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Original Contribution

Posttraumatic Stress Disorder and Completed Suicide

Jaimie L. Gradus*, Ping Qin, Alisa K. Lincoln, Matthew Miller, Elizabeth Lawler, Henrik Toft Sørensen, and Timothy L. Lash

* Correspondence to Dr. Jaimie L. Gradus, National Center for PTSD, VA Boston Healthcare System, 150 South Huntington Avenue (116B-3), Boston, MA 02130 (e-mail: jaimie.gradus@va.gov).

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Most research regarding posttraumatic stress disorder (PTSD) and suicide has focused on suicidal ideation or attempts; no known study of the association between PTSD and completed suicide in a population-based sample has been reported. This study examined the association between PTSD and completed suicide in a population-based sample. Data were obtained from the nationwide Danish health and administrative registries, which include data on all 5.4 million residents of Denmark. All suicides between January 1, 1994, and December 31, 2006, were included, and controls were selected from a sample of all Danish residents. Using this nested case-control design, the authors examined 9,612 suicide cases and 199,306 controls matched to cases on gender, date of birth, and time. Thirty-eight suicide cases (0.40%) and 95 controls (0.05%) were diagnosed with PTSD. The odds ratio associating PTSD with suicide was 9.8 (95% confidence interval: 6.7, 15). The association between PTSD and completed suicide remained after controlling for psychiatric and demographic confounders (odds ratio = 5.3, 95% confidence interval: 3.4, 8.1). Additionally, persons with PTSD and depression had a greater rate of suicide than expected based on their independent effects. In conclusion, a registry-based diagnosis of PTSD based on *International Statistical Classification of Diseases and Related Health Problems*, Tenth Revision, is a risk factor for completed suicide.

case-control studies; stress disorders, post-traumatic; suicide

Abbreviations: ICD-8, *International Classification of Diseases*, Eighth Revision; ICD-10, *International Statistical Classification of Diseases and Related Health Problems*, Tenth Revision; PTSD, posttraumatic stress disorder; RERI, relative excess risk due to interaction.

Posttraumatic stress disorder, or PTSD, is a diagnosis predicated on the experience of a traumatic event (1). Some examples of potentially traumatic experiences that may lead to a diagnosis of PTSD include sexual or physical assault, combat exposure, a motor vehicle accident, or surviving a natural disaster. To meet criteria for a PTSD diagnosis, one must endorse ''reexperiencing'' symptoms, such as nightmares or flashbacks about the trauma; ''avoidance/numbing'' symptoms, such as avoiding trauma reminders or reduced experience of emotions; and ''hyperarousal'' symptoms, such as disrupted sleep or hypervigilance (1).

The association between PTSD and completed suicide has recently received media attention. For example, *The New York Times* reported that the incidence of suicide among US Army members is currently higher than during any period on record and that researchers suspect that the increasing prevalence of PTSD among active-duty military personnel and returning combat veterans is one potential explanation (2). We know of no study, however, that has examined directly the association between PTSD and suicide in any military or civilian population. Research has instead focused on suicidal ideation and suicide attempts because completed suicide is a relatively rare event and it is difficult to obtain information on most predictors of suicide risk once the suicide has occurred. Suicidal ideation and attempt research is important; however, it is not a substitute for studies of suicide completion because there are important differences between suicidal ideation and attempt

and suicide completion. For example, males are more likely than females to complete suicide, but females are more likely than males to attempt suicide (3). Furthermore, only 15% of people who attempt suicide actually complete suicide, and only 30%–40% of suicide completers have made a prior suicide attempt (4, 5).

Although studies of suicidal ideation or suicide attempts are inadequate surrogates for studies of completed suicide, they can provide a foundation for hypotheses about the causes of completed suicide. In a review of the studies published on anxiety disorders and suicidal behavior between January 2006 and May 2007, an association between PTSD and suicidal behavior was found in all studies that examined PTSD (6). A clear association between PTSD and suicidal behavior was also highlighted in a recent review of studies specific to the relation between PTSD and suicide (7). In a nationally representative, cross-sectional psychiatric survey conducted in the United States, PTSD was associated with suicidal ideation and suicide attempts, with odds ratios of 2.8 (95% confidence interval: 2.0, 3.8) and 2.7 (95% confidence interval: 1.8, 3.9), respectively (8). These associations have also been shown among patients with chronic PTSD (9).

Given the strong association between PTSD and suicidal behavior but the absence of research on the association between PTSD and completed suicide, we aimed to examine this latter relation. We hypothesized that PTSD would be associated with a higher rate of completed suicide compared with the rate of completed suicide among similar adults without a diagnosis of PTSD. In addition, we examined comorbid psychiatric diagnoses as modifiers of this association.

MATERIALS AND METHODS

Study population

The study population for this nested case-control study was the entire population of Denmark (5.4 million people) aged 15–90 years at the time of suicide (or the match date for controls). Denmark is an ideal location to study rare events, such as completed suicide, given the availability of high-quality, longitudinal, population-level data with complete follow-up. We defined cases as having completed suicide between January 1, 1994, and December 31, 2006, yielding 9,612 cases. Thirty eligible controls were drawn from a 25% representative sample of the total population of Denmark and were matched to suicide cases on gender, exact date of birth, and calendar time (controls had to be alive and eligible on the date of the matched case's suicide). When 30 or fewer controls matched, all were selected. When more than 30 controls matched, we selected a random sample of 30. This procedure yielded 199,306 controls.

Data collection

Data for the current study were obtained from various Danish medical and administrative registries. The Cause-of-Death Register contains information on the cause and date of all deaths that occur in Denmark. The Psychiatric Central Register includes dates of psychiatric outpatient treatment, psychiatric hospital admissions and discharges, and validated primary and secondary *International Classification of Diseases*, Eighth Revision (ICD-8) and *International Statistical Classification of Diseases and Related Health Problems*, Tenth Revision (ICD-10) diagnostic codes. Data in the Psychiatric Central Register are validated by the Department of Psychiatric Demography. All data are sent to the department with written case summaries, which are reviewed by an independent psychiatrist to confirm the assigned diagnoses (10). Although validation studies of PTSD diagnoses in the Psychiatric Central Register have not been conducted to our knowledge, validation studies of schizophrenia, dementia, and affective disorders diagnoses have consistently shown excellent agreement with computer-generated diagnoses or reinterview by independent assessors (11–13). The National Patients Register contains data on diagnoses and dates of treatment from the somatic hospitals in Denmark. The Civil Registration System was used to select controls. Finally, the Integrated Database for Labour Market Research was used to obtain socioeconomic data for all participants (10, 14–16). We linked these registries using the Civil Registration Number, a unique personal identification number assigned to all citizens and residents of Denmark.

Analytic variables

Diagnoses of illness in the Psychiatric Central Register are coded according to ICD-8 until 1994 (17) and ICD-10 thereafter (18). The ICD-8 and ICD-10 codes for the variables used in the current study can be found in Appendix Table 1. PTSD was not assigned a specific code in ICD-8; therefore, we restricted our study to the time period 1994–2006. According to ICD-10, PTSD follows the experience of an event that is ''exceptionally threatening or catastrophic in nature, which is likely to cause pervasive distress to almost anyone'' (19, p. 120). To be diagnosed with PTSD, symptoms must include reexperiencing the event through intrusive flashbacks, vivid memories, or dreams/nightmares, or experiencing distress when reminded of the event; avoiding circumstances that resemble or are associated with the event; and either 1) being unable to recall some period of the exposure to the stressor or 2) experiencing difficulty falling or staying asleep, irritability, difficulty concentrating, hypervigilance, or an exaggerated startle response. These symptoms must occur within 6 months of the traumatic event. PTSD diagnoses were initially examined in both the Psychiatric Central Register and the National Patients Register. The number of PTSD diagnoses from the somatic hospitals in the National Patients Register was too few to examine them as a separate group, however, so these diagnoses were excluded from the current analyses.

With regard to the psychiatric covariates obtained from the Psychiatric Central Register, the diagnoses of depressive episodes, recurrent depressive disorder, and dysthymia were grouped as ''depression''; mental/behavioral disorders due to use of alcohol and mental/behavioral disorders due to use of drugs were grouped as ''substance abuse''; and phobic

anxiety disorders, other anxiety disorders, and obsessive-compulsive disorder were grouped as ''anxiety disorders.'' Only primary diagnoses, resulting from either inpatient or outpatient treatment, were included in the analyses.

In our primary analyses, we coded only those psychiatric disorders that occurred before the PTSD diagnosis date as positive for that diagnosis. It is possible that these disorders are on the causal pathway between PTSD and suicide, so adjustment for their first occurrence after PTSD diagnosis may have biased the estimates of association toward the null. Given that psychiatric disorders, particularly depression, are commonly comorbid with PTSD or occur following PTSD, we also reanalyzed the data to examine the association between PTSD and suicide, adjusting for psychiatric covariates that occurred either before or after PTSD diagnoses. This method of adjustment did not substantially change the observed associations between PTSD and suicide; therefore, we do not present these results in this paper.

With regard to demographic covariates, we assessed income, marital status, and geographic location. Annual income is based on the calendar year before suicide (or match date) and was categorized into quartiles within strata of gender and age groups. We categorized marital status (living as married, cohabiting, single, or unmarried minor) as of November of the year before suicide or the match date.

Death by suicide is determined in Denmark as follows. All unnatural deaths are reported to the police, who, along with specialized forensic physicians, conduct an inquest into the death. The police and forensic physicians contact the hospitals, the physician of the deceased, the person who found the deceased, and the relatives and close friends of the deceased. They also seek information about place of death, method of dying, and presence of a suicide note. If the cause of death is still uncertain, a forensic autopsy is conducted. The final determination of death by suicide is made by the forensic physician based on the combined information from these sources (20). Therefore, an unnatural death is not coded as a suicide without specific, positive evidence that the death was self-inflicted.

Statistical analyses

We conducted descriptive and stratified analyses to examine the distribution of the variables of interest among cases and controls. Interaction observed in the stratified analyses was explored further by calculating the relative excess risk due to interaction (RERI), a measure of departure from additive effects (21). Choice of reference group for these analyses was based on the results of the stratified analyses. We used regression analyses to calculate the RERI and 95% confidence intervals around the RERI (22).

Next, we used logistic regression conditioned on the matched risk sets to assess the effect of PTSD on completed suicide. Because risk-set sampling was used to sample controls, the odds ratios obtained from these conditional logistic regression analyses provide unbiased estimates of the corresponding rate ratios (23). To select confounders from the psychiatric and demographic covariates described above, we used change-in-estimate methods as a model-building strategy (24).

Misclassification of psychiatric disorders can reduce the validity of psychiatric research (25). To examine whether our results were robust against this concern, we conducted an analysis to assess the potential bias from residual confounding by depression, substance abuse, and anxiety disorders (26). We calculated the corrected odds ratio estimates assuming a sensitivity of ascertainment of psychiatric disorders of 50%, 70%, and 90%. For this bias analysis, we assumed that misclassification was nondifferential and independent for cases and controls because the data on the confounders were collected before the suicide or match date. Finally, because of concern that cases may have been seen by a psychiatrist more often than controls before committing suicide and therefore would have more accurately recorded information on the psychiatric covariates, we conducted a bias analysis to examine differential imperfect sensitivity of confounder classification among cases and controls. For this analysis, we assumed a sensitivity for cases of 0.92 (the minimum sensitivity that resulted in nonnegative cell frequencies in the corrected tables) and a sensitivity for controls of 0.5.

All analyses were conducted by using SAS version 9.1.3 software (27). The current research was approved by the Institutional Review Board for the Boston University Medical Campus.

RESULTS

Descriptive analyses

The descriptive characteristics of the cases and controls are displayed in Table 1. Among suicide cases, 38 (0.40%) had been diagnosed with PTSD, while 95 (0.05%) controls had received this diagnosis. As expected, suicide cases were primarily male (71%), single (58%), and in the lowest income quartile (42%). Compared with controls, cases also more often had a history of other psychiatric disorders—the proportions of cases with a history of depression, substance abuse, or other anxiety disorder diagnoses were 18%, 11%, and 3.7% compared with 1.3%, 1.4%, and 0.66% among controls.

Regression analyses

The results of the conditional logistic regression analyses are displayed in Table 2. The initial conditional logistic regression analysis, which adjusts for the matched factors only, estimated that those with a PTSD diagnosis had 9.8 times the rate of suicide compared with those without a PTSD diagnosis (95% confidence interval: 6.7, 15). Using the model-building strategy, we identified depression, marital status, and income quartile as additional confounders of the PTSD–suicide association. Those with PTSD had 5.3 times the rate of suicide compared with those without PTSD, adjusted for these additional confounders and the matched factors (95% confidence interval: 3.4, 8.1). The RERI analyses (Table 3) revealed that the rate of suicide was greater among those diagnosed with both PTSD and depression than would be expected based on the additive independent effects of depression and PTSD alone

Table 1. Characteristics of Suicide Cases and Matched Controls, Denmark, 1994–2006

	Cases (n = 9,612)		Controls (n = 199,306)	
	No.	%	No.	%
Gender				
Male	6,837	71	142,865	72
Female	2,775	29	56,441	28
Age group, years				
15–34	1,701	18	42,627	21
35–54	3,608	38	93,703	47
55–74	2,818	29	51,176	26
75–90	1,485	15	11,800	5.9
Marital status				
Married	3,121	32	107,758	54
Cohabitating	823	8.0	25,130	13
Single	5,569	58	64,471	32
Unmarried minor	99	1.0	1,947	1.0
Income				
Lowest quartile	4,014	42	49,322	25
Second quartile	2,242	23	50,011	25
Third quartile	1,786	19	49,952	25
Highest quartile	1,570	16	50,021	25
PTSD diagnosis	38	0.40	95	0.05
Other psychiatric diagnoses				
Depression	1,713	18	2,542	1.3
Substance abuse	1,024	11	2,686	1.4
Anxiety disorders	352	3.7	1,309	0.66

Abbreviation: PTSD, posttraumatic stress disorder.

(RERI = 10, 95% confidence interval: −19, 39). There was no discernable pattern of associations as a function of time from PTSD diagnosis to suicide.

Bias analyses

The results of the first bias analyses are displayed in Table 4. At all levels of sensitivity tested, associations between PTSD and suicide remained. This analysis suggests that our results are robust against bias from nondifferential misclassification of psychiatric covariates, assuming a valid bias model and the accuracy of the values assigned to the bias parameters. Depression appeared to be the confounder that would have the largest effect on the PTSD–suicide association were it misclassified.

Table 5 displays the results of the second bias analysis, which explored the impact of differential misclassification of psychiatric confounders among cases and controls. Again, this analysis suggests that, assuming a valid bias model and accurate values assigned to parameters, our results are robust against bias from this type of misclassification.

Table 2. Estimates of the Association Between PTSD and Completed Suicide, Denmark, 1994–2006

	Odds Ratio	95% CI
PTSD and suicide: adjusted for matching[a]	9.8	6.7, 15
PTSD and suicide: adjusted for matching[a] and confounders[b]	5.3	3.4, 8.1

Abbreviations: CI, confidence interval; PTSD, posttraumatic stress disorder.

[a] Matching refers to control-to-case matching on gender, age, and time.

[b] Identified confounders were depression, marital status, and income quartile.

Table 3. Departure From Additive Effects of PTSD and Depression on Completed Suicide, Denmark, 1994–2006[a]

	PTSD+		PTSD–	
	Odds Ratio	95% CI	Odds Ratio	95% CI
Depression+	29	11, 79	13	12, 14
Depression–	6.2	4.0, 9.7	1	
	RERI = 10 (95% CI: −19, 39)			

Abbreviations: CI, confidence interval; PTSD, posttraumatic stress disorder; RERI, relative excess risk due to interaction.

[a] Analyses were adjusted for gender, age, time, depression, marital status, and income quartile.

DISCUSSION

To our knowledge, this study is the first to examine the association between PTSD and completed suicide in a population-based sample. One earlier study of the association between PTSD and completed suicide was conducted among depressed US Veterans Affairs patients (28). Consistent with our hypotheses, PTSD was associated with an increased rate of completed suicide—controlling for gender, age, and calendar time—as well as important psychiatric and demographic confounders. The current study contributes to the scant literature on PTSD and completed suicide by establishing the presence of a strong association. This result is consistent with previous literature that has found a moderate association between PTSD and suicidal ideation or suicide attempts (6–8). Although we found an association between PTSD and completed suicide in the current study, it is important to keep in mind that focusing solely on PTSD treatment as a suicide prevention strategy will likely have little effect on the overall population suicide rate, given the low prevalence of PTSD diagnoses and the multicausal nature of suicide.

We also found that history of depression modifies the association between PTSD and suicide. Patients with a history of both these diagnoses have a suicide rate higher than expected based on the independent effects of the 2 psychiatric conditions acting alone. This synergistic coaction is consistent with earlier research, which also reported that risk of suicidal behavior is increased among people with diagnoses of both depression and PTSD (29, 30). However, the width of the confidence interval around the RERI—our

Table 4. Bias Analyses Exploring the Effects of Nondifferential Misclassified Psychiatric Disorders on the Association Between PTSD and Completed Suicide, Denmark, 1994–2006[a]

	PTSD Odds Ratio
Adjusted for depression (uncorrected)	4.6
Depression sensitivity = 0.5	3.2
Depression specificity = 1.0	
Depression sensitivity = 0.7	3.9
Depression specificity = 1.0	
Depression sensitivity = 0.9	4.4
Depression specificity = 1.0	
Adjusted for substance abuse (uncorrected)	6.5
Substance abuse sensitivity = 0.5	5.4
Substance abuse specificity = 1.0	
Substance abuse sensitivity = 0.7	6.0
Substance abuse specificity = 1.0	
Substance abuse sensitivity = 0.9	6.4
Substance abuse specificity = 1.0	
Adjusted for anxiety disorders (uncorrected)	7.5
Anxiety disorders sensitivity = 0.5	6.8
Anxiety disorders specificity = 1.0	
Anxiety disorders sensitivity = 0.7	7.2
Anxiety disorders specificity = 1.0	
Anxiety disorders sensitivity = 0.9	7.4
Anxiety disorders specificity = 1.0	

Abbreviation: PTSD, posttraumatic stress disorder.

[a] All specificity was set equal to 1.0, because the probability that a person truly without these disorders would be treated at a psychiatric facility with a diagnosis of these disorders is near zero.

Table 5. Bias Analyses Exploring the Effects of Differential Misclassified Psychiatric Disorders on the Association Between PTSD and Completed Suicide, Denmark, 1994–2006[a]

	PTSD Odds Ratio
Adjusted for depression (uncorrected)	4.6
Depression sensitivity cases = 0.92, controls = 0.5	
Depression specificity = 1.0	3.2
Adjusted for substance abuse (uncorrected)	6.5
Substance abuse sensitivity cases = 0.92, controls = 0.5	
Substance abuse specificity = 1.0	5.4
Adjusted for anxiety disorders (uncorrected)	7.5
Anxiety disorder sensitivity cases = 0.92, controls = 0.5	
Anxiety disorder specificity = 1.0	6.8

Abbreviation: PTSD, posttraumatic stress disorder.

[a] All specificity was set equal to 1.0, because the probability that a person truly without these disorders would be treated at a psychiatric facility with a diagnosis of these disorders is near zero.

estimate of departure from additive effects—shows that this estimate of causal coaction was imprecisely measured.

Many potential mechanisms may account for the observed association between PTSD and completed suicide. For example, quality of life may be negatively impacted by PTSD, and decreased quality of life has been shown to be associated with suicidal behavior (9). In addition, traumatic experiences themselves may be associated with an increased risk of suicide. For example, research in Denmark has shown that mothers and fathers who experience the death of a child are at an increased risk of unnatural death themselves (31). Our data do not provide information regarding quality of life or individual traumatic events, so we could not explore them as potential mechanisms that explain this association.

The current investigation has several limitations worth noting. First, we restricted psychiatric diagnoses to those that occurred before PTSD diagnosis. We implemented this restriction to avoid the bias that would be induced by control for psychiatric diagnoses on the causal pathway from PTSD to suicide. Furthermore, we used only primary discharge diagnoses of psychiatric disorders recorded in the registries (and not secondary diagnoses). Therefore, it is possible that there is residual confounding of our observed PTSD–suicide associations due to misclassification of comorbid psychiatric illness. Because of these concerns, we conducted a bias analysis and found that even with a sensitivity of only 50%, the associations between PTSD and suicide could not be accounted for fully by misclassification of confounders. In addition, adjusting for psychiatric conditions first diagnosed either before or after the PTSD diagnosis did not substantially change our estimates of association.

Second, it is possible that suicide cases were seen by psychiatrists more frequently before committing suicide, so psychiatric confounder documentation would have been better than that for controls. We conducted a bias analysis to address this concern; assuming a valid bias model, it appears that differential psychiatric confounder misclassification would not have had a substantial impact on our results. Third, other factors such as prior suicide attempts, psychiatric diagnoses not included in the current investigation (e.g., bipolar disorder, schizophrenia, personality disorders), and somatic illness may influence the association between PTSD and suicide. Fourth, the criteria used to diagnose psychiatric illness in Denmark (i.e., ICD-8 and ICD-10) are slightly different from the criteria used in the United States (i.e., the *Diagnostic and Statistical Manual of Mental Disorders* (1)). These differences are important to recall when applying the current results to populations that do not use ICD-8 or ICD-10 for diagnostic coding.

Finally, we included psychiatric diagnoses (for both PTSD and psychiatric covariates) only when patients received inpatient or outpatient care at a psychiatric facility and had these diagnoses recorded in the Danish Psychiatric Central Register. Although patients diagnosed with PTSD in a somatic hospital setting are usually referred for psychiatric treatment, some cases with mild symptoms might not receive a referral. We examined the number of primary-coded PTSD cases who presented at only somatic hospitals, and there were too few to analyze. It is possible, therefore, that the exposed group in our study comprises severe PTSD cases because they had to have been seen in a psychiatric setting.

Our conservative definition of PTSD (i.e., PTSD diagnosed in a psychiatric setting) could be viewed as a limitation of the current study because PTSD cases seen in only a psychiatric treatment setting may not be representative of all PTSD cases found in the general population. This conservative definition could also be viewed as a strength because it provides a very clear exposure contrast. In addition, national health care registries that contain data on a broader range of PTSD diagnoses do not exist, so a study with a less conservative definition of prospectively collected information on PTSD diagnoses is not possible. A less conservative definition of PTSD would have resulted in a larger number of observed exposed persons, which would improve precision. However, this broader definition would be susceptible to nondifferential exposure misclassification. This misclassification would reduce the validity of the measured association without providing further evidence against the null hypothesis (32).

The association between PTSD and completed suicide is gaining increased attention because of the recent rise in suicide rates among military personnel (2). This study not only adds to the knowledge about the association between PTSD and suicide in the general population but also provides a foundation for future research on this association among members of the military.

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Author affiliations: National Center for PTSD, VA Boston Healthcare System, Boston, Massachusetts (Jaimie L. Gradus); Department of Epidemiology, Boston University School of Public Health, Boston, Massachusetts (Jaimie L. Gradus, Henrik Toft Sørensen, Timothy L. Lash); Centre for Registry-based Research, Aarhus University, Aarhus, Denmark (Ping Qin); Health Sciences Department, Northeastern University, Boston, Massachusetts (Alisa K. Lincoln); Sociology Department, Northeastern University, Boston, Massachusetts (Alisa K. Lincoln); Department of Health Policy and Management, Harvard University School of Public Health, Boston, Massachusetts (Matthew Miller); Department of Medicine, Harvard University, Boston, Massachusetts (Elizabeth Lawler); and Department of Clinical Epidemiology, Aarhus University Hospital, Aarhus, Denmark (Henrik Toft Sørensen, Timothy L. Lash).

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Appendix Table 1. Diagnostic Codes for Analytic Variables Used in the Study of PTSD and Completed Suicide

	ICD-8 Code (1981–1993)	ICD-10 Code (1994–2006)
PTSD		F43.1
Depression		
Depressive episodes	296, 300.4	F32
Recurrent depressive disorder	296, 300.4	F33
Dysthymia	300.4	F34.1
Substance abuse		
Mental/behavioral disorders due to use of alcohol	291, 303	F10
Mental/behavioral disorders due to use of drugs	294, 304	F11–F19
Anxiety disorders		
Other anxiety disorders	300	F40
Phobic anxiety disorders	300.2	F41
Obsessive-compulsive disorder	300.3	F42
Completed suicide		X60–X84

Abbreviations: ICD-8, *International Classification of Diseases*, Eighth Revision; ICD-10, *International Statistical Classification of Diseases and Related Health Problems*, Tenth Revision; PTSD, posttraumatic stress disorder.