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Estimating the association between mental health disorders and suicide: a review of common sources of bias and challenges and opportunities for US-based research

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Abstract

Purpose of review: The purpose of this review is to 1) illuminate prevalent methodological approaches and estimates of association between mental health diagnoses and suicide from the meta-analytic literature; 2) discuss key internal and external validity concerns with these estimates; and 3) highlight some of the unique attributes and challenges in US-based suicide research and opportunities to move the evidence base forward.

Recent findings: Globally, there is considerable variability in measures of association between mental health disorders and suicide and a growing debate over methodological approaches to this research. A high suicide incidence makes the US an outlier, and the decentralized nature of US administrative data poses a unique challenge to data linkage that could otherwise advance this research.

Summary: We offer methodological considerations for future research and discuss opportunities made possible by the recent expansion of the US National Violent Death Reporting System to a nationwide registry.

Keywords

suicide; mental health disorder; validity; generalizability

Introduction

Suicide is a leading cause of death internationally and within the United States (US). While global suicide mortality trends have declined over the last several years,(1) the US suicide rate increased 35% between 1999 and 2018, from 10.5 to 14.2 deaths per 100,000 population.(2) Suicide is now the 10th leading cause of death in the US, accounting for 48,344 deaths in 2018.(3)

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Acknowledging this concerning trend, in 2012 the US Surgeon General released a National Strategy for Suicide Prevention Plan, which advocated for a comprehensive approach to suicide prevention involving both community and clinical action.(4) The Plan highlighted the widespread consensus that mental health disorders (MHDs), including mood disorders, anxiety disorders, borderline personality disorder, schizophrenia, and substance use disorders (SUD), are leading risk factors for suicide and suicidal behavior.(4)

The MHD-suicide association is widely assumed to be established and strong. Perhaps as a result, many publications in this area adopt a seemingly relaxed approach to the methods used to estimate the MHD-suicide association in the literature, with little attention to study specifics (e.g., populations studied, exposure definitions) and variability in magnitudes of associations. For example, it is quite common to find an introductory paragraph in suicide-related studies citing one eye-catching finding that 90% of suicide decedents had a diagnosable MHD, despite the literature's wide variability in estimates and debate generated by this statistic.(5–10)

While estimate variability is not automatically a research shortcoming, it becomes problematic when 1) estimates are biased due to internal validity issues or 2) consumers of research attempt to generalize findings that may hold in certain populations, contexts, and circumstances and not others (e.g., external validity issues). Therefore, as researchers and practitioners develop and discuss suicide prevention interventions and policies, it is critical to have a clear understanding of the population characteristics, design assumptions, analytic methodologies, and potential biases underlying the estimates utilized. As such, the purpose of this review is to 1) illuminate some of the prevalent methodological approaches and estimates of association between MHDs and suicide, as captured in the meta-analytic literature, and 2) discuss key internal and external validity concerns with these estimates. Moreover, because the US has an increasing suicide trend characterized by unique risk factors, like firearm ownership and availability, we 3) also highlight some of the unique attributes and challenges in US-based suicide research and opportunities to move the evidence base forward.

Mental health disorders and suicide: findings from the meta-analytic literature

Many meta-analyses have examined the relationship between MHDs and suicide or suicidal behavior (Table 1). While these studies have contributed considerably to the field, they also illuminate some key limitations in the evidence base.

In an early example, Harris et al. (1997) reported standardized mortality ratios (SMRs) for suicide based on 249 studies from a range of countries dating back to the 1950s, with the majority published in the 1980s and 1990s.(11) This study appears regularly in suicide-related literature, with over 3,000 citations. Despite its landmark status, the lack of specificity in methods exemplifies common deficiencies in this literature. In explaining the inclusion and exclusion criteria for the study, the authors state that they selected papers with "defined disorders" without giving a clear source of the definitions. While it appears that these disorders are likely based on International Classification of Disease, version 9 (ICD-9-

CM) codes, the ICD-9-CM codes utilized by individual investigators may not have been consistent across studies and information is lacking on when the patients were diagnosed or the setting of diagnosis. Although the authors suggest that they only included longitudinal designs, more specific information on the study populations and the rigor of the study designs is warranted. Without this synthesized information, it is difficult to form an impression of which patients are at highest risk or how these associations have trended over time and populations.

Meta-analyses and reviews published since Harris et al. (1997) have generally focused on the associations between specific MHDs, SUDs, and other conditions and suicide, often with highly divergent results.(12) Chesney et al. (2014) reviewed 20 such meta-analyses and published results for many MHDs and SUDs, along with a score reflecting the rigor of the publication in question (Table 1). Unfortunately, Chesney fails to distinguish between analyses of secondary (e.g., specialist) vs. primary care or general population samples, though suicide risks and associations may be quite different across these populations.(13) For example, in another meta-analysis, this one examining MHD prevalence among suicide victims, Bertolote et al. (2004) reported that among those who suicided, the risk of a mood disorder was *higher* in general population samples than in studies of psychiatric inpatients (44.4% vs. 20.8%).(14) This was also true of SUDs (19.2% vs 9.8%) but not of anxiety/somatoform disorders (2.7% vs 2.5%).(14) While attention to study population sources in this analysis is thorough, the authors included studies with extremely diverse methods of MHD ascertainment, which might also explain some of the population-level variability in their findings.(14)

Another common limitation of these meta-analyses is that they reflect data almost exclusively from “Western,” industrialized countries. Too et al. (2019) acknowledged evidence suggesting that MHD-suicide associations may be different in Asian countries, and further found that in their meta-analysis of mostly Scandinavian countries, the study location accounted for a great deal of the heterogeneity in effect estimates.(15) This underscores the importance of context in interpreting these estimates. In the following sections, we delve more deeply into these issues, highlighting common internal and external validity considerations in the MHD and suicide literature.

Internal validity concerns

Internal validity refers to the amount of systematic error in a study’s effect estimate(s). Estimates that have little or no systematic error are described as internally valid. There are three general categories of systematic error that can reduce a study’s internal validity: confounding, selection bias, and measurement or misclassification bias.(16) Below, we highlight key concerns prevalent in the MHD-suicide literature within each of these general categories.

Confounding control

Confounding occurs when effects of extraneous factors are blended with the actual effect of the exposure.(16) There are a number of factors that can and do get blended when attempting to estimate the effect of MHDs on suicide, and these factors can be illuminated

using Directed Acyclic Graphs (DAGs).(17, 18) DAGs are graphs that make explicit researchers' assumptions about relationships between the outcome, exposure, and covariates.

Figure 1 illustrates a possible DAG for the causal relationship between MHD and suicide, which is informed by scientific findings and underlying suicide theory—the Stress-Diathesis Model is a popular theory that explains suicide as the result of an interaction between 1) distal factors and personal vulnerabilities and 2) proximal stressors from life events.(19, 20) While DAGs, like the example in Figure 1, can and should be shaped by the best available evidence and theory, even when they illuminate a minimally sufficient set of factors that should be accounted for in the study design or analyses in order to remove bias, measurement of such factors (e.g., "personality traits") might be very difficult or impossible to achieve on a population scale. Despite these limitations, DAGs support analysts in pinpointing and addressing known, measured confounders (e.g., by adjusting for them in a statistical model); in thinking through potential quantitative bias analyses for unmeasured confounders; and in helping identify mediators (e.g., factors on a causal pathway between the exposure and outcome) that if included in the model, could induce bias. In the DAG in Figure 1, "history of self-harm" and "history of suicide attempts" are considered mediators.

Unfortunately, to date, suicide models generally have not taken advantage of the abundant theory regarding causal pathways between MHDs and suicide. This may be due to at least two reasons: unfamiliarity with robust causal inference methods, such as DAGs, and/or an inability to adjust for a minimally sufficient set of factors because they are not measured in the data sources most commonly used, such as administrative data. Instead, it is the norm for MHD-suicide studies to report SMRs that adjust estimates to reflect solely the age and gender distribution of some broader population of interest and to ignore other confounders, such as socioeconomic status, race, or comorbidities.(12) This common reliance on age/sex-adjusted SMRs has hindered the research community's conversation on confounding control. Moreover, the lack of causal inference theory underlying much of this research may make it more likely for mediators to be considered appropriate members of the adjustment set.(21) While inherent restrictions exist by data source, a much greater degree of attention needs to be paid to the topic of robust confounding control and causal inference in MHD-suicide research in order to inform future data collection, estimation approaches, and quantitative bias analyses meant to address the issue of residual confounding.

Selection bias

Selection bias occurs when the exposure-outcome relationship for a population under study differs from the population that should have been eligible for the study. It results from selecting the study population based on factors related to the exposure and/or outcome and can create a distortion in effect estimates.(16) Many MHD-suicide studies rely on diagnosis codes in health insurance administrative data and medical records to measure both the exposure and outcome. These may be problematic for many reasons. For example, in the US, where health insurance is largely privatized, different populations may have different levels of consistency in their health care coverage and utilization, which means some persons are more likely to be diagnosed (and therefore selected into the study) than others. Additionally, because suicidal behaviors and nonfatal suicide injuries are more likely to

trigger a medical visit, the outcome can also increase the chance of selection in some studies. This differential selection according to exposure and outcome is commonly referred to as Berkson's bias.(22) Tools are available to assess the magnitude of such bias,(16) and researchers should carefully consider how the population they are including in their study might differ from the population they are trying to make inferences about.

Measurement bias or misclassification

Measurement of the exposure and outcome can be a third challenge to internal validity in estimating the effect of MHDs on suicide. Below, we highlight some common sources of exposure and outcome misclassification in this research.

Exposure measurement—As noted above, diagnosis codes are an extremely common means of assessing MHDs and suicidal behaviors; however, in addition to the role they can play in selection bias, researchers should also evaluate their potential measurement bias. First, healthcare providers can be subject to social desirability bias and stigma surrounding MHDs and at times may not be willing to "label" a patient with a MHD, leading to under ascertainment of exposure in diagnosis codes. Second, for those with a diagnosable MHD, patients' records are not always linked across providers, so a diagnosis such as a MHD, which is often treated in an outpatient setting, may not be present in hospital or primary care records. In this scenario, combining claims with medical records may address some of the missingness in MHD exposure. However, even in this case, because diagnoses are not associated with reimbursement, providers are poorly incentivized to be accurate and specific in their claims documentation. Finally, not all diagnosed illnesses are associated with a claim.

Another likely source of measurement error arises from the use of psychological autopsy (PA) methods for ascertaining MHD history. PA involves conducting interviews with a "proxy" (e.g., next of kin) following a death and is an extremely common study design in suicide research.(8) Several PA meta-analyses have been conducted (Table 1). The PA approach was first developed to assist medical examiners and coroners in their work and was never standardized for research purposes. It is vulnerable to inconsistencies and biases, including inconsistent numbers and types of proxies, lack of standardized proxy interview tools, and a lack of consensus on the source of controls (living or dead) for decedent suicide cases.(8) Recall bias, including bias introduced by interviewing people close to the recently deceased, has not been fully evaluated in these studies, and the time lapse between the death and interviews is often inconsistent or lengthy.(8, 13) The PA approach was used by Cavanah et al. (2003) to support the previously discussed (and debated) claim that 90% of people who suicide had a diagnosable MHD.(5) In a critique of the PA approach, Hjelmeland et al. (2012) question the reliability and validity of the approach, calling for the use of other, more systematic approaches for interviewing a high number of key informants around each suicide and taking into account the relationship with the deceased during data collection and analysis stages.(10)

Finally, exposure misclassification may be more common for specific types of suicide, such as firearm-related suicides. Studies show that individuals with easy access to highly lethal

means are more likely to suffer a fatal outcome in the event of a suicide attempt. For example, research indicates that firearm owners are at increased risk of suicide,(23–27) often attributed to the fact that firearms are extremely lethal (85% of people who attempt suicide with a firearm die).(28) On average, very little time lapses between the decision to self-inflict lethal force and the act of suicide and time may be even shorter for those with access to highly lethal means. Boggs et al. (2018), using a linkage between US medical records and death records, found that out of 35 MHD and general medicine diagnoses thought to be predictive of suicide, 32 were more predictive of non-firearm suicide than firearm suicide (Table 1).(29) However, this could be a function of opportunities for accurate exposure measurement and, therefore, potential exposure misclassification. Because the time from onset of suicide ideation until death may be shorter among those using firearms, there may be a shorter window of time for these individuals to be seen by health professionals and diagnosed with MHD-related conditions. In a population like the US, where about half of suicides are by firearm, the effects of MHDs on suicide may, therefore, look different than in a country with a different distribution of methods used.

Outcome measurement—The outcome of suicide also may be prone to misclassification for several reasons. First, there may not be enough evidence to determine intent of death (e.g., unintentional overdose vs. suicide by overdose).(30) Second, deaths may be misclassified due to social desirability bias because suicide is stigmatized, and officials may rule them accidental or of undetermined intent to avoid causing embarrassment or financial penalty to family members. Third, officials may be less likely to classify the death as a suicide if the decedent does not fit the typical race and gender profile. The likelihood for suicide among minorities to be classified as “undetermined” is well-documented.(31)

External validity concerns

In addition to internal validity concerns, there are a number of external validity concerns that researchers and practitioners should note when trying to apply or “transport” study findings from one context to another. External validity refers to the generalizability of a study to the population of interest. The population of interest may be clinic-based, hospital-based, health systems-based, or geographically-based.

The presence of national health registries and more lenient policies surrounding personal health information in European countries often allow for study designs and results that are applicable to larger populations, such as an entire nation.(15, 21, 32–39) In comparison, investigators in countries like the US, which lack similar national health registries, tend to focus on subpopulations, such as the military or members of a common health insurance plan. Relatedly, the majority of suicide research appears to take place in European countries. For instance, in Berotlote et al.’s (2004) international meta-analysis, 45% of the suicide deaths came from the United Kingdom, and an additional 26% were contributed by Denmark.(14) As is commonly observed in meta-analyses on this topic, the US contributed just 4% of deaths.

However, as noted earlier, effect estimates of the association between MHDs and suicide vary considerably by population, highlighting the importance of context-specific studies and

inferences, as opposed to smoothing over estimates from heterogeneous populations. Connor et al. (2019), demonstrated that major depression was much more predictive of suicide in Asia than in Western regions, while SUDs were less predictive (Table 1).(40) With that in mind, we agree with Rothman that, taken too far, “the pursuit of representativeness can defeat the goal of validly identifying causal relationships.”(16) Thus, some balance must be achieved between these two tensions, and researchers should consider that a small well-defined population with strong internal validity may be of more use than an estimate of effect for a larger population but with little confounding control.

United States-based research challenges

The US faces several distinct challenges in its suicide research and prevention efforts, given its unique firearm culture and fragmented data structures. The increasing rate of suicide in this country is likely attributable to a confluence of factors and could benefit from a larger body of rigorous research. We highlight key characteristics and challenges of US suicide-related research and follow with a discussion of promising paths forward.

Recent suicide research from the US is summarized in a review by Steele et al. (2018)(41), which underscores that US studies frequently focus on suicide risk factors for very specific populations (e.g., youth,(42–44) people of advanced age,(45, 46) prisoners,(47) veterans,(48–54) patients with specific diagnoses,(55) twins,(56) patients who otherwise screen as high risk for suicide(57–61), or Medicaid beneficiaries(58, 59, 62, 63)). Because national registries do not exist and the capacity to link data is often limited, much US research has targeted such smaller, high risk populations. Sources such as schools, prisons, the Veterans’ Health Administration, medical records, and senior care programs facilitate easier study population sampling and data collection than studies of the general population. As a result, relatively few US studies reflect the general population. However, the US suicide rate is increasing among a diverse range of demographic groups, not just these specialized populations.(64) Thus, there is a critical need for studies that assess relationships between MHDs and other risk factors and suicide in a wider swath of the population.

Another characteristic of US suicide research is a focus on risk factors for suicidal behavior (e.g., suicidal ideation, attempts, plans), as opposed to suicide itself. Again, this reflects the available data: while probabilistic linkages between medical records or claims data and death data certainly exist,(44, 58, 59, 63, 65–67) they do not approach the scope or detail available in other countries.(21, 34, 37) Meanwhile, US resources such as the National Comorbidity Survey(68–71) and The National Epidemiologic Survey on Alcohol and Related Conditions(72) offer nationally representative survey data but investigate non-fatal outcomes.

While US suicide-related research is generally typified by studies of smaller, specific populations and risk factors for suicidal behaviors, there are a few notable exceptions of larger, population-based suicide studies. The Southern Community Cohort Study was a longitudinal prospective study from 2002–2009 of 85,000 low income Black and White American patients in the Southeast and between the ages of 40–79 years.(73) In this sample, patients who reported that they had been diagnosed with or treated for depression had a

hazard ratio for suicide of 3.05 (95% confidence interval (CI): 1.70, 5.48) compared to those who had not. Unfortunately, other MHDs were not assessed, and given depression assessment procedures, measurement of depression may have been subject to recall bias (Table 1).

The Mental Health Research Network is a more recent example of the potential for large, longitudinal, civilian data linkages in the US.(74) Using 2,674 suicides cases and 100 matched controls per case in eight health care systems,(75) the authors estimated associations between different healthcare settings and suicide based on the timing, number of visits, and history of MHD or SUD diagnoses. Results indicated an increased odds of suicide in every sub-category; for example, the adjusted odds of suicide within one week of being discharged from the hospital with a SUD diagnosis was 103.68 (95% CI: 66.38, 161.92) times the odds of suicide among outpatients who did not have an SUD.(75) While these examples constitute important suicide research efforts in the US, predictors of suicide are still vastly understudied, relative to the considerable public health burden of suicide.

Data linkage studies utilizing the National Violent Death Reporting System: A promising path forward

The National Violent Death Reporting System (NVDRS) is a unique US surveillance system with linkage potential that offers an opportunity to substantially strengthen the suicide-related evidence base. The NVDRS was developed by the US Centers for Disease Control and Prevention (CDC) in 2002, beginning with 6 states (Massachusetts, Maryland, New Jersey, Oregon, South Carolina, and Virginia).(76) It gradually expanded to include all 50 states, Puerto Rico, and the District of Columbia by 2018. The purpose of the system is to integrate detailed proximal death information on violent deaths, including suicide, homicide, deaths caused by law enforcement, deaths of undetermined intent, and unintentional firearm deaths in order to inform prevention efforts. For these deaths, death certificates, law enforcement reports, medical examiner reports, and toxicology reports are collected and linked, and detailed data from each of these sources is mined by state-level abstractors.

Linkages to NVDRS data offer the potential to overcome several of the biases discussed previously. Because it offers general population surveillance data, there is the potential to link NVDRS to general population controls from other surveillance systems (such as statewide hospital discharge data), which may reduce selection bias while affording sufficient power to evaluate for heterogeneity of effects. The rigorous data design instituted by NVDRS make this resource robust to outcome misclassification; however, for some exposures and confounders (i.e., those based on police statements collected from living associates), this resource is likely subject to the same bias introduced by PA studies.

Studies have linked health data to state VDRS data sources to more fully capture risk factors and trajectories leading to violent deaths, like suicides (Table 2). One Oregon study linked VDRS records on 112 veterans who suicided in 2000–2005 to Veteran's Health Administration records in order to better understand health contacts in the year prior to death.(65) Rather than diagnoses, the researchers searched for screenings for depression, SUD, post-traumatic stress disorder, or suicidal ideation. They found that 68% of veterans

were screened for depression and 81% for a SUD in the year prior to death. The authors also described health care utilization before the suicide, noting that almost half had a mental health-related contact and 55% were seen in a primary care setting in the year prior to death, revealing potentially important opportunities for intervention. In another notable example, Weis et al. (2006) linked South Carolina VDRS data to state hospital inpatient and emergency room billing records, as well as State Department of Mental Health data and criminal justice data.(66) Key findings indicated that 57% of suicide victims were hospitalized or had an emergency department visit, and 19% were seen by the Department of Mental Health in the year prior to death. As a final example, a study using Kentucky's VDRS linked to statewide emergency department visit data (2008–2010) described events leading up to the suicide and estimated the impact of critical risk factors, like MHDs, on suicide.(77) Results indicated that the odds of suicide among those with MHDs was 1.93 (95% CI: 1.52, 2.45) times the odds of suicide among those without MHDs.

In sum, these examples demonstrate the feasibility of linking state-level VDRS data to health data. In doing so, they have provided a template, including linkage variables and approaches for "fuzzy" linkages, which can be replicated in future studies. However, one limitation of these studies is that they generally have not made use of the rich circumstantial information that VDRS provides surrounding suicides. VDRS data captures (in many cases) the decedent's recent struggles, mental state, and conflicts prior to death. While this PA-like data come with limitations, these data could be leveraged strategically to flesh out or validate health care backgrounds provided through linkage. Presumably, similar circumstantial information could be collected from controls, or a selection of controls, in order to provide comparisons that could yield a more internally valid measure of association.

Conclusions

Suicide is a leading cause of death around the world, with increasing rates in the US. This likely stems from the US's firearm culture, which has contributed to high availability of this extremely lethal option. In addition to ease of access to lethal force means, MHDs have long been recognized as key risk factors in the global setting. However, estimates of association between MHDs and suicide have typically been generated by studies situated in other countries. Moreover, many of these studies suffer from a variety of internal validity issues, including inappropriate confounding control, selection bias concerns, and potential exposure and outcome mismeasurement. This is due in part to limitations in population-level data resources globally and particularly in the US.

The NVDRS holds considerable potential for US-based research, offering the potential for larger study populations and more complete variable measurement and corresponding confounding control, particularly when linked with other large health-related databases (e.g., Medicaid, Medicare, medical records, etc.). Understanding unbiased, context-specific relationships between MHDs and death by suicide can help researchers and practitioners identify and appropriately customize interventions for populations at greatest risk.

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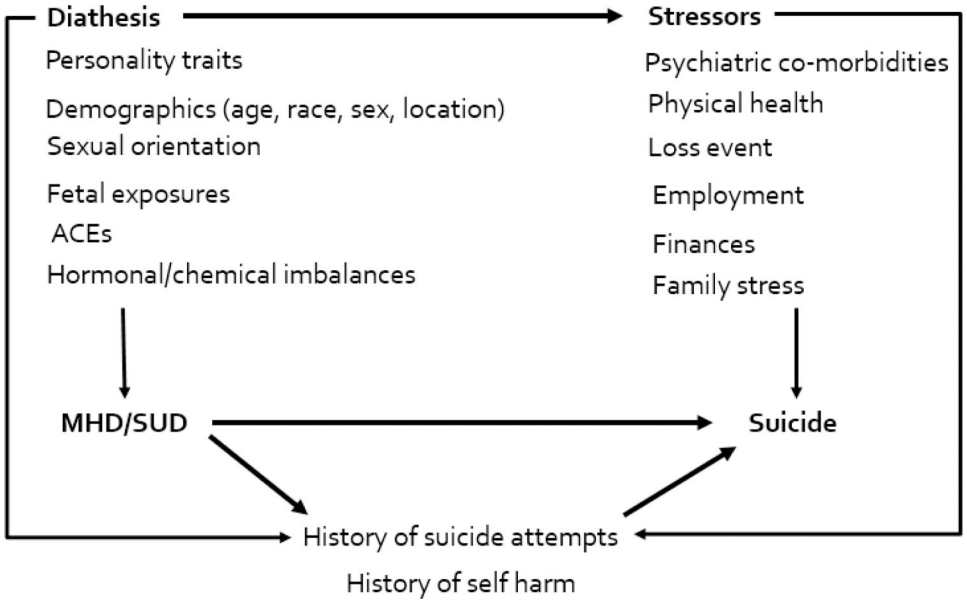

Figure 1.

Example Directed Acyclic Graph (DAG) depicting potential causal and biasing pathways between mental health and substance use disorders and suicide

ACEs=Adverse Childhood Experiences; MHD=Mental Health Disorder; SUD=Substance Use Diagnosis

Table 1.

Select meta-analyses and large cohort studies examining associations between mental health and substance use disorders and suicide

Source	Study design	Inclusion criteria	Exposure	Measure of Association (95% CI)	Effect Measure
Meta-analyses					
Harris et al. 1997 (11)	International Meta-analysis **249 studies**	• Cohort must have a defined disorder with two years of follow up • Less than 10% lost to follow up • Published observed suicide number and expected number, or sufficient information to estimate the expected number	Major depression	20.35 (18.27, 22.58)	SMR
			Opioid use	14.00 (10.79, 17.88)	
			Any SUD	5.47 (5.41, 6.09)	
			Anxiety neurosis	6.29 (5.33, 7.38)	
			OCD	11.54 (2.38, 33.72)	
			Panic disorder	10.00 (4.57, 18.98)	
Chesney et al. 2014 (12)	International Meta-review **20 studies**	• Included the most recent meta-analysis or review, or if not available then the most recent large (N>1000) study reporting risks for suicide	Depression	19.7 (12.2, 32.0)	SMR
			Opioid use	13.5 (10.5, 17.2)	
			Anxiety disorders	3.3 (2.1, 5.3)	OR
Too et al. 2019 (15)	International Meta-analysis of linkage studies **13 studies**	• Comparisons of individuals with and without mental disorders based on a general population sample	Mood disorders	12.3 (8.9, 17.1)	IRR
			SUDs	4.4 (2.9, 6.8)	
			Anxiety disorders	4.1 (2.4, 6.9)	
Conner et al. 2019 (40)	Meta-analysis: Psychological autopsies **35 studies**	• Living or dead controls • Descriptive data on mood disorders and/or alcohol or drug use disorders • In-person proxy interviews using a diagnostic instrument • Controls can be interviewed or a proxy can be interviewed for controls • Must include all suicides in a population or an age, sex, and/or location subgroup	Major depression	26.87 (15.58, 46.36)	OR
			Asia Europe North America	7.95 (3.30, 19.16) 7.68 (2.60, 22.70)	
			SUDs		
			Asia Europe North America	3.35 (2.00, 5.61) 6.54 (3.76, 11.39) 3.97 (1.99, 7.90)	
Large Cohort Studies					

Source	Study design	Inclusion criteria	Exposure	Measure of Association (95% CI)	Effect Measure
Mortensen et al. 2000 (21)	Retrospective longitudinal record linkage case-control study (1980–1994)	• Population: Danish psychiatric inpatients • 811 cases, 79,871 controls • Exposure ascertainment: Psychiatric diagnosis (ICD-9) at most recent inpatient discharge from the Danish Psychiatric Central Register	Reactive psychosis	1.80 (1.28, 2.53)	IRR
			Drug abuse	1.08 (0.82, 1.42)	
			Other psychiatric disorder	1 (reference)	
Sonderman et al. 2014 (73)	Prospective longitudinal cohort survey-based study (2002–2009)	• Population: Black and White residents in Southeastern US • N=85,000 • Exposure ascertainment: “Has a doctor ever told you that you have depression or have you been treated for depression?”	Depression	3.05 (1.70, 5.48)	HR
Boggs et al. 2018 (29)	Retrospective longitudinal health-systems-based case-control study (2010–2013)	• Population: 8 US health systems (Mental Health Research Network) • 2,674 cases (1,298 firearm cases), 267,400 controls • Exposure ascertainment: ICD-9 codes within the previous 12 months of suicide for cases and matched index date for controls	Any psychiatric disorder		OR
			Firearm Other	5.51 (4.92, 6.14) 9.04 (8.06, 10.15)	
			Anxiety disorder	6.53 (5.68, 7.50)	
			Firearm Other	7.74 (6.84, 8.75)	
			Depression		
			Firearm Other	7.29 (6.46, 8.23) 12.28 (10.96, 13.74)	

OR=odds ratio; SMR=standardized mortality ratio; IRR=incidence rate ratio; SUD=substance use disorder; OCD=obsessive compulsive disorder

Table 2.

Studies involving linkage with state Violent Death Reporting System data

Source	Linked databases	Sample	What VDRS added	Findings
Denneson et al. 2010 (65)	Oregon VDRS to Veterans Integrated Service Network 20 Data Warehouse	All veterans aged ≥18 who suicided in Oregon between 2000–2005 who had health care-related contact with a Department of Veterans Affairs Medical Center in the 12 months before death n=112	Patient identifiers (name, DOB, DOD, last 4 of SSN), cause of death, veteran status, sex, race-ethnicity, education, marital status	• 63% had ≥1 primary care contact, 48% had ≥1 VA mental health-related contact in the year before death • 68% were screened for depression, and 41% for SI in year before death • Median number of days between last contact and death = 42 (range 0–358) • The majority who were screened denied SI
Basham et al. 2011(53)	Oregon VDRS to Veterans Integrated Service Network 20 Data Warehouse	All veterans aged ≥18 who suicided in Oregon between 2000–2005 n=968	Patient identifiers (name, DOB, DOD, last 4 of SSN), cause of death, veteran status, sex, race-ethnicity, education, marital status	• 21.9% had any type of VA encounter • Of the patients with a psychiatric inpatient stay, 38.7% had their suicide within 30 days of discharge • 48% of decedents were prescribed antidepressants within 12 month of death
Weis et al. 2006 (66)	South Carolina VDRS to South Carolina Data Warehouse: inpatient and outpatient charges, Department of Mental Health records, and arrest data	All South Carolina suicide decedents in 2004 n=491	Patient identifiers, law enforcement and coroner narratives (used to validate criminal history)	• 57.4% had a hospital or emergency room discharge in 2003 or 2004, with an average of 3 visits per person • 24.8% had a suicide attempt in 2003 or 2004 • 47.5% of the suicide attempt encounters were firearm-related • 16.7% died within 30 days of the final hospital encounter • Median number of days between last contact and death = 110 (many patients had more than 12 months of records linked) • 91 decedents had a median of 8 (range 1–1800+) visits with the Department of Mental Health, where depression was the most common diagnosis
Cerel et al. 2016 (77)	Kentucky VDRS to Kentucky Outpatient Services Claims Files	All Kentucky homicide (n=569) and suicide (n=1,599) decedents from 2008–2010 + ED controls (4/case)	Patient identifiers	• 10.7% of suicide decedents visited an ED in the 6 weeks prior to death • 22% of suicides occurred within 2 days of an ED visit • 9.9% of suicides had a self-injury code within 6 weeks of death • The odds of suicide among those with a mental disorder diagnosis was 1.93 (95% CI 1.52, 2.45) times the odds in those without a mental disorder diagnosis

VDRS=Violent Death Reporting System; DOB=date of birth; DOD=date of death; SSN=social security number; VA=Veterans Administration; SI=suicidal ideation; ED=emergency department; CI=confidence interval