


ORIGINAL ARTICLE

Risk factors for suicide attempts among U.S. military veterans: A 7-year population-based, longitudinal cohort study

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Abstract

Background: Population-based data on risk factors for suicide attempts among veterans remains limited.

Methods: A national probability sample of 2307 veterans was followed over the course of four timepoints spanning seven years to examine how a range of baseline risk factors predict incident suicide attempt. Suicide attempt data were aggregated into a single follow-up timepoint.

Results: Sixty-two veterans (3.1%) reported attempting suicide during the 7-year period. The strongest risk factors for suicide attempts were higher baseline levels of loneliness, lower baseline levels of adaptive psychosocial traits (e.g., dispositional gratitude), baseline thoughts of self-harm, and greater post-baseline trauma exposures (12.3%–41.3% of explained variance). Veterans with multiple co-occurring risk factors were at greatest risk for attempts; of veterans with 0, 1, 2, 3, and all 4 of these factors, the predicted probability of suicide attempt was 2.0%, 5.3%, 13.5%, 30.4%, and 55.0%, respectively.

Conclusions: Baseline loneliness, dispositional gratitude, thoughts of self-harm, and new-onset traumas emerged as the strongest risk factors for suicide attempts among veterans, underscoring the potential importance of targeting these factors in prevention efforts. Veterans with multiple co-occurring risk factors have

substantially greater risk for suicide attempts, suggesting that examination of multiple coinciding vulnerability factors may help improve suicide risk prediction models.

KEYWORDS

military, suicidal ideation, suicide, suicide attempts, trauma, veterans

INTRODUCTION

Military veterans in the United States (U.S.) are at disproportionately high risk for suicide relative to civilians (Department of Veterans Affairs [VA], 2020). According to the most recent population-level data from the VA, U.S. veterans are 50% more likely to die by suicide compared with their civilian counterparts after adjusting for age and sex (Department of Veterans Affairs, 2020). Nearly 20 veterans die by suicide per day in the United States, and the age- and sex-adjusted veteran suicide rate increased by approximately 30% between 2010 and 2018 (Department of Veterans Affairs, 2020). Given the substantial impact of suicide on families, communities, and society at large, researchers and policymakers have increasingly emphasized the need to better identify at-risk veterans, improve outreach efforts, and develop more targeted suicide interventions (Nichter, Hill, et al., 2021; U.S. Department of Health & Human Services, 2020). Although knowledge of risk factors for suicidal behavior among veterans has expanded considerably, most identified risk factors for suicide predict suicidal ideation, rather than suicide attempts (Nock et al., 2018). As suicide attempts are the single strongest risk factor for suicide (World Health Organization, 2014), additional research is needed to advance current understanding of factors that increase risk for suicide attempts among veterans.

Extant research has identified several factors associated with suicide attempt among veterans. These include sociodemographic characteristics, such as younger age (Ashrafioun et al., 2018), female sex (Bryan & Bryan, 2019), Caucasian race (Ashrafioun et al., 2016), and lower education (Fanning & Pietrzak, 2013). Military characteristics, such as being enlisted (vs. drafted; Fanning & Pietrzak, 2013), and experiencing high levels of violent combat exposure are associated with heightened risk for attempting suicide (Nichter et al., 2020; Nichter et al., 2020). Psychiatric characteristics, including major depressive disorder (MDD), posttraumatic stress disorder (PTSD), bipolar disorder, substance use disorders (SUD), and insomnia have been associated with elevated risk for attempts (Ashrafioun et al., 2016). Several psychosocial and physical health characteristics are also associated

with increased odds of attempts, including adverse childhood experiences (Nichter, Haller, Norman, et al., 2020; Nichter et al., 2020), physical health difficulties (Fanning & Pietrzak, 2013; Nichter, Norman, Haller, & Pietrzak, 2019), loneliness (Dobscha et al., 2014), and history of suicidal thoughts and/or behaviors (Fox et al., 2015).

A notable limitation of the existing literature is that the majority of studies have relied on cross-sectional data, which preclude the ability to differentiate risk factors from correlates of attempts. For instance, if loneliness is elevated among veterans who attempt suicide, loneliness may be a correlate of suicide attempt, yet the temporal nature of this association remains unclear (Fox et al., 2015). Indeed, it may be that loneliness heightens risk for attempts, or that individuals who attempt become increasingly socially isolated following suicide attempts. Moreover, while some longitudinal research has examined risk factors for suicide attempts among veterans (i.e. Hartl et al., 2005; Ilgen et al., 2007), nearly all of this work has utilized treatment-seeking or non-representative samples, which may not provide an accurate estimate of the strength of these associations in the general U.S. veteran population. Elucidation of risk factors in representative populations that temporally *precede* and increase risk for suicide attempts may provide critical information about potential causal relationships to help guide suicide prevention efforts.

Another area of research that has received relatively minimal attention among veterans is whether lower levels of protective factors may contribute to risk for suicide attempts. Although this domain is still developing, converging lines of evidence suggest that decrements in social connectedness and resilience-promoting psychosocial characteristics may amplify risk for attempts. For instance, low levels of perceived social support (Bossarte et al., 2012), purpose in life (Sinclair et al., 2016), and religiosity/spirituality (Kopacz et al., 2016) are associated with increased odds of suicide attempt among veterans. There have also been mixed findings regarding whether being married or having an intimate partner may operate as a risk (Iovine-Wong et al., 2019) or protective factor (Fanning & Pietrzak, 2013). Better identification of protective factors that distinguish veterans who attempt suicide

could inform both primary prevention and intervention strategies for suicide.

To address the aforementioned gaps, we analyzed data from the National Health and Resilience in Veterans Study (NHRVS), which prospectively surveyed a nationally representative cohort of U.S. veterans over seven years to evaluate the following aims: (a) characterize the incidence of suicide attempts over a seven-year period; and (b) identify risk factors most strongly associated with incident suicide attempts (i.e., new-onset attempts over the 7-year course). Informed by the vulnerability-stress model of suicidal behavior, which maintains that antecedents of suicidal behavior are complex and multifactorial (Nock et al., 2013), we examined a broad range of sociodemographic, military, psychiatric, and psychosocial factors that have been empirically demonstrated to increase or buffer risk for suicide attempts among service members and veterans (Nock et al., 2013). Further, in light of research highlighting the importance of examining the cumulative impact of multiple compounding risk factors to improve predictive models of suicide (Franklin et al., 2017; Lee et al., 2018), we also evaluated the combined effect of multiple co-occurring risk factors on incident suicide attempts relative to each factor individually.

METHODS

Data were from the 2011–2018 cohort of the NHRVS, a prospective cohort study of veterans aged 21 years and older. Of the 3157 veterans who completed a baseline assessment in 2011, 2307 (73.1%) completed at least one follow-up over the seven-year period. Follow-up assessments were conducted two (2013), four (2015), and seven years (2018) following the baseline assessment. Veterans completed an average of 2.2 ($SD = 0.8$, range = 1–3) follow-up assessments; 41.8% completed all three follow-ups, 31.1% completed two follow-ups, and 27.1% completed one follow-up. Participants were compensated \$15 for each completed survey. To increase statistical power for an analysis of the incidence of suicide attempts over the follow-up period, suicide attempt data were aggregated into a single follow-up timepoint (i.e., a positive endorsement of attempting suicide at one or more follow-up assessments was indicative as an incident case). Attrition analyses revealed that, relative to veterans who completed one or more follow-up assessments, those who did not were slightly younger (59.8 ± 14.9 vs. 62.8 ± 12.3 , $t = 5.70$, $p < 0.001$) and more likely to be female (12.5% vs. 9.3%, $\chi^2 = 6.75$, $p = 0.009$), but did not differ with respect to combat veteran status (36.1% vs. 34.7%, $\chi^2 = 0.52$, $p = 0.47$). Importantly, age- and gender-adjusted odds of lifetime suicide attempt histories and current thoughts of

self-harm at the baseline assessment did not differ (both p 's > 0.10). To account for differences in age and gender, and to promote generalizability of results to the U.S. veteran population at the time the 2011 baseline NHRVS survey was conducted, post-stratification weights were applied to analyses to reflect the demographic composition of the U.S. veteran population using the most contemporaneous U.S. Census data (see below).

At baseline, the mean age of the sample was 61.5 years ($SD = 14.2$, range = 22–93); participants were predominantly male (91.5%), White (77.1%), and married/partnered (74.9%), with a minimum of some college or higher education (68.5%) and a yearly household income of less than \$60,000 (53.8%). On average, participants reported 7.1 years of military service ($SD = 7.7$, range = 1–42), and the majority were non-combat veterans (67.3%).

The sampling methodology of the NHRVS has been described previously (Nichter, Haller, Norman, et al., 2020). Briefly, participants enrolled in the NHRVS study completed an anonymous 60-min web-based survey. The NHRVS sample was drawn from KnowledgePanel®, a probability-based, online non-volunteer survey panel of more than 50,000 U.S. households that is maintained by the research firm GfK Knowledge Networks, Inc. (now Ipsos). KnowledgePanel® recruitment methods allow sampling of households with and without listed telephone numbers, cellphone-only, non-telephone, and without Internet access. In the recruitment process, KnowledgePanel employed an initial screening question that confirmed veteran status (“Have you ever served on active duty in the U.S. Armed Forces, Military Reserves, or National Guard?”). To permit generalizability of results to the entire population of U.S. veterans, post-stratification weights were applied based on the following demographic distributions from the U.S. Census Bureau Current Population Survey: age, gender, race/ethnicity, education, Census region, and metropolitan area. All participants provided informed consent for the study, which was approved by the Human Subjects Subcommittee of the VA Connecticut Healthcare System.

Assessments

Descriptions of study measures are provided in Table 1. The following potential risk factors were examined at the baseline assessment (in 2011): probable psychiatric disorders, current thoughts of self-harm, lifetime suicide attempt(s), cognitive functioning, physical health problems, disability status, loneliness, perceptions of stigma about mental healthcare, somatization, and hostility. The following potentially protective factors were examined at baseline: adaptive psychosocial trait characteristics (e.g.,

TABLE 1 Study measures

Suicidal behaviors	
Thoughts of self-harm	Thoughts of self-harm were assessed using two items adapted from the Patient Health Questionnaire-9 Item 9 that inquired about thoughts during the prior two weeks (Kroenke et al., 2001). Participants were identified as having active thoughts of self-harm if they responded "several days or more" to an item asking: "How often have you been bothered by thoughts of hurting yourself in some way?". Passive thoughts of self-harm were assessed using an item which asked: "How often have you been bothered by thoughts that you might be better off dead?"
Lifetime suicide attempt	Lifetime suicide attempt history was assessed at baseline assessment with the question: "Have you ever tried to kill yourself?" with the response options "No" or "Yes." At the follow-up assessments, these questions were modified to reflect the time since the prior survey: "In the PAST TWO YEARS, have you tried to kill yourself? (Waves 2 and 3); and "In the PAST THREE YEARS, have you ever tried to kill yourself?"
Sociodemographic characteristics	
	Age (continuous), sex (male, female), race/ethnicity (white, non-white), education (college graduate or higher, up to high school diploma), marital status (married/living with partner, not), household income (\$60,000 or more, less than \$60,000), retirement status (retired, not)
Military characteristics	
	Combat status (previously deployed, not), primary healthcare (VA, other), enlistment status (enlisted, not)
Psychiatric risk factors	
Posttraumatic stress disorder (PTSD)	Current PTSD was assessed using The PTSD Checklist-Specific (PCL-S; Weathers et al., 1993), which is based on the Diagnostic and Statistical Manual for Mental Disorders Fourth Edition criteria for PTSD (American Psychiatric Association, 2000). The PCL-S was utilized to determine current (i.e., past month) probable PTSD, asking respondents to report about posttraumatic symptoms in relation to their 'worst' traumatic event endorsed on the Trauma History Screen (Carlson et al., 2011). A positive screen for PTSD was operationalized as a total PCL score ≥ 50 . Cronbach's $\alpha = 0.96$
Depression (MDD)	Depressive symptoms were assessed using the depression questions from the Patient Health Questionnaire-4 (PHQ-4; Löwe et al., 2010), which is a brief, self-report measure, using a cutoff score of ≥ 3 . Cronbach's $\alpha = 0.91$
Generalized anxiety disorder (GAD)	Generalized anxiety symptoms were assessed using the anxiety questions from the Patient Health Questionnaire-4 (PHQ-4; Löwe et al., 2010), which is a brief, self-report measure. A cutoff score of ≥ 3 to indicate a positive screen for probable GAD. Cronbach's $\alpha = 0.87$
Alcohol use disorder (AUD)	Current (e.g., past year) alcohol use disorder was assessed using the Alcohol Use Disorder Identification Test-Consumption (Bush et al., 1998), with a cutoff score of ≥ 5 to indicate probable AUD
Sleep quality	Sleep quality was assessed using item 6 of the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989), which asks: "During the past month, how would you rate your sleep quality overall?" using a scale of 0 ("Very good"), 1 ("Fairly good"), 2 ("Fairly bad"), and 3 ("Very bad"). Poor sleep quality was operationalized as endorsement of "Very bad" or "Fairly bad"
Psychosocial risk factors	
Childhood sexual abuse	Childhood sexual abuse was assessed using a dichotomous item from the Trauma History Screen (Carlson et al., 2011): "Were you ever forced or made to have sexual contact as a child?"

TABLE 1 (Continued)

Lifetime and post-baseline trauma exposure	Lifetime trauma exposure was assessed using the Trauma History Screen (Carlson et al., 2011) at baseline as well as at follow-up periods in order to capture interim traumatic events. The THS is a self-report measure that assesses the lifetime occurrence of 14 potentially traumatic events; the NHRVS additionally assessed exposure to life-threatening illness or injury. The sum of potentially traumatic events endorsed, ranging from 0 to 15, was used as an index of lifetime trauma burden
Low cognitive functioning	Low cognitive functioning during the past month was assessed at baseline using the Medical Outcomes Study Cognitive Functioning Scale (Stewart & Ware, 1992), a reliable and valid measure with score of <1 standard deviation below the sample mean to indicate low functioning. Cronbach's $\alpha = 0.92$
Loneliness	Loneliness was assessed using a three-item loneliness questionnaire adapted from the Revised UCLA Loneliness Scale (Russell et al., 1980); $\alpha = 0.78$
High perceived stigma about mental healthcare	Perceived stigma about mental healthcare was assessed using the Perceived Stigma and Barriers to Care Scale (Britt et al., 2008), with items scored dichotomously (i.e., No vs. Yes). Items included "Mental health care does not work" and "I do not trust mental health professionals"
Hostility	Hostility was measured using the hostility subscale from the Brief Symptom Inventory (Derogatis & Melisaratos, 1983) $\alpha = 0.91$
Physical health risk factors	
Physical health problems	Sum of number of medical conditions: "Has a doctor or healthcare professional ever told you that you have any of the following medical conditions?" (e.g., arthritis, cancer)
ADL and/or IADL disability	Veterans were asked to complete checklists assessing whether they needed help from another person to perform activities of daily living (ADLs; i.e., bathing, walking, dressing, getting in and out of a chair); and instrumental activities of daily living (IADLs; i.e., shopping, managing finances, preparing meals)
Somatization	Somatization was measured using the somatization subscale from the Brief Symptom Inventory (Derogatis & Melisaratos, 1983); $\alpha = 0.80$
Psychosocial protective factors	
Adaptive psychosocial traits	A composite score of adaptive psychosocial traits (Pietrzak & Cook, 2013) was used to assess dispositional attitudes/capacities for coping associated with positive mental health outcomes, including qualities such as resilience; a sense of life purpose; dispositional gratitude, optimism, and curiosity/exploration; and perceived community integration. Resilience was measured using the Connor-Davidson Resilience Scale (Campbell-Sills & Stein, 2007); Cronbach's $\alpha = 0.93$. The Purpose in Life Test, Short Form (Schulenberg et al., 2011) was used to index sense of purpose in life; Cronbach's $\alpha = 0.89$. Dispositional gratitude, optimism, and curiosity were each assessed using single 7-point Likert scale items drawn from the Gratitude Questionnaire (GQ-6; McCullough et al., 2001), the Life Orientation Test-Revised (LOT-R; Glaesmer et al., 2012), and the Curiosity and Exploration Inventory-II (CEI-II; Kashdan et al., 2009), respectively. Sense of community integration was assessed with a single item, "I feel well integrated in my community." Results of an EFA analysis revealed that scores on these measures loaded on a single factor (eigenvalue = 3.46, 57.7% of variance explained); factor loadings ranged from 0.70 to 0.80

(Continues)

TABLE 1 (Continued)

Social connectedness	The social connectedness factor, derived using an EFA, consisted of three indices of social support (Pietrzak & Cook, 2013), including (1) number of close friends and supportive relatives (structural social support), which was assessed with the question, "How many close friends and relatives do you have?"; (2) secure attachment style (Hazan & Shaver, 1990); and (3) perceived social support using the Medical Outcomes Study—Social Support Scale (Sherbourne & Stewart, 1991); Cronbach's $\alpha = 0.91$. Results of an EFA analysis revealed that scores on these measures loaded on a single factor (eigenvalue = 1.72, 57.3% of variance explained); factor loadings ranged from 0.66 to 0.80
Religiosity	Religiosity/spirituality was assessed using the Duke University Religion Index (DUREL; Koenig & Büsing, 2010), which assesses frequency of engagement in organized religious services and private spiritual activities, as well as intrinsic religiosity; Cronbach's $\alpha = 0.92$. Results of an EFA analysis revealed that scores on these measures loaded on a single factor (eigenvalue = 2.21, 73.8% of variance explained); factor loadings ranged from 0.83 to 0.88

dispositional gratitude), social connectedness (e.g., perceived level of social support), and religiosity/spirituality. Trauma exposure was assessed at baseline and each follow-up assessment in order to capture interim traumatic events and were summed.

Data analysis

Statistical analyses were conducted using SPSS version 27.0 statistical software. Missing data (<3%) were multiply imputed using chained equations. Analyses proceeded in five steps. First, we estimated the incidence of suicide attempt(s) during the 7-year follow-up by conducted chi-square and independent-samples *t*-tests to compare characteristics of veterans who did and did not attempt suicide during this time period. Second, we conducted a multivariable logistic regression analysis to identify factors independently associated with incident suicide attempts; variables associated with suicide attempts at the $p < 0.05$ level in bivariate analyses were entered into this analysis. To minimize multicollinearity in multivariable analyses, exploratory factor analyses (EFAs) were conducted (further described in Pietrzak & Cook, 2013) to reduce highly correlated thematically related variables (e.g., adaptive psychosocial traits) into factors; see Table 1. Third, planned post hoc analyses of composite variables that emerged as significant predictors of suicide attempt were conducted to identify specific indicator variables associated with this outcome. Fourth, to determine the relative contribution of each factor to the model explained variance (R-squared), relative importance analyses (Tonidandel & LeBreton, 2011) were conducted using the relaimpo R statistical package. Fifth, to examine the risk for suicide attempt associated with multiple co-occurring risk factors (Franklin et al., 2017), we computed a count of statistically significant factors that emerged in the multivariable model.

Binary variables were counted as positive endorsement of the risk factor. Receiver operating characteristic (ROC) curve analyses were conducted to identify optimal cutoff scores (i.e., highest quality of efficiency: $k[0.5]$) on continuous variables associated with incident suicide attempts; scores equal to or greater than this cutoff were counted as positive endorsement of the risk factor (Kraemer, 1992). We then conducted a binary logistic regression analysis to compute predicted probabilities of suicide attempt as a function of number of significant risk factors; these values were multiplied by 100 to yield an estimate of the percent likelihood of incident suicide attempt.

RESULTS

The incidence of suicide attempt over the seven-year follow-up period was 3.1% ($n = 62$, 95% confidence interval = 2.4–4.0%). The majority of participants with an incident suicide attempt reported one (95.6%; $n = 59$) attempt, with 4.4% ($n = 3$) reporting two attempts. Of veterans who reported attempting suicide during the follow-up period, 83.6% ($n = 51$) reported that it was their first lifetime suicide attempt.

Table 2 shows characteristics of veterans with and without an incident suicide attempt over the 7-year follow-up period. Veterans who reported a suicide attempt in the follow-up period were significantly younger and less likely to have attended college; were more likely to report the VA as their primary source of healthcare and to have enlisted into the military; were more likely to have screened positive for current PTSD, MDD, SUD, generalized anxiety disorder, and poor sleep quality at baseline; were more likely to have reported thoughts of self-harm at baseline, prior suicide attempt history, childhood sexual abuse, lifetime trauma exposure, post-baseline trauma exposure, low cognitive functioning, loneliness, higher

TABLE 2 Characteristics of U.S. military veterans with and without incident suicide attempts over the seven-year study period

	No incident Suicide attempt <i>n</i> = 2245 (weighted 96.9%)		Incident Suicide attempt <i>n</i> = 62 (weighted 3.1%)		Bivariate analyses		Multivariable analysis
	Mean or No.	SD or %	Mean or No.	SD or %	χ^2 or <i>t</i>	<i>p</i> value	RRR (95%CI)
Sociodemographic characteristics							
Age	61.7	14.2	55.1	11.9	3.75	<0.001	0.99 (0.97–1.01)
Male sex	1597	77.1	51	76.1	.04	0.84	–
White race/ethnicity	1597	77.1	51	76.1	.04	0.84	–
College graduate or higher education	639	30.9	11	16.4	6.41	0.011	0.55 (0.26–1.16)
Married/partnered	1555	75.1	46	68.7	1.44	0.23	–
Household income \$60K or higher	962	46.5	24	36.8	2.96	0.08	–
Employed	835	40.4	21	31.3	2.19	0.13	–
Military characteristics							
Combat veteran status	680	33.0	18	26.9	1.1	0.29	–
VA primary source of healthcare	380	18.4	24	35.8	12.85	<0.001	1.44 (0.76–2.72)
Enlisted into military	1783	86.3	63	95.5	4.58	0.03	1.81 (0.53–6.16)
Psychiatric risk factors							
Baseline PTSD	56	3.7	4	13.6	16.01	<0.001	1.03 (0.31–3.39)
Baseline MDD	131	6.4	7	14.9	7.49	0.006	0.36 (0.10–1.26)
Baseline GAD	130	6.8	6	13.4	4.43	0.035	0.47 (0.14–1.57)
Baseline AUD	306	15.3	16	23.9	3.65	0.056	–
Baseline poor sleep quality	500	23.3	17	38.8	8.54	0.003	1.07 (0.56–2.05)
Psychosocial risk factors							
Baseline thoughts of self-harm	164	8.0	20	29.9	39.12	<0.001	2.41 (1.09–5.30) ^a
Prior suicide attempt	115	5.6	11	16.4	13.72	<0.001	1.74 (0.72–4.20)
Childhood sexual abuse	148	7.2	10	14.9	5.54	0.019	0.82 (0.34–1.98)
Baseline total traumas	2.9	2.3	4.3	3.8	–6.09	<0.001	1.00 (0.90–1.12)
Post-baseline total traumas	2.1	1.5	3.4	2.9	–4.43	<0.001	1.20 (1.04–1.40) ^a
Low cognitive functioning	193	9.3	17	25.0	18.26	<0.001	1.27 (0.54–2.98)
Baseline loneliness	4.4	1.7	5.9	2.4	–7.28	<0.001	1.27 (1.08–1.48) ^b
High perceived stigma about mental healthcare	501	24.2	27	39.7	8.51	0.004	1.21 (0.67–2.17)
Hostility	1.2	3.2	3.0	5.6	–4.45	<0.001	0.98 (0.90–1.06)
Physical health risk factors							
Physical health problems	2.6	1.9	2.9	2.1	–1.36	0.17	–

(Continues)

TABLE 2 (Continued)

	No incident Suicide attempt <i>n</i> = 2245 (weighted 96.9%)		Incident Suicide attempt <i>n</i> = 62 (weighted 3.1%)		Bivariate analyses		Multivariable analysis RRR (95%CI)
	Mean or No.	SD or %	Mean or No.	SD or %	χ^2 or <i>t</i>	<i>p</i> value	
ADL and/or IADL disability	237	11.5	15	22.4	7.45	0.006	0.58 (0.25–1.37)
Somatization	2.3	3.5	4.6	7.1	−4.93	<0.001	1.06 (0.98–1.14)
Psychosocial protective factors							
Adaptive psychosocial traits	0.02	0.97	−0.75	1.41	5.82	<0.001	0.74 (0.56–0.97) ^a
Social connectedness	0.02	0.98	−0.77	1.18	5.84	<0.001	1.23 (0.86–1.74)
Religiosity/spirituality	−0.01	0.99	0.01	1.02	−0.10	0.91	–

Abbreviations: 95%CI, 95% confidence interval; ADL, activities of daily living; AUD, alcohol use disorder; GAD, generalized anxiety disorder; IADL, instrumental activities of daily living; MDD, major depressive disorder; PTSD, posttraumatic stress disorder; RRR, relative risk ratio.

^aSignificant at the 0.05 level, determined by use of a 2-sided test.

^bSignificant at the 0.01 level, determined by use of a 2-sided test.

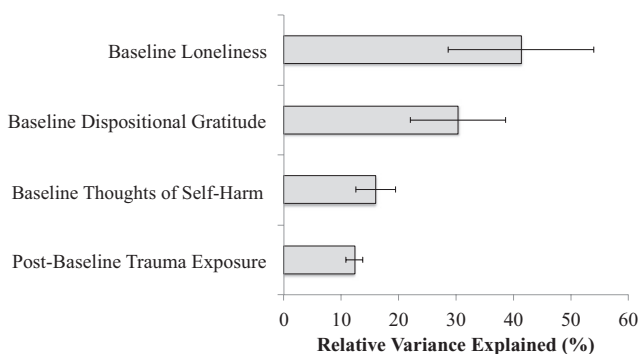


FIGURE 1 Results of relative importance analysis of significant longitudinal predictors of incident suicide attempts

perceived stigma about mental healthcare, and hostility; reported more physical health problems, somatization, and ADL/IADL physical disability; and scored lower on composite measures of adaptive psychosocial traits and social connectedness.

Table 2 additionally displays results of a multivariable regression analysis examining longitudinal predictors of incident suicide attempts. Frequency of thoughts of self-harm and loneliness at baseline were associated with increased risk of suicide attempt. Post hoc analyses revealed that frequency of active thoughts of self-harm (e.g., recent thoughts of harming yourself in some way) drove the association between thoughts of self-harm and suicide attempt (RRR = 2.05, 1.06–3.96); the association between frequency of passive thoughts of self-harm (e.g., wish to be dead) and suicide attempt was non-significant ($p = 0.74$). Veterans who scored lower

on a measure of adaptive psychosocial traits at baseline were at increased odds of suicide attempt. A post hoc analysis revealed that baseline scores on a measure of dispositional gratitude (RRR = 0.76; 95% CI, 0.59–0.97) were independently associated with suicide attempts; none of the other adaptive psychosocial traits were significant (all p 's > 0.22).

Results of a relative importance analysis (Figure 1) revealed that baseline loneliness accounted for the most explained variance in incident suicide attempts (41.3%), with dispositional gratitude (30.4%), frequency of thoughts of self-harm (16.0%), and post-baseline trauma exposure (12.3%) explaining the remaining variance in this outcome.

ROC curve analyses revealed the following optimal cutoff scores: loneliness (≥ 8 ; sensitivity [SEN] = 0.258, specificity [SPEC] = 0.929, positive predictive value [PPV] = 0.091, negative predictive value [NPV] = 0.978), dispositional gratitude (≤ 3 ; SEN = 0.133, SPEC = 0.975, PPV = 0.127, NPV = 0.977), and post-baseline trauma exposure (≥ 10 ; SEN = 0.048, SPEC = 0.996, PPV = 0.273, NPV = 0.974). Of veterans with 0, 1, 2, 3 and 4 risk factors identified in this study, the predicted probabilities of suicide attempt during the study period were 2.0%, 5.3%, 13.5%, 30.4%, and 55.0%, respectively.

Relative to veterans who did not attempt suicide over the follow-up period, those who did attempt suicide endorsed a significantly greater number of these 4 risk factors (0.9 ± 1.1 vs. 0.2 ± 0.6 , $t = 9.73$, $p < 0.001$, $d = 1.20$), and were more than three times as likely to endorse one of more of these risk factors (49.3% vs. 14.4%, $\chi^2 = 59.93$, $p < 0.001$).

DISCUSSION

To our knowledge, the current study is the first population-based longitudinal cohort study to examine risk factors associated with suicide attempts among U.S. veterans. The incidence of suicide attempts over the course of 7 years was 3.1%, which is comparable to estimates reported in prior longitudinal investigations of OEF/OIF veterans (Lee et al., 2018). For example, the Veterans After-Discharge Longitudinal Registry Study (VALOR) surveyed a cohort of OEF/OIF veterans ($N = 1649$), and found that the incidence of suicide attempt was 4.4%, although the follow-up period for this study was approximately one-third the length of the current study (Lee et al., 2018). The slightly elevated incidence rate of suicide attempts observed in Project VALOR is likely due to methodological differences, including oversampling more recently separated, combat-exposed veterans with PTSD, and substantially younger average age of participants compared with the current NHRVS cohort (37.4 vs. 61.5 years). Indeed, prior national data has found that age is one of the strongest correlates of suicide attempts, with veterans aged 18–44 being nearly five times as likely to attempt suicide relative to those aged $\geq 65+$ (Nichter, Stein, et al., 2021). Importantly, approximately 84% of veterans in the current study who attempted suicide over the follow-up period reported that it was their first attempt, underscoring the potential prognostic utility of having population-based information about baseline risk factors for suicide attempts in this population.

Loneliness at baseline emerged as the single strongest risk factor for suicide attempt over the 7-year period, accounting for nearly 42% of the explained variance. This finding is consistent with much of the broader suicide literature from the general population, which has found that social factors (e.g., low social support, loneliness, isolation) are among the strongest and most consistent risk factors for suicide attempts (Franklin et al., 2017). For example, a meta-analysis of 365 studies that spanned 50 years of research and included 3428 total effect sizes for suicide risk factors found that social factors were some of the most robust prospective predictors of suicide attempts (weighted OR = 1.5; Franklin et al., 2017). The emergence of loneliness as a robust risk factor for suicide attempts is consistent with the interpersonal-psychological theory of suicide (Van Orden et al., 2010), which posits that the transition from suicidal ideation to attempt results in part from thwarted belongingness, a construct characterized by feelings of alienation from friends, family, and broader social circles (Ribeiro & Joiner, 2009). Of note, although loneliness was a robust risk factor for suicide attempts, a latent factor of social connectedness, which included measures of social network size, attachment style, and

perceived social support, did not emerge as significant predictors in the current investigation. One explanation for this finding could be that loneliness is associated with painful emotions (e.g., sadness, jealousy; Olié & Courtet, 2020), whereas the social connectedness measures reflect more disparate aspects of social support that are less reflective of perceived quality of social relationships and perceptions of social isolation and belongingness. Taken together, these findings suggest that loneliness may potentially have greater prognostic utility in predicting suicide attempts than previously conceptualized and thus warrants additional attention in future research, particularly in light of recent research from the COVID-19 pandemic, which has demonstrated increasing rates of loneliness (Groarke et al., 2020; Hill et al., 2021).

Lower scores on a composite measure of adaptive psychosocial traits at baseline emerged as the second strongest risk factor for suicide attempts. This association was driven by dispositional gratitude (i.e., the tendency to notice and appreciate the positives in life), such that veterans with higher trait gratitude were approximately 26% less likely to attempt suicide during the follow-up period. These findings add to a growing body of literature from the veteran and general population, which has found trait gratitude to be inversely associated with suicidal ideation (Krysinska et al., 2015), suicide attempt (Kaniuka, Kelliher Rabon, et al., 2020), and depression (McGuire et al., 2021). Several theories have proposed how gratitude may affect risk for suicidal thoughts and behavior, including its role in promoting cognitive flexibility, improving emotion regulation, modulating negative cognitions and expectancies, as well as impacting interpersonal functioning (e.g., increasing prosocial behavior; Fredrickson, 2004; Kaniuka et al., 2020). Yet, in contrast to prior cross-sectional research examining differences in protective correlates of suicide attempts among veterans, the current investigation did not find social connectedness (Kelley et al., 2019), religiosity/spirituality (Smigelsky et al., 2020), or being married or having an intimate partner (Fanning & Pietrzak, 2013) to differ among veterans with suicide attempt histories.

Frequency of thoughts of self-harm at baseline and exposure to traumatic experiences during the 7-year follow-up period emerged as the third and fourth strongest prospective risk factors for suicide attempts, respectively. These findings are consistent with the vulnerability-stress model of suicidal behavior (Nock et al., 2013), which posits that individuals may be at increased risk for suicide attempt due to a combination of having more chronic baseline risk factors (e.g., history of suicidal ideation), as well as experiencing more frequent psychosocial stressors and/or negative life events. In support of this conceptual model, veterans who attempted suicide during the follow-up period reported nearly four times higher rates of

baseline thoughts of self-harm (29.9% vs. 8.0%, $p < 0.001$) and approximately 40% more traumatic life events (e.g., life-threatening illness, physical/sexual assault) over the follow-up period relative to those who did not report an attempt (3.4 vs. 2.0, $p < 0.001$). Post hoc analyses revealed that frequency of active thoughts of self-harm (e.g., recent thoughts of hurting yourself in some way) drove the observed association between baseline thoughts of self-harm and subsequent suicide attempt (RRR = 2.05, 95%CI = 1.06–3.96); whereas, the association between passive thoughts of self-harm (e.g., wish to be dead) and suicide attempt was not significant. These findings are notable in light of other recent meta-analytic work, which has found that passive suicidal ideation is comparable to active ideation with respect to clinical significance (i.e., psychiatric comorbidity) and associated risk for suicide attempts (Liu et al., 2020).

A notable contribution of the current study is our examination of the cumulative effect of multiple co-occurring risk factors on suicide attempts. Indeed, numerous scholars have underscored that the extant literature is substantially limited due to the fact that most studies examine risk variables for suicide-related outcomes independently or in isolation, rather than assessing their combined impact (Franklin et al., 2017; Lee et al., 2018). We found that the ability to predict suicide attempts increased considerably when risk factors were considered collectively, rather than separately. Of veterans with 0, 1, 2, 3 and 4 risk factors identified in this study, the predicted probability of suicide attempt during the study period was 2.0%, 5.3%, 13.5%, 30.4%, and 55.0%, respectively. Put into context, these findings suggest that veterans who endorsed thoughts of self-harm and high levels of loneliness at baseline and who experienced a high number of traumatic events over the 7-year study period had nearly a 1 in 3 likelihood of attempting suicide. Conversely, veterans who endorsed none of these four risk factors had only a 2% likelihood of attempting suicide over the study period.

The current findings should be considered within the context of several limitations. First, previous research has found that stigmatized behaviors are less likely to be reported (Van de Mortel, 2008), so the estimated incidence of suicide attempts described here is likely an underestimation. Second, although recent research suggests the importance of examining risk factors for suicide attempts among suicide ideators (Klonsky & May, 2015; Nock et al., 2018), we were unable to do so due to low statistical power given the relatively limited number of veterans endorsing thoughts of self-harm at baseline. Relatedly, results of this study should be replicated in larger samples, as the logistic regression model may be underpowered to consider a large number of potential risk factors given the low incidence

rate of 3.1%. Third, this study was underpowered to examine interaction effects between the observed risk factors and suicide attempts. As such, our results may obscure the effects of specific combinations of risk factors. Fourth, although results were weighted for non-response, it is possible that the retained sample may reflect an under- or over-estimate of the incidence of suicide attempts in this population. Sixth, the current study used a single item to assess for suicide attempts, and several measures of risk factors were brief or consisted of single items, which introduces the potential for bias (Millner et al., 2015). Finally, veterans in the current study were predominantly white, male, and of older age. Therefore, additional research is needed to evaluate the generalizability of current findings to younger, female, and more diverse veteran samples.

Despite these limitations, the current study provides the first longitudinal population-based characterization of risk factors for suicide attempts in a population-based sample of U.S. military veterans. From a public health perspective, results suggest that loneliness may be an important risk factor to screen for when assessing suicide risk, in addition to other commonly assessed variables—such as depressive symptoms, active thoughts of self-harm, and prior trauma exposure. Indeed, we found that loneliness had greater prognostic utility in predicting future suicide attempts than psychiatric and other risk factors commonly regarded by clinicians as risk factors for suicide among veterans, such as depression, PTSD, suicide attempt history, combat exposure, or alcohol use disorder. Findings also add to a growing body of evidence highlighting the importance of examining the effects of multiple co-occurring risk factors on suicide risk to improve predictive models of suicide (Franklin et al., 2017; Lee et al., 2018). As risk factors for suicidal behavior tend to co-occur rather than manifest independently (Nichter, Monteith, et al., 2021; Ramsawh et al., 2014), additional research is needed to characterize the cumulative risk conferred by multiple coinciding vulnerability factors.

From a prevention standpoint, it is notable that most of the risk factors identified in our study have been empirically demonstrated to be modifiable. Accumulating evidence suggests that group-based telehealth interventions, for example, represent an effective and low-cost method to bolster social support and reduce loneliness in high-risk populations (Gentry et al., 2019). Similarly, suicide-specific cognitive-behavioral interventions, such as cognitive-behavioral therapy for suicide prevention (Stanley et al., 2009), have shown promising preliminary results for decreasing prospective risk for suicidal ideation and suicide attempts among active duty service members and veterans (Rudd et al., 2015). While converging lines

of research suggest that gratitude interventions have positive outcomes on measures of depression and well-being (O'Leary & Dockray, 2015), additional research is needed to determine whether therapeutic treatments designed to enhance gratitude (e.g., gratitude journaling) may decrease prospective risk for suicidal behavior among veterans, active duty service members, and other high-risk groups.

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CONFLICTS OF INTEREST

BN, LM, SH, RH, MH, SN, and RP have no conflicts of interest to declare. MS has previously served as a consultant for Actelion, Dart Neuroscience, Healthcare Management Technologies, Janssen, Oxeia Biopharmaceuticals, Pfizer, Resilience Therapeutics, and Tonix Pharmaceuticals for work unrelated to the current project. JK is a scientific advisor to Biohaven Pharmaceuticals, BioXcel Therapeutics, Inc., Cadent Therapeutics, PsychoGenics, Inc., Stanley Center for Psychiatric research at the Broad Institute of MIT and Harvard, Lohocla Research Corporation. JK owns stock and/or stock options in Biohaven Pharmaceuticals, Sage Pharmaceuticals, Spring Care, Inc., BlackThorn Therapeutics, Inc., Terran Biosciences, Inc. JK reports income <\$10 000 per year from: AstraZeneca Pharmaceuticals, Biogen, Idec, MA, Biomedisyn Corporation, Bionomics, Limited (Australia), Boehringer Ingelheim International, Concert Pharmaceuticals, Inc., Epiodyne, Inc., Heptares Therapeutics, Limited (UK), Janssen Research & Development, L.E.K. Consulting, Otsuka America Pharmaceutical, Inc., Perception Neuroscience Holdings, Inc. Spring Care, Inc., Sunovion Pharmaceuticals, Inc., Takeda Industries, Taisho Pharmaceutical Co., Ltd. JK reports income >\$10000 per year from Biological Psychiatry (Editor). J.K. received the drug, Saracatinib from AstraZeneca and Mavoglurant from Novartis for research related to NIAAA grant "Center for Translational Neuroscience of Alcoholism [CTNA-4] from AstraZeneca Pharmaceuticals. JK holds the following patents: 1) Seibyl JP, Krystal JH, Charney DS. Dopamine and noradrenergic reuptake inhibitors in treatment of schizophrenia. US Patent #:5447948. September 5, 1995; 2) Vladimir, Coric, Krystal, John H, Sanacora, Gerard – Glutamate Modulating Agents in the Treatment of Mental Disorders US Patent No. 8778979 B2 Patent Issue Date: July 15, 2014. US Patent Application No. 15/695164: Filing Date: 09/05/2017; 3) Charney D, Krystal JH, Manji H, Matthew S, Zarate C, - Intranasal Administration of Ketamine to Treat Depression United

States Application No. 14/197767 filed on March 5, 2014; United States application or Patent Cooperation Treaty (PCT) International application No. 14/306382 filed on June 17, 2014; 4) Zarate, C, Charney, DS, Manji, HK, Mathew, Sanjay J, Krystal, JH, Department of Veterans Affairs "Methods for Treating Suicidal Ideation", Patent Application No. 14/197.767 filed on March 5, 2014 by Yale University Office of Cooperative Research; 5) Arias A, Petrakis I, Krystal JH. – Composition and methods to treat addiction. Provisional Use Patent Application no. 61/973/961. April 2, 2014. Filed by Yale University Office of Cooperative Research.; 6) Chekroud, A., Gueorguieva, R., Krystal, J.H. "Treatment Selection for Major Depressive Disorder" [filing date June 3, 2016, USPTO docket number Y0087.70116US00]. Provisional patent submission by Yale University; 7) Gihyun, Yoon, Petrakis I., Krystal J.H.—Compounds, Compositions and Methods for Treating or Preventing Depression and Other Diseases. U.S. Provisional Patent Application No. 62/444552, filed on January 10, 2017 by Yale University Office of Cooperative Research OCR 7088 US01; and 8) Abdallah, C., Krystal, J.H., Duman, R., Sanacora, G. Combination Therapy for Treating or Preventing Depression or Other Mood Diseases. U.S. Provisional Patent Application No. 62/719935 filed on August 20, 2018 by Yale University Office of Cooperative Research OCR 7451 US01.

AUTHOR CONTRIBUTION

Brandon Nichter: Conceptualization (lead); Methodology (lead); Writing – original draft (lead); Writing – review & editing (lead). **Sarah Herzog:** Conceptualization (equal); Writing – review & editing (equal). **Melanie Hill:** Writing – review & editing (equal). **Sonya Norman:** Writing – review & editing (equal). **John Krystal:** Writing – review & editing (equal). **Robert Pietrzak:** Formal analysis (equal); Funding acquisition (equal); Methodology (equal); Supervision (equal); Writing – original draft (equal); Writing – review & editing (equal).

ETHICS APPROVAL AND PATIENT CONSENT

All participants provided informed consent for the NHRVS study, which was approved by the Human Subjects Subcommittee of the VA Connecticut Healthcare System.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, BN, upon request.

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