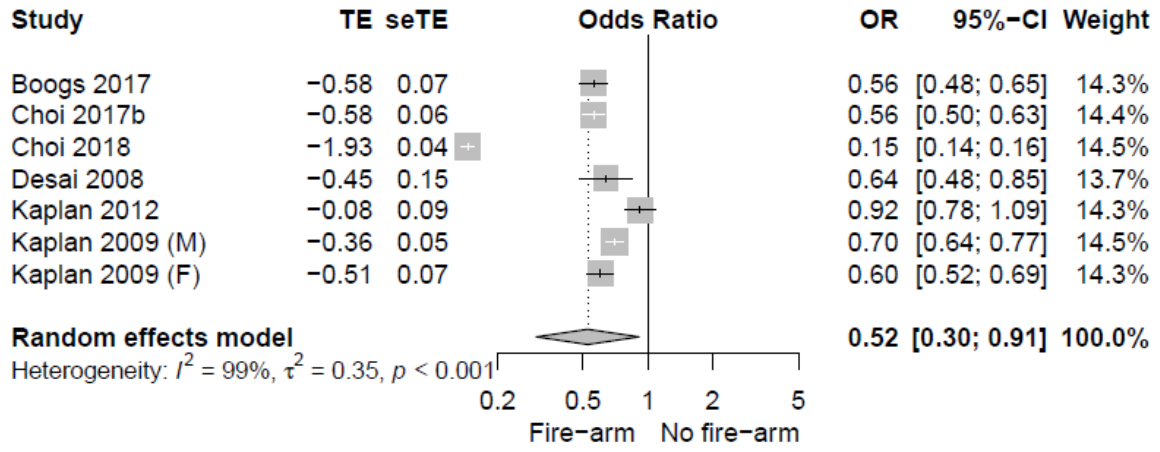

Figure 5. Forest Plot Showing Studies Comparing Suicides Using a Firearm vs. any other Method in Decedents with a Diagnosis of a Mental Disorder; *(M): Men population; (F): Women population*

Figure 6 shows the subgroup analysis comparing studies including decedents with any mental disorder to studies including decedents with a diagnosis of depression. In the four studies that included decedents with any mental disorder, decedents had on average a lower, but non-significant, odds of dying by suicide with a firearm than using any other method (OR: 0.45, 95% CI: 0.20 to 1.01; I^2 = 100%). In the three studies, including decedents with depression, decedents showed no significant change of suicide with a firearm or when using another weapon (OR: 0.78, 95 CI: 0.08 to 7.96, I^2 = 79% (37 to 92%)).

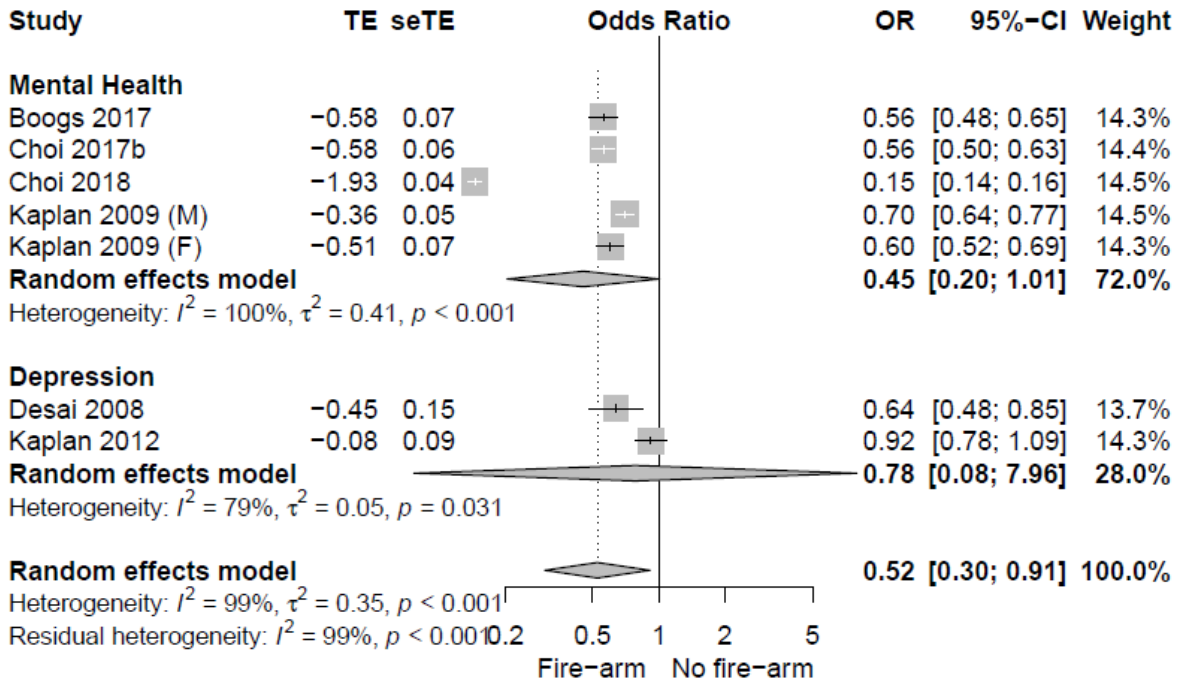

Figure 6. Forest Plot Showing Meta-Analysis of Firearm vs. Non-firearm Suicides on Decedents with a Diagnosis of Mental Disorder other than Depression vs those with Depression. Subgroup Analysis; *(M): Men population; (F): Women population*

In Figure 7, the subgroup analysis comparing men with any mental health diagnosis to women with any mental health diagnosis, showed no significant differences in the odds of dying by suicide by firearm vs. any other method among men (OR: 0.67; 95% CI: 0.43 to 1.04; I^2 = 49% (12 to 89)). However, there was a significant increase in odds of suicide by firearm among women (OR: 0.59; 95% CI: 0.54 to 0.65; I^2 = 0%).

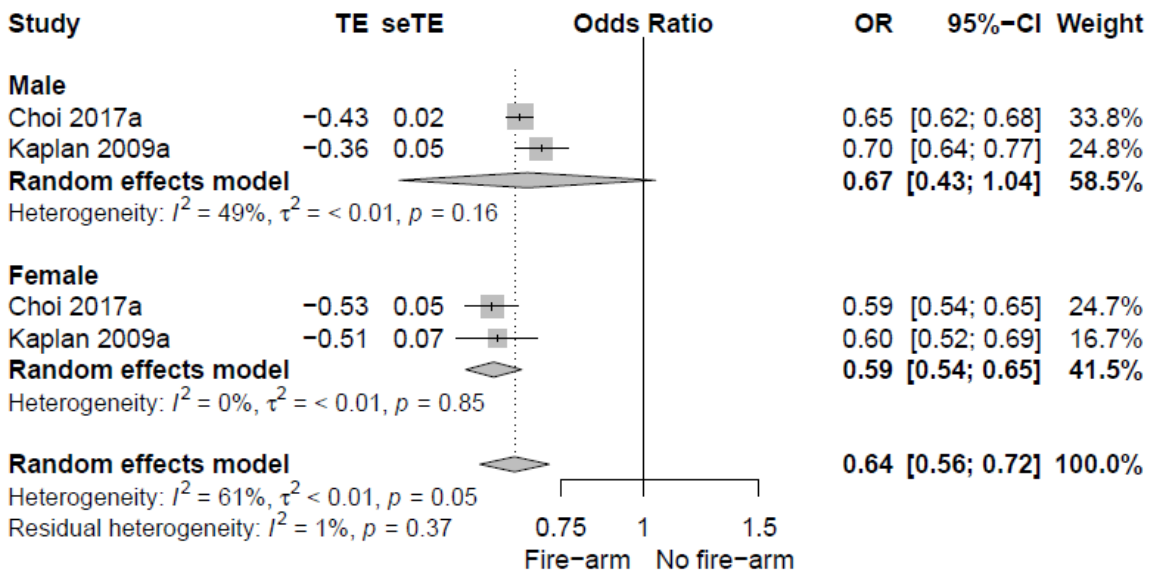

Figure 7. Forest Plot Showing Meta-Analysis Firearm vs. Non-firearm Suicides on Decedents with a Diagnosis of Mental Disorder. Subgroup Analysis Comparing Men and Women

Small-Study Effects

We assessed small-study effects by visual inspection of the funnel plot in Figure 8 using trim and fill method. The funnel plot revealed slight asymmetry, which suggests the presence of small-study effects. Egger's test, however, was not significant (p = 0.829).

3.4 Narrative results of individual studies

The primary outcome of this review was death by suicide with a firearm (Table 3 and 4; S6 S7 Appendix). There were 11 studies examining suicide by firearm as their only outcome (Boggs et al., 2017; Choi et al., 2017a; Desai et al., 2008; Hemenway and Miller, 2002; Joe et al., 2007; Kalesan et al., 2018a; Schnitzer et al., 2019; Shah et al., 2000b; Shields et al., 2007; Streib et al., 2007; Weinberger et al., 2000), 11 studies investigated firearm suicides, but they also included other suicide methods (Boggs et al., 2018; Callanan and Davis, 2012; Choi et al., 2017b ; Choi et al., 2018; Kaplan et al., 2012; Kaplan et al., 2009; Schmutte and Wilkinson, 2020; Shields et al., 2007; Simonetti et al., 2020; Stone et al., 2018; Trigylidas et al., 2016) such as hanging/suffocation and drug poisoning (Callanan and Davis, 2012; Choi et al., 2018; Stone et al., 2018) and blunt injury, jumping, laceration or/and drowning (these

papers did not specified where the injuries occurred or where the decedents were jumping into) (Choi et al., 2017b; Kaplan et al., 2012; Kaplan et al., 2009; Schmutte and Wilkinson, 2020; Shields et al., 2007; Simonetti et al., 2020; Trigylidas et al., 2016). One study did not specify what the other suicide methods were used by decedents other than firearms (Boggs et al., 2018).

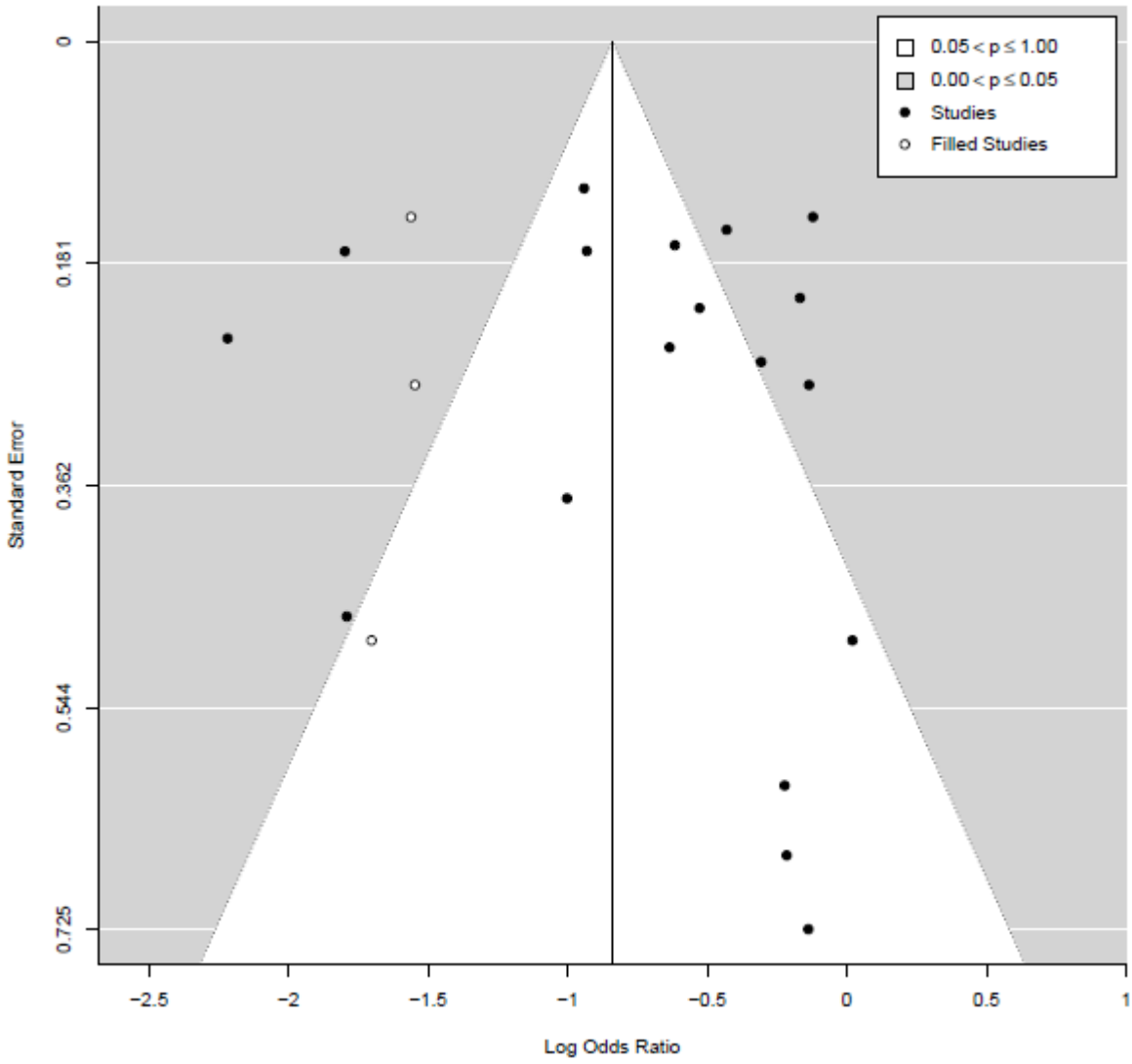

Figure 8. Trim and Fill Funnel Plot

Table 3. Cross-sectional Studies Investigating the Relationship Between Mental Disorders and the Risk of Suicide by Firearm						
Study	**Sample size (N); Age (mean); Sex (n, %)**	**Mood-base disorder**	**Non-mood-based disorder/ suicide attempt**	**Method of diagnosis/data collected from**	**Type of firearm (N or %)**	**Interpretation of results**
Boggs 2017	N=1,298, Overall*=2,674; Age=N/A Overall*Male=75.5% , Female=24.5%	Mental disorder	Suicide attempt	Medical records and claims information	N/A	No sig. difference in the odds of dying by suicide with a firearm between those with a mental health condition and substance abuse and those without
Callanan 2012	N=303, Overall*= 621; Age*=45 (no SD) Male*=249 (51.8%), Female*=54 (38.3%)	Depression, on psychiatric medication	N/A	Information obtained from interviews with law enforcement neighbors, friends, and health care providers	Long guns: Male= 22.4%, Female=11.3%; Handguns: Male=77.6%, Female=88.7%	The odds of using a firearm vs. other methods to die by suicide were significantly lower among men on psychiatric medication than among men not on psychiatric medication. No sig. difference in the odds of dying by suicide between women on psychiatric medications and women not on psychiatric medications
Choi 2018	N=4,190, Overall*N=12,401; Age=61.33 (0.15)[≠]; Female=100%	Mental disorder, depression, Bipolar disorder,	Schizophrenia, PTSD	National Violent Death Reporting System	N/A	The odds of using a firearm to die by suicide were significantly lower in decedents with a mental health condition relative to decedents without a mental health condition
Choi 2017a	Men: N 50–64 years=13,312, Overall*=22,460; Age=56.10 (0.03)[X] N 65+ years=11,383 Overall*=14,153 Age=75.56 (0.06)[X] Women: N 50–64 years=2,466 Overall*=7,473 Age=55.82 (0.05)[X] N 65+ years =1,085 Overall*2,771	Mental disorder	Suicide attempt	National Violent Death Reporting System	N/A	The odds of using a firearm vs. other methods to die by suicide were sig. lower in decedents with a mental health condition relative to decedents without a mental health condition

	Age=73.90 (0.14)[X]					
Choi 2017b	N=3,116, N overall*=7,489; Age=17.62 (0.04)[≠]; Male=2,765 (88.73%), Female= 351 (11.27%)	Mental disorder, depression	Suicide attempt	National Violent Death Reporting System	Handgun= 54.72%; Rifle= 18.7%; Shotgun= 17.72% Unknown= 8.72%	The odds of using a firearm to die by suicide were significantly lower in decedents with a mental health condition relatively to decedents without a mental health condition
Desai 2008	N=440, Overall*=1,057; Age range 18–29=23; 30–39=56; 40–49=193; 50–59=83; 60–69=47; 70+=38; Male=432 (42.44%), Female=8 (20.51%)	Bipolar depression, major depression	Schizophrenia, PTSD, Dual diagnosis	The Patient Treatment File: Veterans Affairs administrative database	N/A	The odds of using a firearm vs. other methods to die by suicide were higher in male decedents with PTSD relatively to male decedents without PTSD. The odds of using a firearm to die by suicide were significantly lower in decedents with major depression relatively to decedents without major depression
Hemenway 2002	N=N/A; Age=33.4 (no SD); N/A	Depression	N/A	Self-reported National Comorbidity Survey	N/A	No sig. correlation between firearm suicide and depression
Joe, 2007	N=977, Overall*=1616; Age range 18-34=30.6%; 35-64= 42.4%; 65+=26.9%; Men=86.9%, Women=13.1%	Use depression medication	N/A	Next-of-kin interview	N/A	The odds of using a firearm vs. other methods to die by suicide were sig. lower in decedents using medications for depression relative to decedents who did not use medications for depression
Kaplan 2012	N=N/A, Overall*=4,338; Age=65+; Men=100%	Mental disorder, depression	Suicide attempt	Interview family and friends	N/A	The odds of using a firearm vs. other methods to die by suicide were sig. lower in male decedents with a mental health condition relative to male decedents without a mental health condition
Kaplan 2009	N=13,294, Overall*=25,491; Male age range:18–34= 2,899; 35–44=2,054;	Mental disorder, depression	Suicide attempt	Proxy (not details provided by authors) and DSM-IV	N/A	The odds of using a firearm vs. other methods to die by suicide were sig. lower in decedents with a mental health condition relative to decedents without a mental health condition. The odds of using a firearm vs. other methods to die by suicide were sig. higher in female decedents with depression relative to female decedents without depression

	45–64=3,995; 65+ =2,605; Female age range:18–34= 382; 35–44= 390; 45–64= 758; 65+=210; Men=11,554, Women=1,740					
Price 2009	N/A	Mental disorder	N/A	DSM-IV (details not provided by authors)	N/A	Firearm suicide was sig. and positively associated with the prevalence of mental health conditions
Shields 2007	N=14, Overall*=2,864; Age=42.0 (11-96); Men=8, Women=6	N/A	Schizophrenia	Documented history of schizophrenia reported by the coroner	N/A	The most common method of suicide among decedents with schizophrenia was firearm.
Schmutte 2020	N=19,158, Overall*=26,884; Age*65–69=7,893; 70–74=6,055; 75-79=4,917; 80-84=4,091; ≥85=3,928 Men=17,449, Female=1,684	Mental disorder	N/A	National Violent Death Reporting System	N/A	The odds of using a firearm to die by suicide were significantly lower in decedents with a mental health condition relatively to decedents without a mental health condition
Schnitzer 2019	N=1,388; Age range=10-14=330;15-18=1,058; Men=1,175, Women=210 (3 cases gender missing**)	Mental health service, on medication	N/A	Not specified. Information taken from "Fatality Review-Case Reporting System"	Handgun=827; Other guns=481; Missing=80	The odds of using a firearm vs. other methods to die by suicide were sig. lower in decedents using medications for a mental health issue relative to decedents who did not use medications for a mental health issue.
Simonetti 2020	N=19,111, Overall*=27,741; Age*=62 (16)[X;] Men*= 26,883, Women*=858	Mental disorder	N/A	ICD-9 codes (codes were not specified by the authors)	N/A	The odds of using a firearm to die by suicide were significantly lower in decedents with a mental health condition relatively to decedents without a mental health condition

Stone 2018	N = 9,909 (48.5%), Overall*=20,446; Age*=46.72 (18.26)[X]; Men*=15,702 (76.8%), Women*=4,744 (23.2)	Mental disorder	N/A	DSM-V (details not provided by authors)	N/A	The odds of using a firearm vs. other methods to die by suicide were sig. lower in decedents with a mental health condition relative to decedents without a mental health condition
Streib 2007	N=200; Age=N/A; Male=168, Female=32	Mental disorder	Suicide attempt	Interview family, friends, neighbors, or physician	Handgun=72%; Shotguns=18%; Rifles=6%; Unknown=4%	Among both sexes, the odds of using a firearm to suicide were significantly lower among those with a mental health condition.
Trigylidas 2016	N=1.020, Overall*=2850 Age*=15.6 (no SD) Men*=2099 (73.6%) Women*=751 (26.4%)	Mental disorder	N/A	Child death Review case Reporting system	N/A	No sig. difference in suicides by firearm between decedents with a mental health condition and substance abuse and decedents without a mental health condition and substance abuse
Weinberger 2000	N = 50; Age=35 (8-78); Men=47 (94%), Women=3 (6%)	Mental disorder, depression, bipolar disorder	Depression and paranoia, drug-induced psychosis, drug abuse and depression	Medical report	Revolver=28; Semi-automatic=15; Rifle=5; Home-made device=1	Among decedents who died by suicide by firearm, 42% of decedents had a mental health condition

DSM-IV/V: Diagnostic and Statistical Manual of Mental Disorders, edition 4/5; ICD-9 codes: the official system of assigning codes to diagnoses and procedures associated with hospital utilization in the United States; MISA: mental illness and substance abuse; non-MISA: no mental illness nor substance abuse; N: number; PTSD: post-traumatic syndrome disorder

[X]: Standard deviation (SD)

≠: Standard error

*: include suicides by firearm and other means

** There were three suicide cases collected in this paper where the gender was not specified

N/A: not available

Table 4. Case-control Studies Investigating the Relationship Between Mental Disorders and the Risk of Suicide by Firearm						
Study	**Sample size (N); Age (mean); Sex (n, %)**	**Mood-base disorder**	**Non-mood-based disorder/ suicide attempt**	**Method of diagnosis/data collected from**	**Type of firearm (N or %)**	**Interpretation of results**
Boggs 2018	Cases N=1,298, Control N=129,800; Cases Age=53 (19.1)[X], Control Age=39.5 (22)[X]; Cases Male=1,158 (89%), Female =140 (11%), Control Male=61,665 (47%), Female=68,145 (53%)	Bipolar disorder, depression	Schizophrenia, anxiety disorder, dementia, other psychosis	ICD-9 codes	N/A	Compared with the control group, the odds of having a mental disorder were significantly larger for the other-means group compared with the firearm group.

Kalesan 2018	N=41,244; Age range less/equal 30=8,413 (20.4%); >30=32,781 (79.5%); Unknown=50 (0.1); Male=35,633 (86.4), Female=35,633 (86.4), Unknown=5 (0.01)	Mental disorder, depression	Disclosed intent of suicide	National Violent Death Reporting System	N/A	The odds of using a firearm vs. other methods to die by suicide were sig. lower in decedents with depression/mental health condition relative to decedents without depression/mental health condition
Shah 2000	Total Cases N=54, Cases died by suicide with firearm=36, Control=36; Age=15 (9-17); Men= 27(75%), Female= 9 (25%)	Mental disorder	Suicide attempt	Questionnaires to parent or guardian	Cases: Handgun=42%; Rifle=46%; Shotgun=4%; Unknown=8%	Comparing with the control, the odds of using a firearm vs. other methods to die by suicide were higher in decedents who ever been treated by mental health professionals or treated by mental health professionals, in the past year, were relative to decedents who were not.

SD: Standard deviation; N: number
*: Includes suicides by all means
[x]: Standard deviation
N/A: not available

4. Discussion

4.1 Summary of evidence

We explored whether mental health is associated with suicide using a firearm. There is evidence showing that individuals with mental health illness have higher odds of dying by suicide using a firearm than other means (Desai et al., 2008; Price et al., 2009; Shah et al., 2000b; Shields et al., 2007). There is also evidence linking mental disorders with a lower risk of dying by suicide using a firearm than using other means (Boggs et al., 2018; Callanan and Davis, 2012; Choi et al., 2017a; Choi et al., 2017b; Choi et al., 2018; Kaplan et al., 2012; Kaplan et al., 2009). To our knowledge, there are no systematic reviews synthesizing the available evidence exploring the link between mental health and suicide by firearm. Because of discrepancies in the literature and the lack of a systematic review in this field, we aimed to synthesize the available evidence in a systematic review.

4.2 Mental disorders vs no-mental disorders on suicide by firearm

Not having a diagnosis of a mental disorder (e.g., depression, bipolar disorder, schizophrenia, and PTSD) was, on average, associated a 55% higher likelihood of using a firearm when dying by suicide than having a mental disorder (Figure 2). The 95% PI showed the magnitude of this relationship varied across different settings. In some settings, this relationship was absent while in others, it ran in the opposite direction (Riley et al., 2011). This wide dispersion of effect sizes is likely to reflect substantial heterogeneity across the studies within this meta-analysis (Figure 2). Several factors may explain this variation in effect sizes including the type of mental disorder, age, or the sex of the decedents (Figure 2). For example, there is evidence suggesting that PTSD is linked with a higher risk of firearm suicide compared with other mental disorders such as depression or schizophrenia (Desai et al., 2008) and men are more likely to use a firearm in suicide (Callanan and Davis, 2012) and,

therefore, men also account for a higher number of deaths by suicide by firearm than women (Fowler et al., 2015).

To explore the observed wide dispersion of effect sizes (Figure 2), we performed a subgroup analysis by comparing studies that had recruited decedents with any mental disorder to studies that had recruited decedents with depression (Figure 3). Results showed similar results as the main meta-analysis (Figure 2), with decedents who had depression having lower odds of dying by suicide using a firearm than decedents who did not have depression (Figure 3). It is also possible that differences in the type of mental disorder might explain differences in the magnitude of effect sizes across different settings (Too et al., 2019). However, since studies did not always report the type of mental disorder, we could not assess whether other disorders such as PTSD or schizophrenia contributed to the observed heterogeneity (Higgins and Green, 2008). From these meta-analyses (Figure 2 and 3), we excluded two studies that did not report a formal diagnosis of a mental disorder among decedents but instead reported that decedents were under psychiatric medication (Joe et al., 2007; Schnitzer et al., 2019).

We also performed a subgroup analysis by comparing studies that included only men to studies that included only women on suicide by firearm. There was no between-subgroup difference between the odds of men and that of women in suicide by firearm. This indicates that the odds of firearm suicide among men was not different from the odds of firearm suicide among women. However, while we found no relationship between mental health and suicide by firearm among men, women without a diagnosis of any mental disorder had higher odds of dying by suicide using a firearm than women diagnosed with any mental disorder (Figure 4). This unexpected finding is not consistent with past literature suggesting that women usually select less lethal methods than men in suicide (Denning et al., 2000) but may use self-poisoning for suicidal acts (Callanan and Davis, 2012). Accessibility of suicide methods can impact the suicide occurrence (Elnour and Harrison, 2008). The restriction in the availability

of particular methods has been related to decreased method-specific suicide rates (Elnour and Harrison, 2008). Therefore, women with mental disorder may have more restrictions accessing firearms than women without mental health diagnoses (Sen and Panjamapirom, 2012).

Of note, the number of studies in most subgroups was small rendering the analysis likely underpowered and increasing the probability of a type I error (Christley, 2010). For example, in the subgroup analysis comparing men and women with and without a mental disorder,there were only five studies included. Give that subgroup analyses are only observational (Thompson and Higgins, 2002), we cannot assume that this relationship existed only among women. It is possible that decedents in the subgroup of studies including only women carried some factor (e.g., level of education, etc.) that increased the risk of dying by suicide in those without a mental disorder that was absent in the subgroup of studies, including men only (Thompson and Higgins, 2002). The explanation can also be related to other factors such as age, ethnic group, economic status or educational level that we could not explore in the subgroup analysis because our included studies did not report data on these demographic variables. In addition, subgroup analyses are by default observational and, therefore, cannot establish cause and effect (Thompson and Higgins, 2002).

We also found that studies investigating the relationship between previous suicide attempts and suicide by firearm found those who used a firearm in suicide were less likely to have had a prior suicide attempt (Boggs et al., 2017; Callanan and Davis, 2012; Choi et al., 2017a; Choi et al., 2017b; Kaplan et al., 2009). It may be that individuals who have attempted to die by suicide and who are not determined about ending their lives avoid using highly lethal methods, while individuals with greater intent on dying by suicide use more lethal methods such as firearms (Kaplan et al., 2009). A study concluded that those who had a prior suicide attempt were associated with a lower probability of firearm access (Ilgen et al., 2008) which

presumably may be because if a firearm had been available during the first attempt, these individuals might have died at that time. Other factors underlying the demographics of the included decedents may also explain the variation in effect sizes (Figure 2). For example, although suicide is the third leading cause of death in young adults between 15-24 years old (Cash and Bridge, 2009), the firearm-suicide rate is higher in adults over 50 years of age (Kalesan et al., 2018b). However, we could not explore this as the data on age was limited and poorly reported in the majority of studies.

Despite the evidence that most individuals seeking healthcare services in the year before suicide death, approximately half of these individuals did not have a psychiatric condition (Ahmedani et al., 2014). However, approximately 31% of the US population is diagnosed with a mental illness every year, but only a third of these individuals are treated (Kessler et al., 2005; Thornicroft, 2008). The high cost and insufficient insurance coverage, long waits as well as lack of awareness (not knowing where to go or being unsure where to find appropriate resources online), and social stigma about having a mental health condition may discourage a person from accessing mental health services (Wood et al., 2018). These barriers might contribute to categorizing decedents between those with an undiagnosed mental health condition as not having a mental health illness in primary research. These factors can in turn contribute to heterogeneity in meta-analyses (Higgins and Green, 2008).

4.3 Suicide by firearm vs other means

We pooled studies that investigated decedents diagnosed with mental health conditions who died by suicide with a firearm compared with those who died by suicide with other means (Figure 5). One group used firearms while the other group used other methods (e.g., hanging/suffocation, drug poisoning, blunt injury, or drowning). Results showed that suicide victims with mental health conditions had lower odds of dying by suicide with a firearm than

other means. A possible explanation for our results might be that people with mental disorders have less access or more obstacles to obtain firearms (Kaplan et al., 2009). Some states in the US, such as Indiana or Connecticut (Kivisto, 2018) which have background checks for both criminal history and mental illness tend to have lower firearm suicide rates than states which only implement criminal history checks(Sen and Panjamapirom, 2012; Sumner et al., 2008). Of note, some studies revealed that individuals with mental disorders were no more or less likely to have access to firearms than others without mental disorders (Ilgen et al., 2008; Swanson et al., 2015).

We excluded some studies from this meta-analysis because they did not specifically examine a consistent research question to the other studies in this meta-analysis(Boggs et al., 2018; Joe et al., 2007; Price et al., 2009; Schnitzer et al., 2019). For example, in two studies, authors did not use a valid measure of mental health diagnosis (Joe et al., 2007; Schnitzer et al., 2019). One of the studies concluded that mental health service or being on antidepressants reduced the chances of suicide by firearm (Joe et al., 2007). Another primary study found that an increased in the number of physicians who wrote prescriptions for psychotropic medications was associated with decreased rates of suicide by firearm, and that firearm suicide was positively associated with the prevalence of serious mental illness (Price et al., 2009).

Results from one meta-analysis (Figure 6) suggested that the odds of dying by suicide are similar regardless of the suicide method in decedents with depression. Likewise, some primary studies found that especially among older decedents those who died by firearms were less likely than the other decedents to have been identified as having depression (Choi et al., 2017a; Choi et al., 2018). A study found that among women, having depression was associated with higher odds of using a firearm in suicide than other means (Kaplan et al., 2009). The absence of differentiation by sex in our meta-analysis might explain the lack of

between-group difference in this meta-analysis. Whether sex plays a role in dying by suicide remains an issue of contention (Callanan and Davis, 2012). For example, one study found that firearms were the most common method of suicide among both sexes (Callanan and Davis, 2012) while another concluded that a firearm was the first method of choice by men but the second selected by women (Kposowa and McElvain, 2006). However, a recent meta-analysis showed mixed results on the relationship between sex and selection of suicide methods (Salk et al., 2017).

4.4 Small-study effects

Small-study effects occur when smaller studies sometimes show different, often larger, treatment effects than large studies (Sterne and Egger, 2001) and may threaten the validity of the results (Sutton et al., 2000). We conducted Egger's test to explore whether the small-study effect was present in any of our meta-analyses (Lin and Chu, 2018). In every meta-analysis, Egger's test was not statistically significant, suggesting that small-study effects were not present. One source of small study effects is publication bias, which is prevalent in psychology, social sciences (Ferguson and Heene, 2012; Franco et al., 2014) and, medicine (Onishi and Furukawa, 2014; van Aert et al., 2019). Consequently, there is reason to suggest that it is also likely to be present in the field of criminology (Rothstein, 2008). As such, given that publication bias is likely present in our meta-analyses, we need to interpret these results with caution.

4.5 Limitations

There are several limitations within the included studies. Most studies did not describe or employ a suitable method to measure mental health conditions (Boggs et al., 2017; Callanan and Davis, 2012; Choi et al., 2017b; Desai et al., 2008; Hemenway and Miller, 2002; Joe et al., 2007; Kaplan et al., 2012; Schmutte and Wilkinson, 2020; Schnitzer et al., 2019; Shields

et al., 2007; Stone et al., 2018; Streib et al., 2007; Weinberger et al., 2000), which limit the studies' external validity (Carlson and Morrison, 2009), and 77% (17/22) of these studies did not specify the type of mental health diagnosis. Decedents with different mental disorders were combined in the same analytic sample. This is a source of uncertainty because unclear whether the type of mental disorder, e.g., PTSD or bipolar disorder, may be differentially related to dying by suicide using a firearm. Also, a few studies used the *National Violent Death Reporting System* to obtain information on decedents' mental health (Choi et al., 2017a; Choi et al., 2017b; Kalesan et al., 2018a; Schmutte and Wilkinson, 2020). While this database is considered one of the most comprehensive sources of data on suicide in the US, the findings may not be generalizable to all US suicide decedents (Choi et al., 2017a; Choi et al., 2017b; Schmutte and Wilkinson, 2020) because during the period the studies were performed half of the states in the US did not provide data to the *National Violent Death Reporting System*.

Other studies collected decedents' mental health diagnosis from families during interviews (Callanan and Davis, 2012; Joe et al., 2007; Kaplan et al., 2012; Kaplan et al., 2009; Shah et al., 2000b; Streib et al., 2007). This method is confounded by recall bias (Grimes and Schulz, 2002). Some of the included cross-sectional studies also did not control for potential confounding factors, such as age, sex, or geographic location, which may limit the internal validity of the included studies (Boggs et al., 2017; Price et al., 2009; Shields et al., 2007; Weinberger et al., 2000). These factors are important because using a firearm as a suicide method may vary by age (Boggs et al., 2018; Choi et al., 2017a; Choi et al., 2017b ; Choi et al., 2018; Kaplan et al., 2012; Kaplan et al., 2009), sex (Boggs et al., 2018; Callanan and Davis, 2012; Choi et al., 2017b; Choi et al., 2018; Kaplan et al., 2012; Kaplan et al., 2009), and geographic region in the US (Choi et al., 2017a; Choi et al., 2017b; Choi et al., 2018; Hemenway and Miller, 2002; Kaplan et al., 2012; Kaplan et al., 2009). Studies did not

provide the typology of the firearm that was used by the decedents, which may be relevant in improving firearm regulations and develop programs and policies designed to reduce the accessibility of firearms (Grossman et al., 2005) as it would provide information about which firearms are used to inflict the greatest harm to oneself or others.

There are also limitations in this systematic review that need to be considered. Firstly, the number of studies included in each meta-analysis is relatively small; standard random-effects meta-analysis methods perform poorly when applied to few studies (Seide et al., 2019). Therefore, whether the estimates are close to the true value is questionable. Second, we included observational studies, which cannot establish cause and effect (Boyko, 2013). The included observational studies may not have accounted for unknown variables that affect the result as they do not have the advantage of random assignment (Boyko, 2013) and may overestimate the effect size due to participants' heterogeneity or they may contain biases that are intrinsic to their design (Muriel et al., 2012).

It is also worth mentioning one of the main challenges in this field, which is the absence of standard psychiatric biomarkers in clinical practice (García-Gutiérrez et al., 2020) such as suicidality risk (Costanza et al., 2014). Psychological autopsies are used to determine the cause of suicide and provide clearer insights into the process of suicide (Isometsä, 2001). This method has shown that around 90% of suicide decedents had a mental disorder prior to suicide (Cavanagh et al., 2003) but several authors have criticized this method by arguing that there is insufficient evidence on the reliability and validity of this method (Hjelmeland and Knizek, 2017; Pouliot and De Leo, 2006) and that the available evidence to support the validity of psychological autopsies is weak (Hjelmeland and Knizek, 2017). As such, standardization of psychological autopsies is recommended (Pouliot and De Leo, 2006).

4.6 Strengths

To our knowledge, this is the first systematic review exploring the relationship between mental disorders and suicides by firearm in which studies were pooled together in a meta-analysis providing a more precise outcome estimate. We also were able to conduct subgroup analyses on type of mental disorder that add new information to the primary studies, allowing us to explore the heterogeneity of the results. This review also provides new evidence-based data, which can help to develop future policies and guidelines.

4.7 Suggestions for future research

Following the results from our risk of bias assessment (Table 1 and Table 2), future studies investigating the link between any mental disorder and risk of dying by suicide by firearm should consider applying reliable and standard diagnostic methods to gather the information (e.g., ICD-10 or DSM-V) for diagnosing decedents' mental disorders and specify the type of mental disorder they are examining. Future research should also consider collecting information on age (provide mean age and related standard deviation, not just the age range), sex, geographical region, ethnicity, and substance misuse, which have been linked to suicide by firearm (Balis and Postolache, 2008; Branas et al., 2016a; Callanan and Davis, 2012; Kaplan and Geling, 1999) to comprehensively describe decedents' demographics. This information will be useful for exploring which demographic factor may be responsible for the possible presence of heterogeneity in the observed effect sizes in future meta-analyses (IntHout et al., 2016).

4.8 Implications

Future preventive strategies focusing on the relationship between mental health and suicide, should also explore other approaches advising to reduce access to the most lethal substances in overdose (such as opioids) and resources used for suffocation (for example, ropes), which

may reduce the suicide rate among people with mental problems dying by methods other than a firearm (Boggs et al., 2018).

In addition, there is a need to increase and improve access to and the quality of mental healthcare in the US (Power et al., 2005) and reduce the stigma associated with mental disorders. A study looking at health care access in the year before suicide death found that the most common healthcare visits were to medical specialty and primary care settings where mental health diagnosis did not occur (Ahmedani et al., 2014). It is also mentionable that some individuals who think about suicide do not directly seek mental health care services (Hom et al., 2015). In addition, self-guided digital interventions are a novel preventive approach that offers the opportunity to reach individuals who do not access conventional health care services (Torok et al., 2020). Gun violence and suicide could be addressed from a population-wide approach (Kaplan and Mueller-Williams, 2019). For example, introducing federal regulations directed to decreasing firearm prevalence would be useful in preventing firearm suicide at the population level (Kaplan and Mueller-Williams, 2019).

Because there is no consensus over the causes of gun violence, including suicide by firearm, and that multiple biopsychosocial factors likely play a role in exacerbating it, policies created to tackle the problem are controversial (Smith and Spiegler, 2020). For example, some groups propose policies to limit the access to firearms, while others propose to improve access to mental health services (Smith and Spiegler, 2020). Researchers involved in exploring the link between firearms and injuries are more likely to report limited funding, political pressure, and concerns about harassment than researchers working in other fields like motor vehicle injury (Donnelly et al., 2020). Although there are still gaps in our knowledge about associations between mental disorders and firearm-suicide, our findings may encourage future researchers to continue working towards exploring the factors that contribute to suicide by firearm.

4.9 Conclusion

The objective of this systematic review was to determine whether mental disorders are linked to dying by suicide by firearm. While at face value our results suggest that having a mental disorder may not be consistently associated with the odds of dying by suicide using a firearm, in reality, the substantial heterogeneity and high risk of bias precludes any conclusions. Therefore, further research in this field is needed, particularly in studies focused on investigating this link among specific mental disorders and improving the measurement of the exposure. The findings of such work would better advise disclosure and evaluation of those at higher risk and allow suitable therapeutic and suicide preventive interventions to be established.

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S1 Appendix. PRISMA checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	0
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, decedents, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	2-3
Objectives	4	Provide an explicit statement of questions being addressed with reference to decedents, interventions, comparisons, outcomes, and study design (PICOS).	3-4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4

Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4-5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	S2 Appendix
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	S6 S7 Appendix
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	6
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	6
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	7

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	6
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	n/a
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	8
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	8-10
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	10-11
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	13,22-27
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	14-21
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	34
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	n/a
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	28-33
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	34-36

Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	36-39
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	n/a

S2 Appendix. Search strategy

age OR sex OR gender OR impulsivity OR impulsive-aggressive OR “mental health” OR “mental illness” OR “mood disorder” OR “personality disorder” OR psychosis OR “psychotic episode” OR “post-traumatic stress disorder” OR PTSD OR “personality disorders” OR “psychotic disorders” OR depression OR stress OR schizophrenia OR anxiety OR “generali$ed anxiety disorder” OR GAD OR “attention deficit hyperactivity disorder” OR ADHD OR panic OR “panic disorder” OR “bipolar disorder” OR incarceration OR imprisonment OR gang OR “gang affiliation” OR “gang membership” OR “gang involvement” OR alcohol OR drug OR “illegal drugs” OR “illicit drug” OR “drug abuse” OR “drug use” OR “drug misuse” OR “socioeconomic status” OR poverty OR “relative poverty” OR “intelligence quotient” OR IQ OR intellect OR cognition OR perceptions OR beliefs OR “cognitive function” OR “cognitive performance” OR “education level” OR religion OR “political climate” OR racism OR “racial tension” OR discrimination OR “risk factor” OR “protective factor” OR “urban county” OR “rural county” OR metropolitan OR urban OR urbani$ation OR countryside OR “background checks” [Tittle and abstract])
AND
(“bump stock” OR “firearm ownership” OR “gun show” OR “gun convention” OR gun OR firearm OR pistol OR rifle OR automatic OR semi-automatic OR AR-15 OR “assault rifle” OR “gun control” OR “gun law” [Tittle and abstract])
AND
((suicide OR suicidal OR “suicide ideation” OR “suicide attempt” OR “self$harm” OR “gun violence” OR attack OR shooting OR “school shooting” OR “mass shooting” OR “mass murder” OR “unintentional shooting” OR “defensive use” OR “officer involved incident” OR “home invasion” OR “firearm violence” OR “firearm control” OR homicide

OR “first degree murder” OR “second degree murder” OR manslaughter OR assassination OR murder OR killing OR lethal OR crime OR injury OR disability OR wound OR “gun$shot wound” OR GSW OR hospital OR “hospital admission” OR “non$fatal firearm injury” [Limit: Tittle and abstract]
Limit: English and articles

S3 Appendix. Study selection initial protocol	
Inclusion criteria	Exclusion criteria
1. All ages 2. Men and women 3. Studies involving gun violence: homicide, suicide and injury 4. All types of observational studies 5. Qualitative and quantitative studies 6. All types of intervention studies (randomised and non-randomised) 7. Studies with other weapons (e.g. knives) as long as they include firearms/guns 8. Terrorism-related gun violence 9. Grey literature (i.e. non-peer reviewed theses, dissertations, unpublished studies)	1. Studies involving animals (e.g. hunting) 2. Studies involving war/militarily related gun violence 3. Studies without firearms 4. Studies with other weapons only 5. Studies without a homicide, suicide, interpersonal violence, fatal/non-fatal injury as outcomes 6. Papers written in a language other than English 7. Editorials, letters, books, book chapters, opinion papers, blogs, case studies 8. Reviews of papers (incl. literature, systematic and meta-analyses)

S4 Appendix. Firearms: definitions

Long guns: “a handheld firearm with a long barrel, as a rifle” (Dictionary, 2012)
Handguns: “any firearm that can be held and fired with one hand; a revolver or a pistol” (Dictionary, 2012)
Revolver: “handgun having a revolving chambered cylinder for holding a number of cartridges” (Dictionary, 2012)
Rifle: “a shoulder firearm with spiral grooves cut in the inner surface of the gun barrel to give the bullet a rotatory motion and thus a more precise trajectory” (Dictionary, 2012)
Semiautomatic: “a self-loading rifle or other firearm” (Dictionary, 2012)
Shotgun: “a smoothbore gun for firing small shots to kill birds and small quadrupeds” (Choi, DiNitto, & Marti, 2017; Dictionary, 2012; Shah, Hoffman, Wake & Marine, 2000; Streib et al., 2007)

S5 Appendix. Mental disorders, suicide attempt and suicidal thoughts: definitions

Depression: defined by ICD-10 as "depressed mood, loss of interest and enjoyment, and reduced energy leading to increased fatiguability and diminished activity" (WHO, 1993).
Dysthymia: known as "a chronic depression of mood which does not currently fulfil the criteria for recurrent depressive disorder, mild or moderate severity" (WHO, 1993).
Bipolar disorder: "is characterized by repeated (i.e. at least two) episodes in which the patient's mood and activity levels are significantly disturbed, this disturbance consisting on some occasions of an elevation of mood and increased energy and activity (mania or hypomania), and on others of a lowering of mood and decreased energy and activity (depression)" (WHO, 1993).
Bipolar depression: "the current episode must fulfil the criteria for a severe depressive episode without psychotic symptoms and (b)there must have been at least one hypomanic, manic, or mixed affective episode in the past" (WHO, 1993).
PTSD: defined as "a delayed and/or protracted response to a stressful event or situation (either short- or long-lasting) of an exceptionally threatening or catastrophic nature, which is likely to cause pervasive distress in almost anyone (e.g. natural or man-made disaster, combat, serious accident, witnessing the violent death of others, or being the victim of torture, terrorism, rape, or other crime)" (WHO, 1993).
Schizophrenia: ICD-10 guidelines states that "the schizophrenic disorders are characterized in general by fundamental and characteristic distortions of thinking and perception, and by inappropriate or blunted affect" (WHO, 1993).
Dementia: "is a syndrome due to disease of the brain, usually of a chronic or progressive nature, in which there is disturbance of multiple higher cortical functions, including memory, thinking, orientation, comprehension, calculation, learning capacity, language, and judgement"(WHO, 1993).
Dual diagnosis: "is the term used to designate the co-occurrence of an addictive disorder and at least one other mental health disorder, independently" (Torales et al., 2019).
Paranoia: "involves intense anxious or fearful feelings and thoughts often related to persecution, threat, or conspiracy. It occurs in many mental disorders but is most often present in psychotic disorders" (America, 2015).
Psychosis: "The word psychosis is used to describe conditions that affect the mind, where there has been some loss of contact with reality" (America, 2015).

S6 Appendix. Systematic review. Cross-sectional study results

Study	Results from firearms suicide
Boggs 2017	**Risk factors associated firearm suicide** Mental health or substance use condition Yes(n)= 627 No(n)= 671 Previous suicide attempt Yes (n)= 109 No (n)=1,189
Callanan 2012	**Risk factors associated suicide by firearm among mental health vs non mental health** History of depression Male OR= 1.020 (0.638-1.629) / $p<0.10$ Female OR= 0.806 (0.339-1.915) Z score=-1.060 Psychiatric medication Male OR= 0.442 (0.213-0.999) / $p< 0.05$ Female OR= 0.829 (0.206-3.328) / Z score= -0.412 / $p\geq 0.05$ Prior attempts Male OR= 0.586 (0.312-1.099) Female OR= 0.138 (0.915-0.915) Z score= 1.380 / $p\geq 0.1$ **Risk factors associated suicide by firearms vs other means** History of depression OR= 0.945 (0.631-1.415) Psychiatric medication OR= 0.546 (0.292-1.023)
Choi 2018	**Risk factors associated with firearm suicide**: Mental health problems Yes(n)=2,007/4,190 No(n)= 2,183/4,190 Depression/dysthymia Yes(n)= 1,637/4,190 No(n)= 2,553/4,190 Bipolar disorder Yes(n)= 216/4,190 No(n)= 3,974/4,190 Schizophrenia Yes(n)= 52/4,190 No(n)= 4,138/4,190 PTSD Yes(n)= 15/4,190 No(n)= 4,175/4,190 **Risk factors associated with firearm suicide vs other means** Mental health problem: OR= 0.15 (0.14-0.16)
Choi, 2017a	**Risk factors associated with firearm suicide** Mental health problem

	Men AOR= 0.65 / 95%CI= 0.62-0.68/ *p*<0.001 Women AOR= 0.59 / 95%CI= 0.54-0.65/ *p*<0.001 Prior suicide attempt Men AOR= 0.38/ 95% CI= 0.36-0.42/ *p*<0.001 Women AOR= 0.53 / 95%CI= 0.48-0.60/ *p*<0.001
Choi, 2017b	**Risk factors associated with firearm suicide vs other means** Mental health problem AOR= 0.56 (0.50-0.63) / *p*<0.001 Male AOR= 0.59 (0.52-0.67) / *p*<0.001 Female AOR= 0.39 (0.29-0.52) / *p*<0.001 Recent depressed mood AOR= 1.00 (0.89-1.11) Male AOR= 0.97 (0.85-1.09) Female AOR= 1.18 (0.89-1.59) Recent suicide attempt or disclosure of suicide intent AOR= 0.72 (0.65-0.81) N= 7489 / *p*< 0.001. Male AOR= 0.70 (0.62-0.80) / *p*< 0.001 Female AOR= 0.83 (0.63-1.10) **Risk factors associated with firearm suicide** Mental health problem Yes(n)= 773/3,116 No(n)**=** 2,343/3,116 Recent depressed mood **Yes=** 914/3,116 **No=** 2,202/3,116
Desai 2008	**Risk factors associated with firearm suicide vs other means** Schizophrenia Firearm(n)= 210 /324 Other means(n)= 114 /324 Bipolar depression Firearm(n)= 136/221 Other means(n)= 85/221 Major depression Firearm(n)= 208/374 Other means(n)= 166/374 PTSD Firearm(n)= 117/253 Other mean(n)s= 136/253 **Risk factors associated with firearm suicide** Schizophrenia Yes(n)= 114/440 No(n)= 326/440 Bipolar depression Yes(n)= 85/440 No(n)= 355/440 Major depression Yes(n)= 166/440 No(n)= 274/440 PTSD Yes(n)= 136/440

	No(n)= 304/440
Hemenway 2002	**Correlation coefficient in firearm suicide** Major depression= -0.18 Suicidal thoughts= 0.39
Joe 2007	**Use depression medication: YES** Firearm= 153 (15.7%) / Non-firearm= 143 (23.3%) **Use depression medication: NO** Firearm= 824 (84.3%) / Non-firearm= 490 (76.7%) ($\chi 2 = 8.93$, df = 1, $p < .003$)
Kaplan 2012	**Risk factors associated with firearm vs other means** <u>Ever treated for a mental health problem</u> AOR= 0.43/ 95%CI (0.36–0.51)/ $p < .001$. <u>Diagnosed with a mental health problem</u> AOR= 0.45/ 95%CI (0.38–0.53)/ $p < .001$. <u>Current treatment for a mental health problem</u> AOR= 0.43/ 95%CI (0.36–0.51)/ $p < .001$. <u>Current depressed mood</u> AOR= 0.92/ 95%CI (0.78–1.09) <u>Disclosed intent to die of suicide</u> AOR= 0.99 (0.82-1.19) / p=N/A <u>Previous nonfatal suicidal behaviour</u> AOR= 0.31 (0.24-0.41) / $p< .001$
Kaplan 2009	**Risk factors associated with firearm vs other means** <u>Depressed mood</u> Male OR= 1.03 (0.94-1.13) Female OR= 1.20 (1.05-1.38)/ $p<0.05$ <u>Diagnosis and treatment</u> Male OR= 0.70 (0.64-0.77) / $p<0.05$ Female OR= 0.60 (0.52-0,69) / $p<0.05$ <u>Previous suicide attempts</u> Male OR= 0.38 (0.34-0.42) / $p<0.05$ Female OR= 0.62 (0.54-0.72) / $p<0.05$ <u>Disclosed intent to complete suicide</u> Male OR= 1.00 (0.91-1.10) Female OR= 1.13(0.98-1.31) **Risk factors associated with firearm suicide** <u>Depressed mood</u> Male: Yes(n)= 2,765/11,554 No(n)= 6,384/ 11,554 Female: Yes(n)= 862/1,740 No(n)= 878/1,740 <u>Diagnosis and treatment</u> Male: Yes(n)= 5,170/11,554 No=(n) 8,789/11,554 Female: Yes(n)= 720/ 1,740 No(n)= 1,020/1,740
Price 2009	**Risk factors associated with firearm suicide** <u>Serious mental illness</u> *Pearson r* = 0.40 / $p<0.01$ <u>Psychotropic medication</u> *Pearson r* = -0.52 / $p<0.01$
Schmutte 2020	**Risk factors associated with firearm suicide**: <u>Mental health vs non mental health</u> Male OR= 0.54 (0.50,- 0.57) / $p <0.001$

	Female OR= 0.53 (0.47-, 0.60) / *p* <0.001
Schnitzer 2019	**Risk factors associated with firearm suicide**: Currently receiving mental health services? Yes(n)= 184/1,388 No(n)= 558/1,388 Child on meds for mental health issue? Yes(n)= 152/1,388 No(n)= 602/1,388 Previous suicide attempt or threat about suicide Yes(n)= 494/1,388 No(n)= 894/1,388
Shields 2007	**Risk factors associated with firearm suicide** Schizophrenia(n)= 14/29 No schizophrenia(n)= 15/29
Simonetti 2020	**Risk factors associated with firearm suicide**: MH(n)= 9,265 /19,111 No MH(n)= 9,846/ 19,111
Stone 2018	**Risk factors associated with firearm suicide** Mental health Yes(n)= 3,821/9,909 No(n)= 6,088/9,909 OR 1.8 (1.7–1.9) / *p <0.01*
Streib 2007	**Risk factors associated with firearm suicide** Mental disorders Yes(n)= 58/200 No(n)= 142/200
Trigylidas 2016	**Risk factors associated with firearm suicide** Mental Health versus non-Mental Health: OR 0.8 (0.4- 1.7) / *p*=0.5
Weinberger 2000	**Psychological risk factors related with suicide** (n, %,) Mental illness Yes(n)= 21 (42%) / Missing data(n)= 29 (66%) Medical or Psychological Treatment disorder Yes(n)= 11 (22%)/ Missing data(n)= 39 (78%) Suicide attempts Yes(n)= 4 (8%)/ No(n)= 14 (28%)/ Missing data(n)= 32 (64%)

S7 Appendix. Systematic review. Case-Control study results

Study	Results from firearms suicide
Boggs 2018	**Risk factors associated with firearm vs other means among cases** Any psychiatric disorder 55.39%/ OR 5.51/ 95%CI (4.92-6.16) / *p*<0.01 Anxiety disorder 21.96%/ OR 6.53 / 95%CI (5.68–7.50) / *p*<0.01 Bipolar disorder 4.01%/ OR 8.04 / 95%CI (5.97–10.83) / *p*<0.01 Dementia 2.31%/ OR 2.20 / 95%CI (1.50–3.29) / *p*<0.01 Depression 35.13%/ OR 7.29/ 95%CI (6.46–8.23) / *p*<0.01 Other psychosis 2.62%/ OR 5.49/ 95%CI (3.79–7.96) / *p*<0.01 Schizophrenia 1.31%/ OR 9.82/ 95%CI 5.82–16.56 / *p*<0.01
Kalesan 2018	**Risk factors associated with firearm suicide**: Depression/mental health issue: Yes(n)= 15,856 (38.4%) /41,244 No(n)= 25,388 (61.6%) /41,244 Disclosed intent of suicide: Yes(n)= 10,911 (26.5%) /41,244 No(n)= 30,333 (73,5%) /41,244
Shah 2000	Comparison of Suicide Risk Factors Between Firearm Suicides and Controls; Ever been treated by mental health professional Cases(n)= 17 (47%) Controls(n)= 7 (19%) *p*=0.01/ Crude OR=6.00/ 95%CI= (1.34-26.81) Treated by mental health professional in past year Cases(n)= 12 (33%) Controls(n)= 3 (8%) *p*=0.01/ Crude OR=4.00/ 95%CI= (1.13-14.17) Ever been hospitalized for mental health problems Cases(n)= 4 (11%) Controls(n)= 0 *p*=0.11 Ever attempted suicide Cases(n)= 3 (8%) Controls(n)= 1 (3%) N=36 *p*= 0.61