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A test of the interpersonal theory of suicide in a large, representative, retrospective and prospective study: Results from the Army Study to Assess Risk and Resilience in Servicemembers (Army STARRS)

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ABSTRACT

The interpersonal theory of suicide hypothesizes that perceived burdensomeness, thwarted belongingness, and hopelessness lead to active suicidal thoughts and individuals with active suicidal thoughts and elevated capability for suicide are most likely to attempt suicide. We retrospectively and prospectively tested this theory in a large sample of 7677 U.S. Army soldiers followed post-deployment for up to nine months. The interaction of perceived burdensomeness and hopelessness (*OR* = 2.59) was significantly associated with lifetime suicidal thoughts; however, the interactions of thwarted belongingness and perceived burdensomeness and of thwarted belongingness and hopelessness were not. Consistent with the theory, capability for suicide prospectively predicted suicide attempts during and following deployment (*OR* = 1.22); however, among soldiers reporting lifetime suicidal thoughts, capability did not predict attempts, only perceived burdensomeness did (*OR* = 1.36). Results supported some, but not all, theory hypotheses, suggesting that additional constructs may be needed to better identify the psychological factors that lead soldiers to attempt suicide.

Suicide is a leading cause of death among current United States (U.S.) military service members, particularly among Army soldiers (Hoge & Castro, 2012). Thus, efforts to understand the factors that contribute to risk for suicidal thoughts and suicide attempts in this population are needed. It is clear from recent work that factors that predict suicidal thoughts differ from those that predict suicide attempts among people thinking about suicide and that many more predictors of suicidal thoughts have been documented than predictors of suicide attempts (Franklin et al., 2017; Nock, Kessler, & Franklin, 2016). For these reasons, greater emphasis on the distinction between suicidal thoughts and suicide attempts is needed. However, only limited research has been carried out on the transition from suicidal thoughts to suicide attempts among Army soldiers (Nock et al., 2018; Zuromski et al., 2019).

One theory that has been used to understand the distinction between predicting suicidal thoughts and suicide attempts is the interpersonal theory of suicide (Joiner, 2005; Van Orden et al., 2010). This theory has three main hypotheses. First, it states that *perceived burdensomeness* (the perception that one's death is worth more to others than one's life) and *thwarted belongingness* (cf. loneliness; the perception that one does not belong and is not accepted by others) are sufficient and proximal causes of passive suicidal desire (desire to be dead). Second, it hypothesizes that the simultaneous presence of perceived burdensomeness, thwarted belongingness, and *hopelessness* about these states improving in the future are sufficient and proximal causes of active suicidal desire (desire to kill oneself). Although the presence of either perceived burdensomeness or thwarted belongingness may contribute to suicidal desire, the presence of both constructs results in the

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greatest risk for potentially lethal levels of suicidal ideation. Third and most importantly, this theory states that thoughts about suicide are insufficient in themselves to prompt suicidal behaviors—among individuals with active suicidal desire, those who are most likely to engage in near-lethal or lethal suicidal behaviors have the *capability for suicide* through increased pain tolerance and fearlessness about death. This theory acknowledges that there are other risk factors for suicidal behavior—that is, the simultaneous presence of thwarted belongingness, perceived burdensomeness, hopelessness about thwarted belongingness and perceived burdensomeness, and the capability for suicide are sufficient, but not necessary, for suicidal behavior.

A recent meta-analysis of published and unpublished, largely cross-sectional work found support for all three hypotheses of the interpersonal theory across a variety of populations (Chu et al., 2017). In particular, the studies reviewed found that repeated exposure to painful and provocative events (Smith, Cukrowicz, Poindexter, Hobson, & Cohen, 2010; Van Orden, Witte, Gordon, Bender, & Joiner, 2008), engagement in self-injurious or risky behaviors (Kerbrat et al., 2015; Smith et al., 2010), genetic risk factors for aggression, pain tolerance, and impulsivity (Smith et al., 2012), and significant exposure to death and violence, including combat experiences (Bryan & Cukrowicz, 2011; Bryan, Cukrowicz, West, & Morrow, 2010) and familiarity with firearms (Butterworth, Daruwala, & Anestis, 2018), all contribute to a greater capability for suicide. Military service members are more likely to have a higher capability for suicide (Assavedo et al., 2018), possibly due to self-selection for to exposure to experiences that facilitate habituation to violence, death, and pain (e.g., Bryan & Cukrowicz, 2011; Selby et al., 2010). Thus, elevated capability for suicide may, in part, explain why military service members who are thinking about suicide have higher rates of suicidal behaviors than civilians (Reger et al., 2018).

Nevertheless, in military samples, studies investigating the associations between the interpersonal theory of suicide constructs and suicidal outcomes have yielded mixed results. For example, in studies of active duty U.S. Air Force personnel (N = 88, 62.5% male; Bryan, Morrow, Anestis, & Joiner, 2010) and deployed current military members seeking psychiatric treatment ($N_{sample1}$ = 137, 92.7% male; $N_{sample2}$ = 55, 87.9% male; Bryan, Clemans, & Hernandez, 2012), the interaction of perceived burdensomeness and capability for suicide was associated with greater suicide risk, but not the interaction between perceived burdensomeness, thwarted belongingness, and capability for suicide. Bryan and colleagues' (2010; 2012) results suggested that perceived burdensomeness was more robustly associated with suicidal thoughts than thwarted belongingness for soldiers given that perceived burdensomeness may be worsened by the perception that one is unable to fulfill one's responsibilities to the unit and thwarted belongingness may be mitigated by the culture of collectivism and in-group bonding (Bryan, Jennings, Jobes, & Bradley, 2012). However, these two studies by Bryan, Morrow, Anestis, and Joiner (2010; 2012) did not distinguish between suicidal thoughts and suicide attempts. In one study that differentiated between suicidal thoughts and attempts and examined 185 Veterans seeking inpatient psychiatric treatment (48.1% male), the three-way interaction of theory constructs was also not associated with suicide attempt history; however, the interaction of thwarted belongingness and perceived burdensomeness was associated with current suicidal thoughts (Monteith, Menefee, Pettit, Leopoulos, & Vincent, 2013). In contrast, other studies have supported the interpersonal theory's hypotheses. In both Anestis and colleagues' (2015) study of 934 U.S. military personnel (National Guard, 77.7% male) and Silva and colleagues' (2017) study of 3428 U.S. active duty Army recruiters (90.5% male), the interaction of thwarted belongingness and perceived burdensomeness was associated with suicidal thoughts, and the interaction of thwarted belongingness, perceived burdensomeness, and capability for suicide was associated with suicide attempt history.

There are five important limitations to existing research on this topic. First, the studies reporting partial support for the theory used smaller sample sizes; therefore, these studies had limited statistical power for analyses testing the joint effect of three independent variables, which increases the likelihood that the observed effects were overestimated (Button et al., 2013). Second, existing studies have focused on explaining history of suicide attempts using cross-sectional study designs and thus, were unable to examine whether the interpersonal theory constructs prospectively predict suicide attempts. This is an important question given that the interpersonal theory of suicide specifically posits that the intersection of thwarted belongingness, perceived burdensomeness, hopelessness, and capability for suicide predicts *future* near-lethal or lethal suicide attempts (Joiner, 2005; Van Orden et al., 2010). Third, only one prior cross-sectional study has examined this theory in a sample of active duty Army soldiers. Given that Army soldiers have the highest rate of suicidal behavior among U.S. military personnel (Hoge & Castro, 2012), larger prospective studies of this subset of the military population are indicated. Fourth, none of the aforementioned military studies examined the construct of hopelessness, which is hypothesized to be an important contributor to active suicidal desire according to the theory. Fifth and finally, Chu and colleagues' (2017) meta-analysis of the literature on this theory found that associations *not* directly hypothesized by the interpersonal theory—such as that between the interaction of perceived burdensomeness and capability for suicide (absent thwarted belongingness), and suicide attempts—were also statistically significant. To determine the specificity of the interpersonal theory hypotheses, evaluation of these non-hypothesized associations is needed.

The purpose of this work was to test the interpersonal theory of suicide by examining the association between theory constructs and suicidal thoughts and suicide attempts in a large sample of 7677 active duty Army soldiers evaluated prior to deployment and for up to nine months after returning from deployment. Consistent with the interpersonal theory (Van Orden et al., 2010), we expected thwarted belongingness, perceived burdensomeness, and general hopelessness and the interactions between these variables to be significantly associated with lifetime suicidal thoughts. We also expected the capability for suicide at baseline to significantly predict suicide attempts during and following deployment. This research addressed the five aforementioned limitations of existing work—in addition to using a large sample of Army soldiers, this study investigated suicide attempts using a prospective study design, the role of general hopelessness in the context of this theory, and non-hypothesized associations between theory constructs and suicidal thoughts and behaviors.

1. Method

1.1. Participants and procedures

Data are from the Pre-Post Deployment Study (PPDS) of the *Army Study to Assess Risk and Resilience in Servicemembers* (Army STARRS; (Ursano et al., 2014)). The PPDS was a four-wave panel survey of three Army Brigade Combat Teams (BCTs) assessed 1–2 months before deployment to Afghanistan (average deployment length of 10 months) in 2012 (baseline [T0]) and three times after returning from deployment (within one month after [T1], two months after T1 [T2], and six months after T2 [T3]). The last T3 survey was administered 30 months after T0. Retrospective questions about suicide attempts during deployment and the period since the deployment were asked in the T2 and T3 surveys. Participants provided written informed consent to have their de-identified administrative records linked to their de-identified survey responses for the purposes of analysis. The recruitment, consent, and data protection procedures in the above surveys were approved by the Harvard University's Committee on the Use of Human Subjects (Harvard University Area IRB #F18173; Harvard Medical School IRB #M18189) and all other collaborating organizations. Additional details on PPDS design and sampling are described elsewhere (Kessler et al., 2013a, 2013b).

Of the 9949 soldiers in the BCTs, 9488 (95.4%) consented to

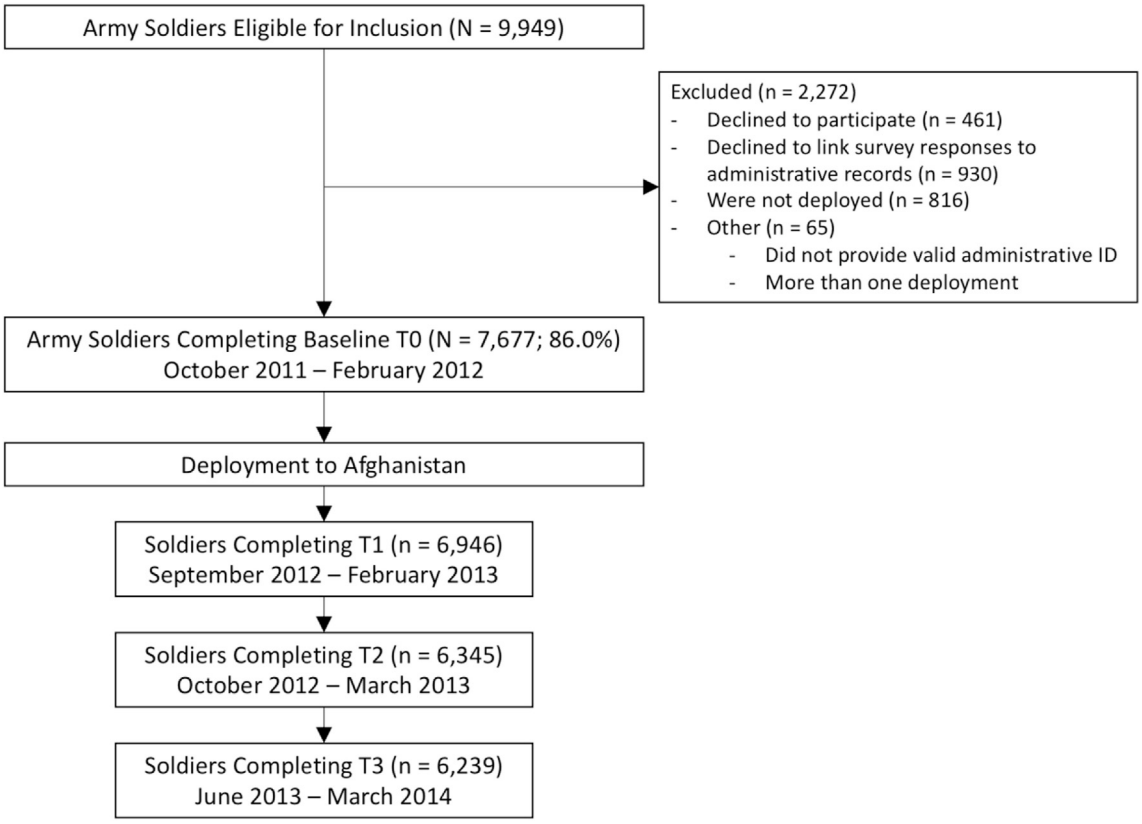

Fig. 1. Participants. Army soldiers in this study completed baseline assessments (T0; October 2011–February 2012) prior to unit deployment to Afghanistan and post-deployment, follow-up surveys were completed within one month (T1; September 2012–February 2013), two months (T2; October 2012–March 2013), and 9–12 months T3; June 2013–May 2014) after return.

participate in the T0 survey, with 8558 (86.3%) completing that survey and consenting to link their survey responses to their administrative records. Of the latter respondents, 7742 (90.5%) subsequently deployed to Afghanistan. Analyses were restricted to the 7677 T0 respondents who agreed to administrative record linkage and provided a valid administrative ID number and had only one deployment between T0 and T3 (see Fig. 1). All soldiers included in this study were in the full-time active component of the U.S. Army (i.e., Regular Army) at T0, and primarily male (94.9%, SE = 0.5) with an average age of 26.9 years (*SE* = 0.2, min = 18, max = 54). Soldiers in this sample identified as non-Hispanic White (68.0%, *SE* = 0.7), non-Hispanic Black (12.6%, *SE* = 0.6), Hispanic (12.1%, *SE* = 0.4), and Other (7.3%, *SE* = 0.3). Importantly, we did not require participation in either the T2 or T3 surveys to be included in the analysis, as information about administratively recorded suicide attempts available in medical records could be used as the outcome among respondents with missing survey data. The analysis dataset was additionally weighted to adjust for non-response bias in the baseline sample with respect to administrative information available for the soldiers approached to participate in the study.

1.2. Measures

Socio-demographic and Army career characteristics. Information about socio-demographic and Army career characteristics was abstracted from administrative records. In all multivariable models, we controlled for the following four socio-demographic characteristics, including the respondent's age, gender (two categories: male; female), education (two categories: high school or less; some college or more), and marital status (two categories: previously married and not currently engaged; single and never married, or married). Additionally, we controlled for two dummy variables of deployment-related characteristics—one dummy variable reflected deployment history (two categories: previously deployed; never deployed) and the other reflected deployment timing (two categories: deployed within the first year of service; not deployed within first year). Soldiers identifying as male who report a history of high school education or less, have previously been married and are not currently engaged, and were deployed within the first year of service were more likely to endorse suicidal thoughts and suicide attempts in previous Army STARRS studies (e.g., Millner et al., 2018; Zuromski et al., 2020). Thus, the aforementioned characteristics were included as covariates.

Suicidal thoughts. Lifetime suicidal thoughts were assessed at T0 using two self-report items adapted from the Columbia-Suicide Severity Rating Scale (C-SSRS), a clinician-administered measure of suicidal thoughts and behaviors with adequate psychometric validity (Posner et al., 2011). One item assessed active suicidal thoughts ("*Did you ever have thoughts of killing yourself?*") and the other assessed passive suicidal thoughts ("*Did you ever wish you were dead or would go to sleep and never wake up?*"). In this study, positive responses were combined into a single dichotomous measure of lifetime suicidal thoughts at baseline.

Suicide attempt. Self-reported suicide attempts at T2 or T3 were assessed using one self-report item adapted from the C-SSRS ("*Did you ever make a suicide attempt; that is, purposefully hurt yourself with at least some intention to die?*"; Posner et al., 2011). At T2, soldiers were additionally asked to indicate any suicide attempts that occurred during their recent deployment and since returning from that deployment. At T3, soldiers who participated in the T2 survey were also asked to indicate any suicide attempt that occurred following T2, and soldiers who did not participate in T2 were asked to report any suicide attempt that occurred during the recent deployment or since returning from that deployment. Specifically, suicide attempts occurring after T0 were coded yes if (1) the soldier reported a suicide attempt at any time during or following their recent deployment in either the T2 or T3

surveys or, (2) a suicide attempt was documented in the soldier's administrative record in the 30 months after T0. Administrative records of suicide attempts were obtained from the Army STARRS Historical Administrative Data Study (HADS), which includes individual-level records from 38 Army and DoD administrative data systems for all soldiers on active duty between January 1, 2004 and December 31, 2014 (Kessler, Colpe et al., 2013). Records specifically relating to suicide attempts were retrieved from four HADS data systems. The first was the Department of Defense Suicide Event Report (DoDSER; Gahm et al., 2012), a DoD-wide surveillance mechanism that aggregates information on suicidal thoughts and behaviors (suicide attempts, suicide deaths) involving hospitalization via a standardized form completed by medical providers at DoD treatment facilities. The other three HADS data systems were the three healthcare encounter systems available for soldiers: the Military Health System Data Repository, the Theater Medical Data Store, and the TRANSCOM (Transportation Command) Regulating and Command and Control Evacuating System (TRAC^{2}ES). These data systems together provide healthcare encounter information from military and civilian treatment facilities, combat operations, and aeromedical evacuations. In this study, suicide attempt history was based on the presence of either (1) DoDSER records indicating a suicide attempt or, (2) an International Classification of Diseases, 9th Revision-Clinical Modification (ICD-9-CM) diagnostic code from one or more of the healthcare encounter systems for a suicide attempt (E950-E958).

Perceived burdensomeness. The Interpersonal Needs Questionnaire (INQ; Van Orden et al., 2008) was developed to measure perceived burdensomeness (INQ-PB 6 items) and thwarted belongingness (INQ-TB 9 items). Consistent with all prior military studies on the interpersonal theory (Anestis, Khazem, Mohn, & Green, 2015; Bryan et al., 2012, 2010; Silva et al., 2017), the INQ was used to measure perceived burdensomeness at T0; however, in this study, to reduce participant burden, two items from the INQ-PB were administered. Each item was rated on a 5-point Likert scale ranging from 1 (not at all like me) to 5 (exactly like me) and subsequently standardized (mean = 0, standard deviation = 1), summed, and re-standardized to create a total score for perceived burdensomeness. Similar to a previous military study on the interpersonal theory (Bryan et al., 2010), a dummy variable was created for respondents in the top one-third of the total distribution of perceived burdensomeness. With equal weights across items, Cronbach's α was 0.83 ($p < 0.001$).

Thwarted belongingness. Prior military studies on the interpersonal theory have used the INQ to measure thwarted belongingness (Anestis et al., 2015; Bryan et al., 2012, 2010; Silva et al., 2017). The INQ was not used to measure thwarted belongingness as this study was a secondary analysis of data collected by the Army STARRS, which did not include the INQ-TB items. To comprehensively capture soldiers' perceptions of thwarted belongingness in the context of military service and deployment, we incorporated not only soldiers' general experience of social disconnection, but also their perceptions of unit cohesion, which reflects their connectedness and bond with other soldiers in their unit and unit leaders on whom they rely while deployed (Van Epps, 2008). Social disconnection (i.e., lack of perceived social support; You, Van Orden, & Conner, 2011) and the lack of unit cohesion have both been shown to be significantly associated with thwarted belongingness and suicidal thoughts and behaviors (Anderson et al., 2019; Trachik et al., 2020; You et al., 2011).

To assess for social disconnection, respondents were asked to indicate the number of individuals in their lives who fall into four categories (e.g., *People who you feel close to*). Response categories were 0, 1, 2, 3, 4, 5, 6–10, 11–20, 21–30, and 31+. The scale was standardized and reverse-scored, such that higher scores indicated less interpersonal connection or greater thwarted belongingness; Cronbach's α for a scale with equal weights across these items was 0.85 ($p < 0.001$). Unit cohesion was derived from 16 self-report items created for this study; items were rated on Likert scales of varying ranges. This scale was also standardized such that higher scores on this scale indicated lower unit cohesion; Cronbach's α for this scale with equal weights across these items was 0.89 ($p < .001$). The scales for social disconnection and lack of cohesion with their military unit were standardized, combined, and equally weighted to create a proxy measure of thwarted belongingness at T0.[1] Again, similar to Bryan, Morrow, et al.'s (2010) military study on the interpersonal theory, to examine the association between high levels of thwarted belongingness and other interpersonal theory constructs, a dummy variable was created for respondents in the top one-third of the total distribution of thwarted belongingness (i.e., the lowest one-third in terms of number of people in their personal lives).

Hopelessness. The interpersonal theory proposes that suicidal desire results when thwarted belongingness and perceived burdensomeness are both perceived to be intractable. A measure for this component of the theory is in development (Tucker et al., 2018) and was unavailable in this study. No military studies of this theory have included hopelessness. Thus, consistent with previous non-military studies (e.g., Hagan, Podlogar, Chu, & Joiner, 2015), we used general hopelessness (i.e., the belief that one's current overall state is intractable) as a proxy. To measure hopelessness, three items were adapted from the Beck Hopelessness Scale (Beck, Weissman, Lester, & Trexler, 1974), a self-report, true-false measure of negative expectations and hopelessness about the future. Items were rated on a 5-point Likert scale ranging from 1 (not at all like me) to 5 (exactly like me). Cronbach's α for this scale with equal weights across these three items was 0.84 ($p < 0.001$). Consistent with our approach for thwarted belongingness and perceived burdensomeness, this scale was also standardized and a dummy variable reflecting high levels of hopelessness was created for respondents in the top one-third of the total distribution of hopelessness.

Capability for suicide. The Acquired Capability for Suicide Scale (Van Orden et al., 2008) is a 20-item measure of capability for suicide that has been used in all prior military studies on this theory (Anestis et al., 2015; Bryan et al., 2012, 2010; Silva et al., 2017). In this study, only three self-report items adapted from the ACSS (Van Orden et al., 2008) that measure fearlessness about death were used to assess capability for suicide to reduce participant burden. Given that the interpersonal theory hypothesizes that individuals with the capability for suicide also demonstrate elevated pain tolerance, two self-report items from the UPPS Impulsive Behavior Scale (Whiteside & Lynam, 2001) were included. All five items were rated on a 5-point Likert scale ranging from 1 (not at all like me) and 5 (exactly like me). Cronbach's α for this scale with equal weights across these items was 0.76 ($p < 0.001$). Consistent with Bryan, Morrow, et al.'s (2010) military study, this scale was also standardized and a dummy variable was created for respondents in the top one-third of the total distribution of this construct.

Details regarding the items comprising each of the four interpersonal theory constructs and construct validity are presented in the Supplemental Appendix A; we view these validity data as robust.

1.3. Analysis method

Primary analyses. First, we examined bivariate associations of each interpersonal theory construct with suicidal thoughts and suicide attempts. A logistic link function was used to estimate initial models for the bivariate associations of T0 perceived burdensomeness, T0 thwarted belongingness, T0 hopelessness, and T0 capability for suicide with T0 reports of suicidal thoughts and suicide attempts subsequent to T0.

Second, we examined the three two-way interactions between thwarted belongingness, perceived burdensomeness, and general hopelessness at baseline as correlates of lifetime suicidal thoughts; we were unable to evaluate a three-way interaction between these constructs due to insufficient statistical power. We expected that all of

[1] Social disconnection was also entered into analyses individually, without unit cohesion, and the pattern of results remained the same.

Table 1
Summary of models evaluating the association between the interpersonal theory of suicide and suicidal thoughts and prospective suicide attempts.

Model	Sample	Predictors	Outcome
A	All soldiers	PB,TB,Hopeless	Suicidal thoughts
B	All soldiers	PB,TB,Hopeless PBxTB, PBxHopeless, TBxHopeless	Suicidal thoughts
C	All soldiers	PB,TB,Hopeless,CS	Suicide attempt
D	Soldiers with lifetime suicidal thoughts	PB,TB,Hopeless,CS	Suicide attempt
E	All soldiers	PB,TB,Hopeless,CS	Suicidal thoughts
F	All soldiers	PB,TB,Hopeless,CS PBxTB, PBxHopeless, TBxHopeless	Suicidal thoughts
G	All soldiers	PB,TB,Hopeless	Suicide attempt
H	All soldiers	PB,TB,Hopeless,CS CSxPB, CSxTB, CSxHopeless	Suicide attempt

Note. PB = perceived burdensomeness; TB = thwarted belongingness; CS = capability for suicide; Hopeless = hopelessness. Lifetime suicidal thoughts were measured at T0 baseline and suicide attempts were measured during and following deployment at T2 and T3.

these two-way interactions would be associated with lifetime suicidal thoughts. Third and finally, we examined whether perceived burdensomeness, thwarted belongingness, hopelessness, and capability for suicide at baseline would prospectively predict suicide attempts during deployment; this was analyzed in two ways as there was insufficient power to examine three- or four-way interactions. We expected that the capability for suicide at baseline would significantly predict suicide attempts during and following deployment beyond the other interpersonal theory constructs, and we also hypothesized that among the subset of soldiers reporting lifetime suicidal thoughts, baseline capability for suicide would predict suicide attempts at follow-up.

Next, we examined the association between the interpersonal theory constructs (individually) at baseline and lifetime suicidal thoughts in Model A where we examined whether the joint additive associations of T0 thwarted belongingness, T0 perceived burdensomeness, and T0 hopelessness predicted T0 suicidal thoughts. In line with the interpersonal theory, we expected that soldiers reporting high levels of social disconnection and lack of cohesion with their military unit (i.e., thwarted belongingness), perceived burdensomeness, and/or general hopelessness would be more likely to endorse lifetime suicidal thoughts.

Third, we examined whether the interactive presence of perceived burdensomeness, thwarted belongingness, and hopelessness predicted lifetime suicidal thoughts. Due to insufficient statistical power (detailed below), we were unable to estimate the significance of the three-way interaction among these hypothesized predictors. However, there was sufficient power to evaluate the significance of the three two-way interactions between each of the pairs made up of the three predictors. The main effects of these predictors in addition to the three two-way interactions were included in a multivariable model predicting T0 suicidal thoughts (Model B). We expected that all of these two-way interactions would be associated with lifetime suicidal thoughts.

Given that the interpersonal theory of suicide emphasizes that thwarted belongingness, perceived burdensomeness, and hopelessness are proximal indicators of suicidal thoughts (Van Orden et al., 2010), we conducted exploratory analyses examining the aforementioned Models A and B with T0 past-month suicidal thoughts as the outcome variable (for details, see Supplemental Appendix B). However, caution is warranted when interpreting these findings as few soldiers reported T0 past-month suicidal thoughts (n = 79) and consequently, these models were likely overfit.

Fourth, we examined whether perceived burdensomeness, thwarted belongingness, hopelessness, and capability for suicide at baseline would prospectively predict suicide attempts during deployment; this was analyzed in two ways as there was insufficient power to examine three- or four-way interactions—a challenge that other studies on this theory have faced (e.g., Silva et al., 2017). Among the entire sample of deployed soldiers, we constructed a multivariable model with T0 perceived burdensomeness, T0 thwarted belongingness, T0 hopelessness, and T0 capability for suicide as predictors of suicide attempts subsequent to T0 (Model C). We also examined T0 perceived burdensomeness, T0 thwarted belongingness, T0 hopelessness, and T0 capability as predictors of suicide attempts subsequent to T0 in the subset of respondents endorsing T0 lifetime suicidal thoughts (n = 854; Model D). We expected that the capability for suicide at baseline would significantly predict suicide attempts during and following deployment beyond the other interpersonal theory constructs, and we also hypothesized that among the subset of soldiers reporting lifetime suicidal thoughts, baseline capability for suicide would predict suicide attempts at follow-up.

Fifth and finally, we examined non-hypothesized associations between the interpersonal theory constructs and suicidal thoughts and suicide attempts. First, we evaluated whether T0 capability for suicide is a significant correlate when added to the additive predictors in Model A (Model E) and the more complex set of interactions in Model B (Model F). We did not expect capability for suicide to be significantly associated with suicidal thoughts in either Model E or F. Next, we modeled T0 perceived burdensomeness, T0 thwarted belongingness, and T0 hopelessness (without T0 suicidal thoughts or T0 capability for suicide) as predictors of suicide attempts following T0 (Model G). The theory hypothesizes that without the capability for suicide, a suicide attempt is unlikely to occur; thus, we did not expect perceived burdensomeness, thwarted belongingness, and hopelessness to significantly predict subsequent suicide attempts. Finally, given evidence that the interaction of perceived burdensomeness and capability for suicide (without thwarted belongingness) predicts suicide attempts (e.g., Bryan et al., 2012), in Model H, we examined alternative two-way interactions between the interpersonal theory variables as prospective predictors of suicide attempts. We used dummy variables for the two-way interactions between high levels of capability for suicide (i.e., top tertile) and each of the other three interpersonal theory variables and included these interactions and their corresponding main effects in a multivariable model predicting subsequent suicide attempts (Model H).

See Table 1 for a summary of tested models. For all models, logistic coefficients and their 95% confidence intervals (CIs) were exponentiated to generate odds-ratios (*OR*s) and their 95% CIs. As the PPDS data were both clustered and weighted, the design-based Taylor series linearization method was used to estimate standard errors of logistic coefficients. Significance of predictor sets was evaluated using design-based Wald χ^2 tests. For each model, we tested the hypothesis that any given predictor from the set of predictors was significantly different from the null. Due to the number of models we tested, we applied the Bonferroni correction for multiple comparisons, where k = 8 multivariable models and adjusted two-tailed α = 0.00625, to maintain a family-wise error rate of $<$ 0.05.

Covariates. In addition to sociodemographic and Army career characteristics, two other variables were included as covariates in all models *a priori*. First, respondents varied both in the amount of time

Table 2
Bivariate associations between the interpersonal theory of suicide and suicidal thoughts and prospective suicide attempts.

Predictors	Lifetime Suicidal Thoughts		Suicide Attempt	
	OR	[95% CI]	*OR*	[95% CI]
Perceived Burdensomeness	1.44*	[1.34, 1.56]	1.26*	[1.13, 1.41]
Thwarted Belongingness	1.75*	[1.61, 1.90]	1.34*	[1.09, 1.65]
Hopelessness	1.86*	[1.77, 1.95]	1.32*	[1.15, 1.51]
Capability for Suicide	1.20*	[1.10, 1.31]	1.28*	[1.04, 1.57]

Note. * < 0.05 (two-sided). N = 7677. *OR* = odds ratio; CI = confidence interval. All bivariate models controlled for demographics, Army career characteristics, months in administrative data, and T2/T3 survey completion.

they were in service after returning from deployment and in the amount of time they were followed in administrative records (which, as noted above, were available through December 31, 2014 for all respondents regardless of duration of deployment). This issue would normally be addressed by using survival analysis, but this was not possible in the current case because of the coarseness of assessing the timing of a suicide attempt in the surveys (i.e., during deployment vs. since returning from deployment). Second, as noted above, respondents varied in whether they completed the T2 and/or T3 surveys, leading to data on suicide attempts being more complete for some respondents than others. Consequently, the analysis was carried out at the person level with controls for length of time between T0 and the end of availability of administrative data (either December 31, 2014 or date of separation from active duty service, whichever came first) and for the surveys that were completed (separate dummy control variables for participation in both the T2 and T3 surveys, T2-only, and T3-only, with a contrast category for not participating in either the T2 or T3 surveys).

Power Analyses. Based on effect sizes drawn from a meta-analysis of the interpersonal theory (Chu et al., 2017), we conducted power analyses. With a sample size of 7,677, we had sufficient power (> 0.80) to detect the main effects of the interpersonal constructs (*ORs* = 1.38–7.27; Chu et al., 2017) and the effects of the two-way interactions between theory constructs (*ORs* = 1.55–2.09; Chu et al., 2017) on suicidal outcomes using logistic regression. Given that only 1.3% of respondents in this sample reported a suicide attempt at follow-up, we did not have sufficient power (< 0.80) to examine the effects of the interactions between more than two theory constructs on suicide attempts (*ORs* = 1.24–1.73; Chu et al., 2017).

2. Results

2.1. Prevalence and distribution of suicide attempts

A total of 103 T0 PPDS respondents (1.3%) were found to have a suicide attempt in the 30 months after T0. About half (52.1%) of the cases of suicide attempts were found in administrative records, 68.3% in survey reports, and 20.3% in both (Supplemental Table C2 for the distribution of prospective suicide attempts across these sources). The *OR* between the two sources of information is 100.6 (95% CI: 51.9–194.9; χ^2_1 = 199.1, p < 0.001), indicating significant concordance, but the Kappa value of 0.33 (95% CI: 0.22-0.44; Cohen, 1960) indicated only fair concordance (Landis & Koch, 1977, pp. 159–174). Concordance could be lowered by the fact that all respondents had data on administratively recorded suicide attempts whereas some respondents completed neither survey (6.8%) and others completed only one survey (11.0% T2-only, 11.5% T3-only), but even in the subsample of respondents who completed both surveys, Kappa was poor (0.31, 95% CI: 0.18-0.44). Some respondents with complete survey data failed to report suicide attempts in their surveys even though they were recorded in administrative records (27.6% of all documented suicide attempts) and others reported suicide attempts in their surveys that were not documented administratively (44.6% of all documented suicide attempts). Using a conservative capture-recapture method based on the assumption of uncorrelated errors in the two measures, true incidence can be estimated from these results as 2.3% (1.6%–3.0%; Brittain & Bohning, 2009). This estimate may be considered a lower bound on true incidence under the assumption that the errors in the two measures are either uncorrelated or positively correlated such that those with true cases who reported a suicide attempt in the survey were more likely than others to have a suicide attempt detected administratively (Chao, 1987, pp. 783–791).

2.2. Correlates of lifetime suicidal thoughts

The distributions of sociodemographic and Army career characteristics, the bivariate models evaluating the individual association between suicide attempts and each demographic and Army career characteristic, and the multivariate model evaluating the association between suicide attempts and all demographic and Army career characteristics are shown in the Supplemental Table C1. Bivariate associations between the interpersonal theory constructs and lifetime suicidal thoughts and suicide attempts are shown in Table 2.

Perceived burdensomeness, thwarted belongingness, and hopelessness were all uniquely associated with lifetime suicidal thoughts;

Table 3
Interpersonal theory of suicide predictors of lifetime suicidal thoughts and prospective suicide attempts.

	Multivariable Model A		Multivariable Model B		Multivariable Model C		Multivariable Model D[a]	
Outcomes	Suicidal Thoughts		Suicidal Thoughts		Suicide Attempts		Suicide Attempts	
Predictors	*OR*	95% CI	*OR*	95% CI	*OR*	95% CI	*OR*	95% CI
Main Effects								
PB	1.13*	[1.05, 1.23]	0.99	[0.89, 1.10]	1.13	[0.96, 1.33]	1.36*	[1.09, 1.70]
TB	1.36*	[1.24, 1.48]	1.40*	[1.25, 1.56]	1.16	[0.90, 1.49]	0.96	[0.66, 1.41]
Hopeless	1.61*	[1.53, 1.71]	1.56*	[1.45, 1.67]	1.12	[0.91, 1.39]	0.94	[0.69, 1.29]
CS					1.22*	[1.01, 1.47]	0.82	[0.45, 1.52]
Interaction Effects								
High PB x High TB			0.84	[0.52, 1.36]				
High PB x High Hopeless			2.59*	[1.77, 3.79]				
High TB x High Hopeless			0.91	[0.65, 1.27]				

Note. * < 0.0063 (two-sided, Bonferroni-corrected). N = 7677. PB = perceived burdensomeness; TB = thwarted belongingness; CS = capability for suicide; Hopeless = hopelessness. *OR* = odds ratio; CI = confidence interval. All multivariable models controlled for demographics, Army career characteristics, months in administrative data, and T2/T3 survey completion.

[a] Multivariable Model D was tested only among deployed soldiers reporting lifetime suicidal thoughts at T0 baseline (n = 854).

however, effect sizes for these associations were small, ranging from $OR = 1.13$ to $OR = 1.61$ ($p < 0.0063$; Table 3, Model A). Furthermore, the interaction of thwarted belongingness and perceived burdensomeness was not significantly associated with lifetime suicidal thoughts ($OR = 0.84$; Table 3, Model B). The odds of presenting with lifetime suicidal thoughts were greater among those only reporting significant feelings of hopelessness ($OR = 1.40$, $p < 0.0063$) and even greater among those reporting high levels of both hopelessness and perceived burdensomeness ($OR = 2.59$, $p < 0.0063$; Table 3, Model B).

Next, we conducted exploratory analyses examining Models A and B using T0 past-month suicidal thoughts. The pattern of findings remained largely the same as that observed in models with T0 lifetime suicidal thoughts (Supplemental Table B2); however, there were two main differences. First, the effects thwarted belongingness, hopelessness, and the interaction of hopelessness and perceived burdensomeness on suicidal thoughts were stronger in models examining past-month thoughts than in those examining lifetime thoughts. Second, perceived burdensomeness was significantly associated with lifetime suicidal thoughts and not significantly correlated with past-month suicidal thoughts (Model A; Table 3, Supplemental Table B2).

2.3 Prospective predictors of suicide attempts

We examined the interpersonal theory constructs as prospective predictors of suicide attempts. Capability for suicide prospectively predicted suicide attempts after accounting for the effects of other interpersonal theory constructs ($OR = 1.22$, $p < 0.0063$; Table 3, Model C). However, among soldiers reporting lifetime suicidal thoughts at T0, capability for suicide was not a significant predictor of suicide attempts during and following deployment ($OR = 0.82$) and only perceived burdensomeness was a significant predictor of attempts ($OR = 1.36$, $p < 0.0063$; Table 3, Model D).

2.4. Non-hypothesized associations

When T0 capability for suicide was included in Models A and B, capability for suicide was not significantly associated with lifetime suicidal thoughts after accounting for other interpersonal theory constructs ($OR = 1.08$; Table 4, Model E) and after accounting for both the theory variables and the two-way interactions between theory constructs ($OR = 1.08$; Table 4, Model F). T0 perceived burdensomeness, thwarted belongingness, and hopelessness were not associated with suicide attempts ($ORs = 1.14$–1.18; Table 4, Model G). Finally, the main effects of T0 perceived burdensomeness, thwarted belongingness, hopelessness, and capability for suicide as well as the two-way interactions between capability for suicide and each of the other theory constructs were also not significantly associated with suicide attempts ($ORs = 0.92$–1.61; Table 4, Model H).

3. Discussion

We obtained mixed results in this retrospective and prospective study examining the interpersonal theory of suicide hypotheses in a large representative sample of Army soldiers. In retrospective analyses, we found that perceived burdensomeness, thwarted belongingness, and hopelessness, individually, were significant predictors of lifetime suicidal thoughts. However, the simultaneous presence of high levels of perceived burdensomeness and thwarted belongingness was not significantly associated with lifetime suicidal thoughts. In prospective analyses, capability for suicide at baseline predicted suicide attempts during and following deployment, beyond the other interpersonal theory constructs; however, among soldiers reporting lifetime suicidal thoughts, capability for suicide did not predict attempts. Non-hypothesized associations between the interpersonal theory constructs and suicidal thoughts or suicide attempts were not statistically significant. Some, but not all, of these findings were consistent with the interpersonal theory of suicide; several important implications for future research should be highlighted.

First, it is notable that we did not find evidence for a robustly tested hypothesis of the interpersonal theory—the interaction of thwarted belongingness and perceived burdensomeness in the prediction of lifetime suicidal thoughts. Notably, this finding also emerged when we explored past-month suicidal thoughts. Instead, relative to the interpersonal theory constructs, general hopelessness was the most strongly associated with lifetime suicidal thoughts, both individually ($OR = 1.61$) and interactively with perceived burdensomeness ($OR = 2.59$). This suggests that soldiers who feel hopeless about their present circumstances and perceive themselves to be a burden on others are more likely to report suicidal thoughts. However, overall, thwarted belongingness and perceived burdensomeness, though indicators of suicidal thoughts, were not better than general hopelessness. Similar patterns have been described in the broader literature on non-military samples—studies have found that not only is general hopelessness one

Table 4
Non-hypothesized associations between interpersonal theory of suicide predictors and lifetime suicidal thoughts and prospective suicide attempts.

	Multivariable Model E		Multivariable Model F		Multivariable Model G		Multivariable Model H	
Outcomes	Suicidal Thoughts		Suicidal Thoughts		Suicide Attempts		Suicide Attempts	
Predictors	*OR*	95% CI	*OR*	95% CI	*OR*	95% CI	*OR*	95% CI
Main Effects								
PB	1.13*	[1.04, 1.23]	0.99	[0.88, 1.10]	1.14	[0.98, 1.33]	1.36*	[1.09, 1.70]
TB	1.37*	[1.25, 1.49]	1.40*	[1.26, 1.56]	1.18	[0.90, 1.54]	0.96	[0.66, 1.41]
Hopeless	1.60*	[1.51, 1.69]	1.54*	[1.44, 1.65]	1.15	[0.94, 1.42]	0.94	[0.69, 1.29]
CS	1.08	[0.98, 1.20]	1.08	[0.97, 1.20]			0.82	[0.45, 1.52]
Interaction Effects								
High PB x High TB			0.84	[0.52, 1.36]				
High PB x High Hopeless			2.58*	[1.76, 3.78]				
High TB x High Hopeless			0.91	[0.65, 1.27]				
High CS x High PB							0.92	[0.31, 2.72]
High CS x High TB							0.92	[0.38, 2.26]
High CS x High Hopeless							1.61	[0.62, 4.21]

Note. * < 0.0063 (two-sided, Bonferroni-corrected). $N = 7677$. PB = perceived burdensomeness; TB = thwarted belongingness; CS = capability for suicide; Hopeless = hopelessness. *OR* = odds ratio; CI = confidence interval. All multivariable models controlled for demographics, Army career characteristics, months in administrative data, and T2/T3 survey completion.

of the more robust predictors of suicidal thoughts (Franklin et al., 2017), but also that it is more strongly correlated with suicidal thoughts than either thwarted belongingness or perceived burdensomeness (Hagan et al., 2015). Our findings suggest a stronger emphasis on hopelessness as a contributor to suicidal thoughts is needed in future work on this theory.

Second, we found that among all Army soldiers in this study, greater capability for suicide significantly predicted suicide attempts during and following deployment, beyond the other theory constructs. Capability for suicide was specifically a predictor of suicide attempts as it was not associated with suicidal thoughts in this study. The association between capability for suicide and suicide risk has been reported by other studies of deployed soldiers (e.g., Bryan & Anestis, 2011; Bryan, Clemens, & Hernandez, 2012; Shelef, Levi-Belz, & Fruchter, 2014); however, no military studies have directly examined capability for suicide as a prospective predictor of suicide attempts. Our results may in part explain why research on the impact of combat experience, prior deployments, and exposure to violence—in short, factors that may all contribute to greater capability for suicide (Bryan & Cukrowicz, 2011)—on suicide risk has been inconclusive (Bryan, 2015; Kang et al., 2015; LeardMann et al., 2013). These combat and deployment factors, alone, may not distinguish those who will attempt suicide. Rather, the confluence of multiple factors that all specifically contribute to greater capability for suicide, including exposure to killing and atrocities during deployment (Bryan et al., 2015) and experiences outside of deployment that increase fearlessness about death and pain tolerance, appears to be a strong indicator of Army soldiers' risk for attempting suicide in the future. This finding was not exclusive to soldiers reporting lifetime suicidal thoughts at baseline, suggesting that capability for suicide is an important suicide attempt indicator regardless of self-reported history of suicidal thoughts. However, it is possible and likely that the severity of suicidal thoughts *during* and *following* deployment determines the impact of capability for suicide on suicide risk. Future military studies should gather information regarding severity of suicidal thoughts after baseline to account for this possibility.

Third, among the subset of Army soldiers reporting a lifetime history of suicidal thoughts, only perceived burdensomeness predicted attempts during and following deployment. No prior studies have shown that perceived burdensomeness may be a predictor of future suicide attempts. However, that perceived burdensomeness is more robustly associated with suicidal thoughts than thwarted belongingness has been observed in other military samples (e.g., Bryan et al., 2012; Chu et al., 2018). For soldiers, perceived burdensomeness may be heightened by the perception that one is not an asset to unit and/or unable to fulfill one's responsibilities, which potentially results in harm to unit members. In contrast, researchers have proposed that thwarted belongingness may be mitigated by the military culture of collectivism and in-group bonding (Bryan, Jennings, Jobes, & Bradley, 2012). Although thwarted belongingness and perceived burdensomeness are often linked, findings suggest that for soldiers, perceived burdensomeness is a more critical suicide risk factor than thwarted belongingness.

It is important to note that all prior studies testing the third hypothesis of the interpersonal theory have examined the three-way interaction between perceived burdensomeness, thwarted belongingness, and capability for suicide or the four-way interaction that includes hopelessness as predictors of suicide attempts as there was insufficient power to evaluate these higher-order interactions. Some military studies on this theory have reported models with three-way interactions without discussing statistical power and it is unclear whether these studies were also underpowered (e.g., Anestis et al., 2015; Bryan et al., 2010; Monteith et al., 2013). Nevertheless, though we could not test either of these interactions, it is likely that in this sample, we would not find support for either the three-way (without hopelessness) or the four-way interactions between interpersonal theory constructs given that the two-way interaction of thwarted belongingness and perceived burdensomeness was not significantly associated with suicidal thoughts.

Overall, our findings were mixed and the effect sizes reported in this study were small-to-moderate, indicating that the interpersonal theory constructs explained little variance in lifetime suicidal thoughts and suicide attempts during and following deployment. In recent meta-analyses (Chu et al., 2017; Franklin et al., 2017), it has become increasingly clear that individual suicide risk factors explain a small proportion of suicides and of variance in suicidal outcomes—this concern is not specific to the interpersonal theory and is also true for other suicide theories (e.g., Integrated Motivational-Volitional Model; O'Connor, 2011) as well as other models of psychopathology. Indeed, most of the effect sizes reported in this study were comparable or even smaller than those reported in Franklin and colleagues' (2017) meta-analysis of suicide risk factors. Although impairments in interpersonal functioning and the development of the capacity for suicide are clearly relevant to understanding suicidal thoughts and behaviors, the specific interpersonal theory constructs are, alone, insufficient for predicting suicidal thoughts and suicide attempts in clinical settings. In light of the small effect sizes obtained in the current study, clinicians seeking to implement the interpersonal theory of suicide into clinical practice should most likely continue with current practices. However, the interpersonal theory constructs may have clinical utility when viewed as individual treatment targets (Stellrecht et al., 2006) and/or evaluated in the context of the broader clinical presentation of suicide risk indicators (Chu et al., 2015). For example, clinicians could consider cognitive-behavioral interventions to target soldiers' sense of burdensomeness (Stellrecht et al., 2006) and means safety approaches for mitigating soldiers' capability for suicide (Barber & Miller, 2014).

3.1. Limitations and future directions

These results need to be considered in the context of several limitations. First, we were unable to evaluate all of the interpersonal theory hypotheses in this sample. For one, the interpersonal theory hypothesizes that the intersection of hopelessness *specifically* about thwarted belongingness and perceived burdensomeness predicts *current* suicidal desire. In this study, there was no measure of hopelessness *specifically* about thwarted belongingness and perceived burdensomeness (a limitation of nearly all of the literature on this theory; Chu et al., 2017). We also examined lifetime suicidal thoughts due to insufficient power to draw conclusions from analyses examining past-month suicidal thoughts. Additionally, in contrast to prior tests of the interpersonal theory, including those reported in a meta-analysis of the theory (Chu et al., 2017), we were unable to evaluate the hypothesized three-way interaction between the interpersonal theory constructs as a predictor of suicide attempts. Although the suicide rate in this sample was is comparable to the rate among US Active Duty Army soldiers (DoDSER, 2014–2016; Military OneSource, 2014–2016), this study did not select for at-risk soldiers. Thus, a relatively small number of respondents attempted suicide, which necessitated a focus on the two-way interactions between theory constructs. Future studies targeting military service members with severe suicidal symptoms during a high-risk period (e.g., following hospitalization for a suicide attempt) may have a higher base rate of attempts and more power to examine three-way interactions. Further, the interpersonal theory constructs and suicidal thoughts were only measured at baseline and not evaluated during or following deployment. Consequently, the temporal order between the putative predictors and the relationship between severity of suicidal thoughts could not be established. Some research suggests that the theory predictors and suicidal outcomes can fluctuate rapidly (Kleiman et al., 2017), while others have found that capability for suicide is stable over two years during deployment (Bryan, Sinclair, & Heron, 2015)—replication studies measuring the theory constructs and suicidal outcomes during and following deployment are needed to adequately test this theory in military populations. Given the malleability of the

interpersonal theory constructs, deployment itself may also impact these constructs; thus, prospective evaluations of the interpersonal theory among non-deployed military service members are also needed. Unfortunately, the optimal timeframe for the proximal prediction of suicide risk in the context of the interpersonal theory is an issue that has yet to be resolved in the literature. Consistent with earlier studies testing the interpersonal theory (e.g., Van Orden et al., 2008), the final follow-up in this study occurred nine months after baseline. In existing work on the longitudinal course of the interpersonal theory constructs in non-military samples, the timeframe between baseline and follow-up has ranged from hours (Kleiman et al., 2017) and months (Chu, Rogers, & Joiner, 2016; George, Page, Hooke, & Stritzke, 2016) to several years (Batterham et al., 2018; Christensen, Batterham, Mackinnon, Donker, & Soubelet, 2014). Continued emphasis on prospective design is needed to understand this theory's window of suicide prediction.

Second, the effects reported may have been attenuated by the use of abbreviated measures of perceived burdensomeness and capability for suicide and proxy measures for thwarted belongingness and hopelessness. Although the inclusion of unit cohesion did not alter the pattern of results and the measures used in this study demonstrated adequate reliability and validity, further work is needed to evaluate the external validity of this approach. Third, concordance between attempts reported in surveys and administrative records was low, with some attempts reported in administrative records that were not reported in the survey and vice-versa. One possibility is that some self-reported suicide attempts may not have been captured in administrative records if they did not result in or necessitate treatment or if soldiers sought treatment at non-military facilities (Zuromski et al., 2019b). Alternatively, it is possible that aborted or interrupted suicide attempts were self-reported as non-lethal suicide attempts. Fourth, suicidal thoughts and suicide attempts may have been underreported given concerns about confidentiality, stigma, and/or biases in recollection of suicidal symptoms (Zinzow et al., 2013). Prior research has sought to reduce these biases through the development of implicit suicide risk measures (Nock et al., 2010) and use of machine learning and natural language processing to determine suicide risk from written text (Velupillai et al., 2019). Fifth, we were unable to obtain complete follow-up data for all baseline respondents. Thus, attrition bias may have occurred due to the nonrandom loss of data to follow-up. It is unclear whether this bias—to the extent that it existed—led to results being either conservative or anti-conservative with respect to the hypotheses evaluated. Finally, the emphasis of this study was on a narrow sample of Army soldiers in three Brigade Combat Teams during deployment to Afghanistan. As such, these findings may not generalize to other military services or underrepresented military service members (e.g., female service members). Relatedly, we examined soldiers with non-lethal suicide attempts and as such, this work was not representative of all military suicides deaths, which are often the result of self-inflicted gunshot wounds incurred during an initial suicide attempt (Anestis & Bryan, 2013).

There have been relatively few longitudinal studies of the interpersonal theory of suicide. To fill this gap, this large study of Army soldiers during deployment examined the hypotheses of the interpersonal theory of suicide. Results were mixed and replication of this study is needed to test the external validity of these results beyond U.S. Army soldiers. Overall, the interpersonal theory constructs contributed small effect sizes and consequently, limited clinical significance. There is potential clinical utility in a broader model that encompasses the interpersonal theory constructs and additional constructs for distinguishing predictors for suicidal thoughts from those for suicide attempts.

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Role of the sponsors

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Disclaimer

The views, opinions and/or findings contained in this research are those of the authors and do not necessarily reflect the views of the Department of the Army, Department of Defense, Department of Health and Human Services, NIMH, or Military Suicide Research Consortium, and should not be construed as an official DoD/Army position, policy or decision unless so designated by other documentation. No official endorsement should be made.

Author declaration

We wish to draw the attention of the Editor to the following facts which may be considered as potential conflicts of interest and to significant financial contributions to this work.

Dr. Stein has in the past three years been a consultant for Actelion, Alkermes, Aptinyx, Bionomics, Dart Neuroscience, Healthcare Management Technologies, Janssen, Neurocrine Biosciences, Oxeia Biopharmaceuticals, Pfizer, and Resilience Therapeutics. Dr. Stein has stock options in Oxeia Biopharmaceticals. The remaining authors report nothing to disclose.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

We further confirm that any aspect of the work covered in this manuscript that has involved human patients has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript.

We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). She is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address, which is configured to accept email and accessible by the Corresponding Author: carol_chu@fas.harvard.edu.

CRediT authorship contribution statement

Carol Chu: Conceptualization, Writing - original draft, Writing - review & editing. **Kelly L. Zuromski:** Writing - original draft, Writing - review & editing. **Samantha L. Bernecker:** Writing - original draft, Writing - review & editing. **Peter M. Gutierrez:** Supervision, Conceptualization, Writing - review & editing. **Thomas E. Joiner:** Supervision, Conceptualization, Writing - review & editing. **Howard Liu:** Software, Formal analysis. **James A. Naifeh:** Writing - review & editing. **Murray B. Stein:** Funding acquisition, Writing - review & editing. **Robert J. Ursano:** Funding acquisition, Writing - review & editing. **Matthew K. Nock:** Supervision, Conceptualization, Writing - review & editing.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.brat.2020.103688.

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