PTSD Symptoms and Suicide Risk among Firefighters: The Moderating Role of Sleep Disturbance

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ABSTRACT

Posttraumatic stress disorder (PTSD) symptoms are prominent among firefighters and related to suicidal ideation and behavior, a major public health concern among first responders. The role of sleep disturbance in the associations between PTSD symptoms and suicide risk is not well understood. The present study examined the moderating effect of global sleep disturbance and five disturbance facets (sleep efficiency, perceived sleep quality, daily disturbances, bad dreams, and pain), on the association between PTSD symptom severity and suicide risk among firefighters. This study was a secondary analysis of data from a larger ongoing project. The sample was comprised of 802 trauma-exposed firefighters, recruited from a large urban fire department in the southern U.S., who completed an online survey. Results indicated that there were significant interactive effects of PTSD symptom severity and global sleep disturbance, sleep efficiency, perceived sleep quality, and daily disturbances with regards to global suicide risk. These findings were maintained after adjusting for gender, prior suicide attempt history, years in the fire service, trauma load, and occupational stress. This study is the first to concurrently examine these variables among firefighters and this line of inquiry has the potential to inform evidence-based policy as well as prevention and treatment programs for this vulnerable, understudied population.

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INTRODUCTION

Suicide is a major public health concern among firefighters (McIntosh et al., 2016; Stanley et al., 2016; Tiesman et al., 2015). Firefighters report higher rates of suicidal thoughts and behaviors as compared to the general population (Martin et al., 2017; Stanley et al., 2015; 2017). It is estimated that approximately 15.5% of firefighters reported having made at least one suicide attempt during their years of service, with 46.8% endorsing career suicide ideation (Stanley et al., 2015). Comparatively, in the general population, the lifetime prevalence rates for suicide attempts and ideation ranged from 1.9-8.7% and 5.6-14.3%, respectively (Nock et al., 2008). Despite the elevated risk of suicidal ideation and risk among firefighters, there is a relative dearth of research examining relevant psychological factors in this vulnerable and understudied population (e.g., Bartlett et al., 2018; Stanley et al., 2016).

Posttraumatic stress disorder (PTSD) offers one pertinent avenue for better understanding suicidal ideation and risk among firefighters (Bartlett et al., 2018; Martin, Tran, & Buser, 2017). Prevalence rates of trauma exposure (e.g. natural disaster relief, accidents, domestic terror events) and PTSD among firefighters have been estimated to be as high as 91.5% (Meyer et al., 2012; Zegel et al., 2019) and 33% (Tomaka et al., 2017), respectively. A well-established body of research has suggested that both trauma exposure and PTSD are related to heightened suicide risk (Arsenault-Lapierre et al., 2004; Bartlett et al., 2018; Bentley et al., 2016; Brenner et al., 2011; Cavanagh et al., 2003; Jankovic et al., 2013; Krysinska & Lester 2010; Krysinska & Martin 2009; Lopez-Castroman et al., 2015; Tarrier & Gregg 2004). Additionally, a growing body of work among firefighters has documented associations between PTSD symptom severity and both suicidal ideation and suicide risk

(Boffa et al., 2017, 2018; Martin et al., 2017; Stanley et al., 2017, 2018). Given firefighters' elevated rates of suicide risk and PTSD symptomatology, it is critical to better understand related behavioral factors, targetable via intervention or occupational policy reform, that may impact the association between PTSD symptoms and suicide risk in this understudied and vulnerable population.

Sleep disturbance, which refers to both the quantitative (e.g. sleep duration, sleep latency, and number of arousals) and qualitative (e.g. depth and restfulness) aspects of sleep (Buysse et al., 1989; Smith et al., 2018), is one such behavioral factor that may be relevant to the investigations of PTSD-suicide risk associations among firefighters (Betts et al., 2013). Sleep disturbance is highly relevant to firefighters because their work often requires frequent sleep disturbances due to long shifts or overnight schedules (Beaton & Murphy, 1993; Harvey et al., 2016; Haugen et al., 2012; Saijo et al., 2008; Smith et al., 2018). Indeed, prevalence rates for sleep-related disturbances among firefighters are estimated to be 51%-59% (Carey et al., 2011; Vargas de Barros et al., 2013), a substantively higher prevalence than the nationally representative rates of 6%-33% estimated among the general population (Ohayon, 2002). Furthermore, approximately 70% of individuals with PTSD have co-occurring sleep problems (Babson & Feldner, 2010; Ohayon & Shapiro, 2000), and sleep disturbance has been identified as both a risk (Gehrman et al., 2013; Germain, 2013; Mellman et al., 1995; Pace-Schott et al., 2015) and maintenance (Germain, 2013; Pace-Schott et al., 2015) factor for PTSD as well as a core feature of the PTSD diagnosis (Calhoun et al., 2007; Dagan et al., 1997; Gilbert et al., 2015; Spoormaker & Montgomery, 2008). PTSD is associated with reduced sleep efficiency, increased sleep latency, increased sleep fragmentation, and greater night-to-night variability in sleep (Breslau et a., 2004; Calhoun et al., 2007; Gilbert et al.,

2015; Habukawa et al., 2007; Mellman et al., 1995; Straus et al., 2015). In congruence with its significant relevance to PTSD, sleep disturbance has been increasingly identified as a potential risk factor for suicide (Bernert & Joiner, 2007; Pigeon et al., 2012; Ribeiro et al., 2012). Cross-sectional and longitudinal studies have shown that global sleep disturbance and multiple sleep problems (e.g. insomnia, poor sleep quality, and nightmares) are related to an elevated risk for suicide and suicide-related behaviors (Goldstein et al., 2008; Hom et al., 2019; Ribeiro et al., 2012; Wong et al., 2011; Ağargün & Cartwright, 2003; Ağargün et al., 1998; Bernert et al., 2005; 2015; Bernert & Joiner, 2010; Fawcett et al., 1990; Tanskanen et al., 2001).

Therefore, both heightened levels of PTSD symptom severity and sleep disturbance are associated with increased suicidal ideation and risk for suicide (Bernert et al., 2005; 2015; Ribeiro et al., 2012; Steyn et al., 2013), particularly among firefighters (Hom et al., 2016; Stanley et al., 2015; 2016; Vargas de Barros et al., 2013). It is theorized that those with more severe PTSD symptoms may experience higher levels of sleep disturbance (Germain et al., 2004; Gilbert et al., 2015; Vargas de Barros et al., 2013) due to recurrent trauma-related intrusions (e.g., nightmares) and arousal and reactivity (e.g., difficulty falling or staying asleep) (APA, 2013; Babson et al., 2012; Insana et al., 2013). The interactive effect of PTSD symptom severity and increased sleep disturbance may ultimately result in elevated suicidal ideation and suicide risk possibly due to the evocation and exacerbation of general emotional dysphoria and emotional dysregulation (Gerhart et al., 2014; Walker & van der Helm, 2009). Firefighters with elevated PTSD symptoms and sleep disturbances may experience an amplification in maladaptive cognitive functioning (e.g., negative self-appraisals, impairments in attending to trauma or sleep-related stimuli and memory consolidation of feared stimuli

habituation; Mellman et al., 2007; Spoormaker et al., 2010; Walker, 2008) and impaired emotion regulation and processing (Hom et al., 2016; 2019; Littlewood et al., 2017). As an individual's risk for suicide is partly predicated on an adaptive capacity to cognitively and affectively cope and confront stressful life events (Vargas de Barros et al., 2013), it is proposed that trauma-exposed firefighters with elevated PTSD symptoms and sleep disturbance would experience greater difficulty coping with traumatic and occupational stressors. More specifically, sleep disturbances may impair emotion modulation (Gerhart et al., 2014; Hom et al., 2019; Walker & van der Helm, 2009), judgment, concentration (Liu, 2004), impulse control (Joiner et al., 2005), and problem-solving ability (Goldstein et al., 2008) while increasing one's susceptibility to fatigue and hopelessness, all demonstrated risk factors for suicidal ideation and suicide risk (Joiner et al., 2005).

Despite the emergent gains in this empirical arena, there remains a relative paucity of research examining suicidal ideation and risk among firefighters (Bartlett et al., 2018; Stanley et al., 2016). Our understanding of the role of sleep disturbance with regard to PTSD symptoms and suicide risk among firefighters is developing but still in a nascent stage. Currently, we are aware of two published studies that have investigated sleep disturbance and its association with risk for suicide and related behaviors among firefighters (Stanley et al., 2016; Vargas de Barros et al., 2013). Furthermore, no studies to date have evaluated the interplay of PTSD symptomatology and sleep disturbance with regard to suicidal ideation and risk in firefighters. These issues represent critical gaps in the literature given the firefighting profession's unique responsibilities, demands, and inherent chronic exposure to both traumatic and stressful events and sleep disruption (Jones, 2017; Stanley et al., 2015; 2016; Zegel et al., 2019).

The present study aimed to fill extant gaps in the empirical literature by examining associations among PTSD symptom severity, sleep disturbance, and suicide-related outcomes among firefighters. First, we hypothesized that higher PTSD symptom severity would be positively associated with global suicide risk. Second, we hypothesized that higher levels of perceived sleep disturbance would be positively associated with global suicide risk. Lastly, we hypothesized that sleep disturbance would moderate the association between PTSD symptom severity and suicide risk. Specifically, it was expected that heightened levels of reported sleep disturbance would amplify, or strengthen, the association between PTSD symptomatology and risk for suicide (see Figure 1). These effects were expected to manifest above and beyond theoretically relevant covariates, including gender, prior suicide attempt history, years in the fire service, trauma load (i.e., total number of traumatic event types experienced), and occupational stress. Covariates were selected due to statistically significant associations with suicide risk among firefighters in the existing literature (Bartlett et al., 2018; 2019; Boffa et al., 2017; 2018; Martin et al., 2017; Vujanovic et al., 2017). Exploratory post hoc analyses were proposed to individually examine five facets of sleep disturbance (i.e. sleep efficiency, perceived sleep quality, daily disturbances, the presence of bad dreams, and pain) as moderators in the model outlined above.

METHOD

Participants

This study was a secondary analysis of data from a larger project examining stress and health-related behaviors among firefighters (Bartlett et al., 2018; 2019; Stanley et al., 2018; Zegel et al., 2019). This sample included 802 career firefighters (93.5% male; M_{age} = 38.68; *SD* = 8.53) recruited from a fire department in a large metropolitan area in the southern

United States. Please see Table 1 for a summary of participant characteristics. All firefighters in this department perform emergency medical services (EMS) in addition to fire suppression. This department assigns shifts based on a schedule consisting of four different 24-hour blocks (A, B, C, D), each beginning at 6:30am. Firefighters are assigned to two non-consecutive shifts (e.g., A and C), while being unassigned to 5 consecutive blocks before assuming the same non-consecutive sequence of shifts (e.g., A and C) (S. Buser, personal communication, May 5, 2020). To be considered eligible for the parent study, participants must have been current firefighters aged 18 years or older who provided consent to completion of online questionnaires. Exclusionary criteria consisted of an inability or unwillingness of consenting to complete the online questionnaires. To be included in this secondary analysis, participants must have endorsed at least one PTSD Criterion A traumatic life event (APA, 2013).

Measures

Demographic questionnaire. Participants were asked to self-report demographic and medical history information including sociodemographic characteristics and firefighter service history. For the current study, dichotomous gender (Coded: 1 = Male, 2 = Non-male [Female, Transgender]) and prior suicide attempt history (Coded: 1 = History of a prior attempt, 2 = No history of a prior attempt) variables were created. In the present analyses, gender, prior suicide attempt history, and years in the fire service were included as covariates.

Life Events Checklist for DSM-5 (LEC-5; Weathers et al., 2013). The LEC-5 is a self-report questionnaire used to screen for potentially traumatic events experienced at any time throughout the lifespan. Respondents are provided a list of 16 potentially traumatic events (e.g., combat, sexual assault, transportation accident) as well as an additional item assessing for 'other' potentially traumatic events not listed. Respondents are asked to indicate

(via check mark) whether each listed event "happened to me", "witnessed it", "learned about it", "part of my job", or "not sure". If participants endorsed that an event "happened to me", "witnessed it", or "part of my job", this was coded as positive exposure to that particular type of traumatic event. The total number of trauma exposure types was summed to produce a 'trauma load' variable. Trauma load (i.e., number of trauma exposure types) was included as a covariate in the current study.

PTSD Checklist for DSM-5 (PCL-5; Blevins, Weathers, Davis, Witte, & Domin, 2015). Respondents were asked to complete the PCL-5 with regard to the "worst" traumatic event endorsed on the LEC-5. The PCL-5 is a 20-item self-report questionnaire that measures PTSD symptom severity over the past month. Each of the 20 items reflects a symptom of PTSD according to *DSM-5* criteria (APA, 2013). Participants are asked to rate each item on a 5-point scale (0 = *Not at all* to 4 = *Extremely*) to indicate how much they have been bothered by the symptom in the past month. Total symptom severity scores range from 0 to 80, with higher scores indicating greater symptom severity. A score of 33 or greater is the suggested cut-off for a probable diagnosis of PTSD (e.g., Bovin et al., 2016). Internal consistency was excellent for the PCL-5 total score in the present study ($\alpha = 0.97$). Total symptom severity was evaluated as a predictor in the proposed analyses.

Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). The PSQI is a 19-item self-report measure of past-month sleep quality and sleep disturbance. The PSQI subscales include subjective sleep quality (Component 1; rating of sleep quality), sleep latency (Component 2; length in minutes to typically fall asleep), sleep duration (Component 3; hours of actual sleep per night), habitual sleep efficiency (Component 4; number of hours slept divided by number of hours spent in bed, multiplied by 100), sleep

disturbance (Component 5; sum of sleep-related problems, such as using the bathroom during the night or coughing/snoring loudly), use of sleeping medication (Component 6; frequency of sleep medication use), and daytime dysfunction (Component 7; difficulty staying awake or becoming motivated). Component scores were added together to create a global sleep score that may range from 0 to 21, with higher scores indicating increased sleep disturbance. Factor analyses of the PSQI have demonstrated support for a 3-factor model over and above support for the original single-factor or 2-factor model, which includes sleep efficiency (i.e., using sleep duration and sleep efficiency variables), perceived sleep quality (i.e., using subjective sleep quality, sleep latency, and sleep medication variables), and daily disturbances (i.e., using sleep disturbances and daytime dysfunctions variables) (Casement, Harrington, Miller, & Resick, 2012; Cole et al., 2006; Mariman et al., 2012; Tomfohr, Schweizer, Dimsdale, & Loredo, 2013). A PSQI total score greater than 5 is indicative of significant sleep disturbance (Buysse et al., 1989; Backhaus et al., 2002). The PSQI demonstrates strong test-retest reliability, as well as convergent and discriminant validity (Mollayeva et al., 2016). Using the seven component scores, the internal consistency for the PSQI global sleep disturbance score was acceptable in the present study ($\alpha = 0.73$). The internal consistencies of the three PSQI subscales were in the questionable to good range: sleep efficiency ($\alpha = 0.67$), perceived sleep quality ($\alpha = 0.70$), and daily disturbances ($\alpha = 0.81$). The PSQI global sleep disturbance score was examined as a moderator in the main analysis. The PSQI subscales (sleep efficiency; perceived sleep quality; daily disturbances) based upon the 3-factor model, in addition to two item-specific variables (trouble sleeping because of experiences with [1] bad dreams and [2] pain; scale 0-3), were examined independently as moderators in the post hoc exploratory analyses.

Suicide Behaviors Questionnaire-Revised (SBQ-R; Osman et al., 2001). The SBQ-R, identified as a gold standard assessment of suicide risk (Batterham et al., 2015), is a 4-item self-report measure. Each item assesses a different aspect of suicidality, including lifetime suicide ideation and/or suicide attempts; frequency of suicidal ideation over the past twelve months; threat of suicide attempt; and self-reported likelihood of suicidal behavior in the future. Total scores range from 3 to 18, with higher scores indicating greater levels of suicide risk. The suggested cutoff score to identify at-risk individuals and specific risk behaviors for the adult general population is 7 or greater (Osman et al., 2001). The internal consistency for the SBQ-R total score in the present study was acceptable ($\alpha = 0.77$). The SBQ-R total score was evaluated as an outcome in the current analyses.

Sources of Occupational Stress-14 (SOOS-14; Kimbrel et al., 2011). The SOOS-14 is an abbreviated version of the Sources of Occupational Stress Scale (Beaton & Murphy, 1993), which was designed to measure job-related stress for firefighters (e.g., financial strain due to inadequate pay, disruption of sleep, feelings of isolation from family due to work demands and stress). Respondents are asked to rate each of the 14 items on a 5-point Likert scale (1 = *Not at all bothered* to 5 = *Extremely bothered*), with higher scores indicating greater occupational stress. The SOOS-14 has demonstrated good psychometric properties (Kimbrel et al., 2015). In the present study, the internal consistency for the SOOS-14 total score was excellent ($\alpha = 0.91$). The SOOS-14 total score was included as a covariate in the present study.

Procedure

All firefighters were recruited for participation in the parent study through one fire department. A fire department-wide email was sent to all firefighters, notifying them of the

opportunity to complete an online research survey for one continuing education (CE) credit and a chance to win one of several raffle prizes (e.g., movie tickets, restaurant gift certificates). Notification emails indicated that the purpose of the survey was to better understand how firefighters cope with stress and how much firefighters engage in health-related behaviors. Firefighters were given access to the informed consent form and survey through an online fire department CE portal. Once firefighters accessed the portal, they were provided with a description of the survey and the choice to review the informed consent form, which delineated all aspects of the study. Those who did not wish to participate or consent to the study were given the option to indicate (by clicking 'no') that they did not wish to participate. The total amount of time required for participation in this study was estimated at 45–60 min. Firefighters could discontinue participation at any time without penalty. Firefighters who considered completion of the online survey, by clicking 'yes' or 'no', received one CE credit for participation.

Data Analytic Plan

All analyses were conducted using IBM SPSS version 26.0 (IBM, 2019). See Figure 1. First, the database was evaluated for normality and missingness. Second, descriptive statistics and bivariate correlations among all study variables were examined. Third, one hierarchical regression analysis was conducted. At step one, the covariates of gender, prior suicide attempt history, years in the fire service, trauma load (LEC-5 total), and occupational stress (SOOS-14 total) were entered. At step two, the predictor variables of PTSD symptom severity (PCL-5 total score) and sleep disturbance (PSQI global score), both mean-centered, were entered. At step three, the interactive effect of PTSD symptom severity (PCL-5 total score) by sleep disturbance (PSQI global score) was entered. The main and interactive effects

were evaluated with regard to global suicide risk (SBQ-R total score). Simple slope post-hoc analyses were conducted to probe the significant interactions at different levels of the moderator.

To evaluate *post hoc* exploratory analyses, a series of five additional hierarchical regression analyses was conducted to examine the following as moderators in the models proposed above: (1) sleep efficiency, (2) perceived sleep quality, (3) daily disturbances, (4) bad dreams (PSQI item #5h), and (5) pain (PSQI item #5i). Given the exploratory nature of these analyses, a Bonferroni correction was applied to control for Type I error (α=.05/5=.01). Simple slope analyses examined the strength of the interactive impacts of the five facets of sleep disturbance on the association between PTSD symptom severity and suicide risk (Bauer and Curran, 2005; Preacher et al., 2006; Spiller et al., 2013).

RESULTS

Bivariate Correlations

Please see Table 2 for bivariate correlations and descriptive statistics of all study variables. PTSD symptom severity was positively associated with global sleep disturbance, global suicide risk, each of the three PSQI subscale factors (i.e., sleep efficiency, perceived sleep quality, daily disturbances), and the two PSQI item-specific variables (i.e., bad dreams and pain). Global sleep disturbance was positively associated with global suicide risk, each of the three PSQI subscale factors, and the two PSQI item-specific variables.

A positive history of suicide attempts (yes/no), as compared to a negative history, was associated with occupational stress, PTSD symptom severity, and global sleep disturbance. Non-male gender (female or transgender), as compared to male gender, was associated with higher daily sleep disturbances and greater trouble sleeping due to pain. Years in the fire

service was positively associated with the PSQI daily disturbances subscale severity and the PSQI pain item. Prior suicide attempt history was negatively associated with PTSD symptom severity, global sleep disturbance, global suicide risk, sleep efficiency, daily disturbances, bad dreams, and pain. Both trauma load and occupational stress were positively associated with PTSD symptom severity, global sleep disturbance, global suicide risk, perceived sleep quality, daily disturbances, and pain. Occupational stress was positively associated with sleep efficiency and bad dreams.

Hierarchical Regression Analyses

Main Analysis

Please refer to Table 3 for a summary of the main analysis results. With regard to global suicide risk, the first step was statistically significant and accounted for 26.3% of the variance; prior suicide attempt history and occupational stress were significant predictors. The second step accounted for an additional 7.6% of unique variance; both PTSD symptom severity and global sleep disturbance demonstrated significant incremental associations with global suicide risk. In the third step, the interactive effect of PTSD symptom severity by global sleep disturbance contributed an additional, significant 1.8% of unique variance. This analysis was also conducted with an alternative version of the PCL-5 total score (excluding the sleep disturbance item), and the pattern of results and the magnitude of the effects remained consistent.

Post Hoc Exploratory Analyses

Please see Table 3 for a summary of the results for all post hoc analyses. For each of the five post hoc exploratory analyses, the outcome (i.e., global suicide risk) and covariates remained consistent and contributed 26.3% of variance to step one of all models. When PSQI

– sleep efficiency was evaluated as a moderator, the second step of the model contributed 6.1% of unique variance; both PTSD symptom severity and sleep efficiency demonstrated significant main effects with regard to global suicide risk. At step three, the interactive effect was statistically significant and contributed an additional, significant 0.8% of unique variance to the model.

When PSQI – perceived sleep quality was evaluated as a moderator, step two contributed to an additional 6.6% in unique variance beyond step one; both PTSD symptom severity and perceived sleep quality demonstrated significant main effects. At step three, the interactive effect was significant, contributing an additional 1.4% of unique variance to the model.

When PSQI – daily disturbances was evaluated as a moderator, the second step contributed 8.5% of unique variance; both PTSD symptom severity and daily disturbances demonstrated significant main effects. At step three, the interactive effect was also statistically significant, contributing an additional 1.5% of unique variance to the model.

When the PSQI – bad dreams item was evaluated as a moderator, the second step contributed an additional 5.7% of unique variance; only PTSD symptom severity demonstrated a significant main effect. At step three, the interactive effect was not statistically significant. Finally, when the PSQI – pain item was evaluated as a moderator, step two contributed 5.7% of unique variance; only PTSD symptom severity demonstrated a significant main effect. The interactive effect at step three was not statistically significant.

All of the aforementioned post hoc exploratory analyses were also conducted with the alternatively scored version of the PCL-5 wherein the sleep disturbance item was excluded. The pattern of results and the magnitude of the effects remained consistent. Furthermore, for

the PSQI – bad dreams item analyses, the PCL-5 total score was computed excluding the disturbing dreams and sleep disturbance items. The pattern of results and the magnitude of the effects remained consistent.

DISCUSSION

The present study examined the main and interactive effects of PTSD symptom severity, sleep disturbance, and suicide-related outcomes in a large sample of urban firefighters. The results were consistent with hypotheses. First, PTSD symptom severity was significantly positively associated with global suicide risk, suggesting that firefighters with more severe PTSD symptom severity demonstrated a greater global risk for suicide. These effects were demonstrated after controlling for covariates, including gender, prior suicide attempt history, number of years in the fire service, trauma load, and occupational stress, which accounted for 26.3% of variance with regard to global suicide risk. Results are consistent with a well-established body of literature demonstrating that PTSD is related to increased risk of suicide across various populations, including firefighters (e.g., Bartlett et al., 2018; Boffa et al., 2017, 2018; Martin et al., 2017; Stanley et al., 2017, 2018). Indeed, PTSD is one of few disorders that reliably differentiates suicidal ideation from behavior (Vujanovic & Zegel, 2020; Bernal et al., 2007; Bryan, Grove, & Kimbrel, 2017; Wilcox, Storr, & Breslau, 2009).

Second, as predicted, global sleep disturbance was significantly positively associated with global suicide risk, indicating that firefighters with greater levels of perceived sleep disturbance also report higher global suicide risk. This is consistent with the postulation that sleep disturbance may serve as a potential risk factor for suicide (e.g., Bernert & Joiner, 2007; Pigeon et al., 2012; Ribeiro et al., 2012). It is possible that sleep disturbance confers this risk

by impairing one's ability to cognitively and affectively cope with stressful life events (Vargas de Barros et al., 2013). Extant literature suggests that sleep disturbance may maladaptively implicate cognitive-related processes (e.g., attention, judgement, concentration, impulse control, memory consolidation, and problem-solving ability; Liu, 2004; Goldstein et al., 2008; Joiner et al., 2005; Walker, 2008; Mellman et al., 2008; Spoormaker et al., 2010) and potentially increase one's susceptibility to fatigue and hopelessness due to difficulties with emotion regulation and processing (Hom et al., 2016; 2019; Littlewood et al., 2017); all demonstrated risk factors for suicidal ideation and suicide risk (Joiner et al., 2005).

Third, as hypothesized, global sleep disturbance significantly moderated – or exacerbated – the association between PTSD symptom severity and global suicide risk. That is, heightened sleep disturbance amplified the association between PTSD symptom severity and greater global suicide risk. This finding suggests that those firefighters with the highest levels of PTSD symptom severity and perceived sleep disturbances demonstrated the highest level of suicide risk (see Figure 2). This model builds upon extant research demonstrating that heightened PTSD symptom severity and sleep disturbance may interactively amplify emotion modulation difficulties, potentially through the evocation and exacerbation of trauma-related emotional dysphoria and fear-related arousal, ultimately leading to an increased risk for suicidal ideation and behaviors (e.g., Gerhart et al., 2014; Hom et al., 2019; Walker & van der Helm, 2009). Notably, the observed interactive effect was significant above and beyond relevant covariates but contributed only 1.8% of unique variance. Therefore, the clinical significance of this effect should be explored through experimental or longitudinal designs to more rigorously assess the associations of this interplay with suicidal ideation and/or behavior.

Furthermore, post hoc exploratory analyses indicated that each of the three PSQI factors (i.e., sleep efficiency, perceived sleep quality, and daily disturbances), when examined independently, demonstrated significant, incremental main and interactive effects with regard to global suicide risk (see Figures 2.2-2.4). More specifically, the interactive effects of PTSD symptom severity with sleep efficiency, perceived sleep quality, and daily disturbances respectively contributed an additional 0.8%, 1.4%, and 1.5% of unique variance with regard to global suicide risk, above and beyond main effects and relevant covariates. Firefighters with elevated PTSD symptom severity who reported the most severe impairment in each of these sleep disturbance-related facets demonstrated the highest levels of global suicide risk. This finding supports and expands upon the main analysis demonstrating that various aspects of sleep disturbance may exacerbate the well-established association between PTSD symptom severity and suicide risk.

However, the item-specific PSQI facets of sleep disturbance, including sleep problems due to (a) bad dreams and (b) pain, did not demonstrate significant main or interactive effects (with PTSD symptom severity) with regard to global suicide risk. Notably, both item-specific PSQI facets of sleep disturbance demonstrated significant bivariate correlations with both PTSD symptom severity and global suicide risk (r's = .19 to .49, p's < .05), suggesting that these associations dissipated with the addition of covariates and concurrent predictors in the moderation models. Indeed, these constructs were based upon one-item variables derived from the PSQI, which may have limited corresponding validity. For more definitive conclusions to be drawn about the roles of 'bad dreams' (i.e., trauma-related dreams or nightmares) or pain in the association between PTSD symptoms and suicide risk, this work would need to be extended using more rigorous methodologies, such as more comprehensive

self-report or interview-based measures and experimental paradigms. For example, experimental manipulation of sleep deprivation, in-lab sleep studies, and personalized sleep tracking would provide more accurate in vivo assessments of the impact of sleep on these associations. Clinical trials of novel interventions that target PTSD symptoms and sleep disturbance concurrently might be evaluated with regard to their efficacy in reducing suicidal ideation or behavior in firefighters.

Although not the primary aims of the study, several additional findings are worthy of note. First, approximately 9.22% of firefighters met clinical cut-off criteria for a probable PTSD diagnosis, based on the PCL-5; 46.88% met clinically significant criteria for disturbed sleep, based on the PSQI; and 8.48% of firefighters met suggested criteria for suicide risk, based on the SBQ-R. These rates are consistent with rates documented among other firefighter samples (Del Ben et al., 2006; Berger et al., 2012; Carey et al., 2011; Vargas de Barros et al., 2013). Second, number of years in the fire service demonstrated a significant positive association with occupational stress, daily sleep disturbances (e.g., snoring/coughing, fatigue, lack of motivation), and sleep problems due to pain. This suggests that firefighters with longer careers in the fire service may experience greater occupational stress, daily sleep disturbances, and sleep problems due to pain. Future work, employing longitudinal designs and interview-based or qualitative data collection methods, is needed to better understand these important associations. Third, occupational stress was shown to have a significant positive association with all study variables of interest, with the exception of gender, which may be due simply to the relatively small subsample of women in this study. Thus, occupational stress in the fire service is an important factor worthy of greater empirical

scrutiny given its strong policy implications and relevance to various mental health symptoms.

Several study limitations are worthy of note. First, while self-report measures facilitated the screening of a large sample of firefighters, effects of response biases and method variance cannot be ruled out. Future research may benefit from the inclusion of interview-based measures of PTSD and suicide risk as well as multimodal (e.g., self-report and behavioral indices) and/or experimental methods (e.g., actigraphy, polysomnography, electroencephalogram) to more accurately assess sleep patterns and disturbances. Two subscales of the PSQI, sleep efficiency ($\alpha = 0.67$) and perceived sleep quality ($\alpha = 0.70$), demonstrated relatively low levels of internal consistency, underscoring the need for more objective measurements of sleep patterns. Relatedly, the present study relied on the SBQ-R as the only measure for assessing suicide risk. The SBQ-R is considered a gold standard suicide risk screening instrument, but it indexes current and past suicidal ideation and behavior. Thus, our reliance on this measure poses an obstacle to distinguishing between suicidal ideation versus suicidal behavior (Anestis et al., 2011a; b), capability for suicide (e.g., suicide behaviors or attempts; Anestis et al., 2012), and current/past month ideation from lifetime ideation. Future studies may benefit from integrating additional measures to assess suicidal ideation, suicidal behavior, capability for suicide, and suicide risk separately using a multidimensional approach. Second, this study did not gather information about station assignments or job duties, and future research should consider how station locations, job duties (e.g., office or desk-related tasks compared to field-related experiences), and secondary part- or full-time employments may contribute to firefighter sleep variability and suicide-related outcomes. Third, given the cross-sectional study design, inferences about causality or

temporality cannot be made. Future research should integrate experimental and longitudinal designs to better understand the relations among PTSD symptoms, sleep disturbance, and suicidal ideation or behavior. Finally, these results were based on a sample of predominantly white/Caucasian male firefighters. It is thus imperative that future studies include national samples based on higher proportions of racially and ethnically diverse firefighters and greater numbers of female firefighters to enhance the generalizability across sociodemographic strata and more accurately capture the role of sociocultural factors on the variables of interest.

Overall, results of this study provide preliminary evidence to suggest that sleep disturbance may be a promising clinical factor with relevance to both PTSD and suicide risk among firefighters. Indeed, it has been well-documented that firefighters are chronically exposed to trauma (Stanley et al, 2016; 2015; Martin et al., 2017; Zegel et al., 2018; Bartlett et al., 2018; Vargas de Barros et al., 2013; Meyer et al., 2012) and are at risk for chronic sleep disturbance (Carey et al., 2011; Vargas de Barros et al., 2013; Smith et al., 2018) as well as suicide (Stanley et al., 2015; 2016; 2018; Martin et al., 2017; Bartlett et al., 2018). Thus, mental health prevention and intervention programs for firefighters may benefit from the inclusion of sleep disturbance screeners and adjunctive psychoeducational or skills-based interventions to target suicide risk. Furthermore, targeting sleep disturbance via occupational policy reform and/or specialized cognitive-behavioral interventions designed for the unique needs of the fire service may have the potential to reduce PTSD symptoms and suicide risk in firefighter populations.

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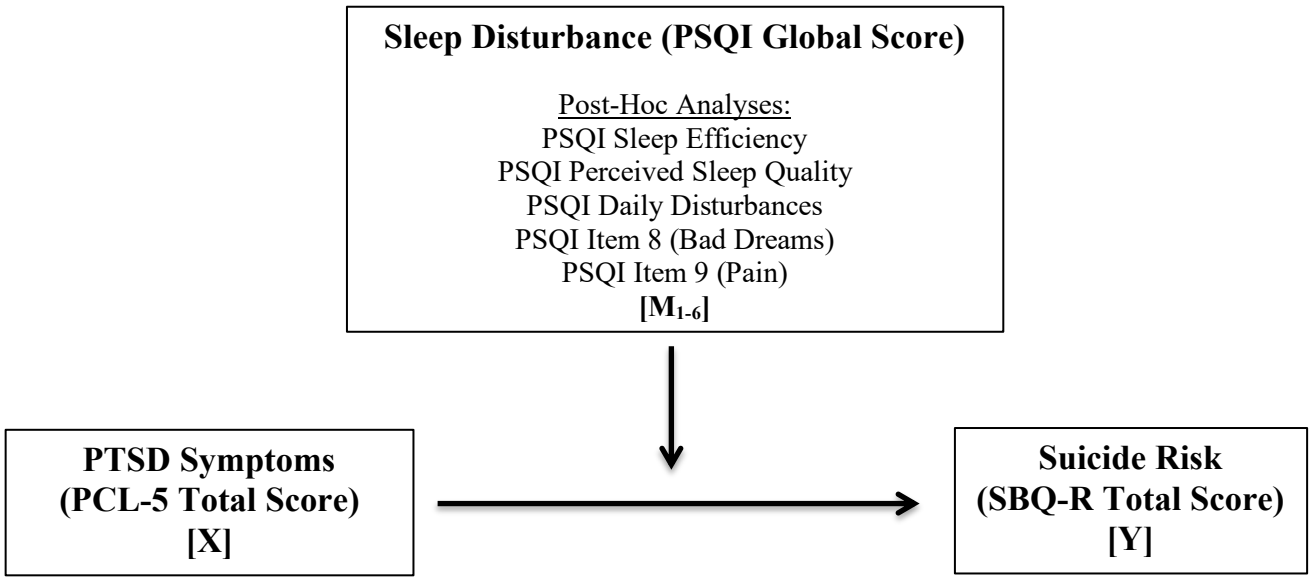
Figure 1.

PTSD Symptoms and Suicide Risk among Firefighters: The Moderating Role of Sleep Disturbance



Note. PCL-5 = Posttraumatic Stress Disorder Checklist for DSM-5 total score (Blevins et al., 2015); PSQI = Pittsburgh Sleep Quality Index (Buysse et al., 1989); SBQ-R = Suicide Behaviors Questionnaire – Revised total score (Osman et al., 2001). Sleep disturbance is hypothesized to moderate the association between PTSD symptom severity and suicide risk. Covariates will include years of service in the fire department, trauma load, and occupational stress.

Table 1

Participant sociodemographic characteristics

	Mean	*SD*
Age	38.68	8.53
Years in the fire service	13.3	8.79
Trauma load	11.39	3.94
Occupational stress	24.84	10.09
	n	**Valid %**
Gender		
Male	750	93.5
Female	46	5.7
Transgender	6	0.7
Race		
White	608	75.8
Black or African American	99	12.3
Other	67	8.4
Asian	14	1.7
American Indian or Alaskan Native	13	1.6
Native Hawaiian or other Pacific Islander	1	0.1
Ethnicity		
Hispanic or Latinx	212	26.4
Not Hispanic or Latinx	590	73.6
Marital Status		
Married	548	68.3
Single	151	18.8
Divorced	60	7.5
Living with partner	41	5.1
Widowed	2	0.2
Education		
8th Grade	5	0.6
Partial Completion of high school or GED equivalent	6	0.7
High school graduate	66	8.2
Partial completion of college	375	46.8
College graduate	350	43.6
Trauma Exposure		
Natural disaster	755	94.1
Fire or explosion	765	95.4
Transportation accident	778	97

Serious accident at work, home, or during recreational activity	685	85.4
Exposure to toxic substance	629	78.4
Physical assault	651	81.2
Assault with a weapon	582	72.6
Sexual assault	461	57.5
Other unwanted or uncomfortable sexual experience	338	42.1
Combat or exposure to a war-zone	163	20.3
Captivity	121	15.1
Life-threatening illness or injury	528	65.8
Severe human suffering	533	66.5
Sudden violent death	652	81.3
Sudden accidental death	640	79.8
Serious injury, harm, or death you caused to someone else	286	35.7
Any other very stressful event or experience	569	70.9
Suicide Thoughts & Behaviors		
Current/past-month ideation [a]	12	1.5
Prior attempt history [b]	52	6.5
Meeting criteria for:		
Probable PTSD diagnosis (PCL-5)	74	9.22
Clinically significant disturbed sleep (PSQI)	376	46.88
Suicide risk (SBQ-R)	68	8.48

*Note: N = 802; SD = standard deviation

[a] Represents participants who endorsed positive ideation

[b] Represents participants who endorsed prior suicide attempt(s)

Table 2

Bivariate correlations of study variables

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Gender [a]	-												
2. Prior suicide attempt history [a]	0.13**	-											
3. Years in the fire service [a]	-0.04	0.02	-										
4. Trauma load (LEC-5 Total)[a]	-0.01	-0.02	0.07	-									
5. Occupational stress (SOOS-14 Total)[a]	-0.01	-0.12**	0.07*	0.16**	-								
6. PTSD symptom severity (PCL-5 Total)[b]	0.04	-0.17**	0.03	0.10**	0.67**	-							
7. Sleep disturbance (PSQI Global)[d]	0.04	-0.09*	0.02	0.13**	0.46**	0.46**	-						
8. Global suicide risk (SBQ-R Total)[c]	0.07	-0.39**	0.04	0.11**	0.37**	0.45**	0.36**	-					
9. Sleep efficiency (PSQI Sleep duration & Sleep efficiency) [d]	0.02	-0.08*	-0.05	0.06	0.16**	0.23**	0.70**	0.19**	-				
10. Perceived sleep quality (PSQI Subjective sleep quality, Sleep latency, & Sleep medication) [d]	0.01	-0.02	0.02	0.12**	0.41**	0.38**	0.87**	0.27**	0.35**	-			
11. Daily disturbances (PSQI Sleep disturbances & Daytime dysfunctions) [d]	0.09**	-0.14**	0.10**	0.14**	0.54**	0.50**	0.75**	0.41**	0.27**	0.58**	-		
12. Bad dreams (PSQI Item 5h) [d]	0.05	-0.10**	0.03	0.06	0.38**	0.49**	0.45**	0.27**	0.21**	0.36**	0.52**	-	
13. Pain (PSQI Item 5i) [d]	0.16**	-0.08*	0.17**	0.10**	0.32**	0.29**	0.44**	0.19**	0.17**	0.37**	0.52**	0.35**	-
Mean/*n*	750	12	13.3	11.39	24.84	9.93	5.81	3.88	1.87	2.46	1.48	0.37	0.45
Standard Deviation/%	93.5	1.50%	8.79	3.94	10.09	14.28	3.71	1.79	1.58	1.94	1.22	0.75	0.91

**Note:* $N = 802$; ** $p<0.01$; *$p<0.05$; [a] Covariate. [b] Predictor. [c] Outcome. [d] Moderator. Gender = % listed for participants identifying as male; 1 = Male, 2 = Non-male [Female, Transgender]; Prior suicide attempt history = % endorsing previous attempt; Suicide attempt history: 1 = Yes, 2 = No; LEC-5 = Life Events Checklist for DSM-5 (Weathers et al., 2013); PCL-5 = Posttraumatic Disorder Checklist for DSM-5 (Blevins et al., 2015); PSQI = Pittsburgh Sleep Quality Index (Buysse et al., 1989); PSQI Bad dreams item 5h = "During the past month, how often have you had trouble sleeping because you have bad dreams?"; PSQI Pain item 5i = "During the past month, how often have you had trouble sleeping because you have pain?"; SBQ-R = Suicide Behaviors Questionnaire - Revised (Osman et al., 2001); SOOS-14 = Sources of Occupational Stress (Kimbrel et al., 2011).

Table 3

Main and interactive effect of PTSD symptom severity and sleep disturbance on global suicide risk.

Global suicide risk	ΔR^2	*B*	SE	*t*	*p*
Main analysis					
Step 1	**0.263**				**<0.001**
Gender		0.03	0.22	0.88	0.38
Prior suicide attempt history		-0.35	0.46	-11.36	<0.001
Years in the fire service		0.02	0.01	0.54	0.59
Trauma load		0.05	0.01	1.65	0.10
Occupational stress		0.32	0.01	10.22	<0.001
Step 2	**0.076**				**<0.001**
PTSD symptom severity		0.28	0.01	6.84	<0.001
Global sleep disturbance		0.16	0.02	4.91	<0.001
Step 3	**0.018**				**<0.001**
PTSD symptom severity x Global sleep disturbance		0.16	0.00	4.74	<0.001
Post hoc exploratory analyses					
Step 1	**0.263**				**<0.001**
Gender		0.03	0.22	0.88	0.38
Prior suicide attempt history		-0.35	0.46	-11.36	<0.001
Years in the fire service		0.02	0.01	0.54	0.59
Trauma load		0.05	0.01	1.65	0.10
Occupational stress		0.32	0.01	10.22	<0.001
Step 2	**0.061**				**<0.001**
PTSD symptom severity		0.31	0.01	7.63	<0.001
Sleep efficiency		0.07	0.03	2.44	0.02
Step 3	**0.008**				**<0.001**
PTSD symptom severity x Sleep efficiency		0.10	0.00	3.06	<0.001
Step 1	**0.263**				**<0.001**
Gender		0.03	0.22	0.88	0.38
Prior suicide attempt history		-0.35	0.46	-11.36	<0.001
Years in the fire service		0.02	0.01	0.54	0.59
Trauma load		0.05	0.01	1.65	0.10
Occupational stress		0.32	0.01	10.22	<0.001
Step 2	**0.066**				**<0.001**
PTSD symptom severity		0.30	0.01	7.46	<0.001
Perceived sleep quality		0.11	0.03	3.42	<0.001
Step 3	**0.014**				**<0.001**
PTSD symptom severity x Perceived sleep quality		0.13	0.00	4.05	<0.001
Step 1	**0.263**				**<0.001**
Gender		0.03	0.22	0.88	0.38

Prior attempt history		-0.35	0.46	-11.36	<0.001
Years in the fire service		0.02	0.01	0.54	0.59
Trauma load		0.05	0.01	1.65	0.10
Occupational stress		0.32	0.01	10.22	<0.001
Step 2	**0.085**				**<0.001**
PTSD symptom severity		0.27	0.01	6.76	<0.001
Daily disturbances		0.21	0.05	5.96	<0.001
Step 3	**0.015**				**<0.001**
PTSD symptom severity x Daily disturbances		0.15	0.00	4.39	<0.001
Step 1	**0.263**				**<0.001**
Gender		0.03	0.22	0.88	0.38
Prior suicide attempt history		-0.35	0.46	-11.36	<0.001
Years in the fire service		0.02	0.01	0.54	0.59
Trauma load		0.05	0.01	1.65	0.10
Occupational stress		0.32	0.01	10.22	<0.001
Step 2	**0.057**				**<0.001**
PTSD symptom severity		0.30	0.01	7.19	<0.001
Bad dreams		0.04	0.08	1.26	0.21
Step 3	**0.001**				**0.19**
PTSD symptom severity x Bad dreams		0.05	0.00	1.31	0.19
Step 1	**0.263**				**<0.001**
Gender		0.03	0.22	0.88	0.38
Prior suicide attempt history		-0.35	0.46	-11.36	<0.001
Years in the fire service		0.02	0.01	0.54	0.59
Trauma load		0.05	0.01	1.65	0.10
Occupational stress		0.32	0.01	10.22	<0.001
Step 2	**0.057**				**<0.001**
PTSD symptom severity		0.32	0.01	7.96	<0.001
Pain		0.03	0.06	0.81	0.42
Step 3	**0.000**				**0.71**
PTSD symptom severity x Pain		-0.01	0.00	-0.38	0.71

*Note: *N* = 802; Gender = % listed for participants identifying as male; 1 = Male, 2 = Non-male [Female, Transgender]; Prior suicide attempt history = % endorsing previous attempt; Suicide attempt history: 1 = Yes, 2 = No; Global suicide risk = SBQ-R (Osman et al., 2001); Trauma load = LEC-5 Weathers et al., 2013); Occupational stress = SOOS-14 (Kimbrel et al., 2011); PTSD symptom severity = PCL-5 (Blevins et al., 2015); Global sleep disturbance = PSQI (Buysse et al., 1989); Sleep efficiency = PSQI factor subscale (Cole et al., 2006); Perceived sleep quality = PSQI factor subscale (Cole et al., 2006); Daily disturbances = PSQI factor subscale (Cole et al., 2006); Bad dreams = PSQI item 5h (Buysse et al., 1989); Pain = PSQI item 5i (Buysse et al., 1989).

Figure 2.1

Interaction of PTSD symptom severity and global sleep disturbance on global suicide risk.

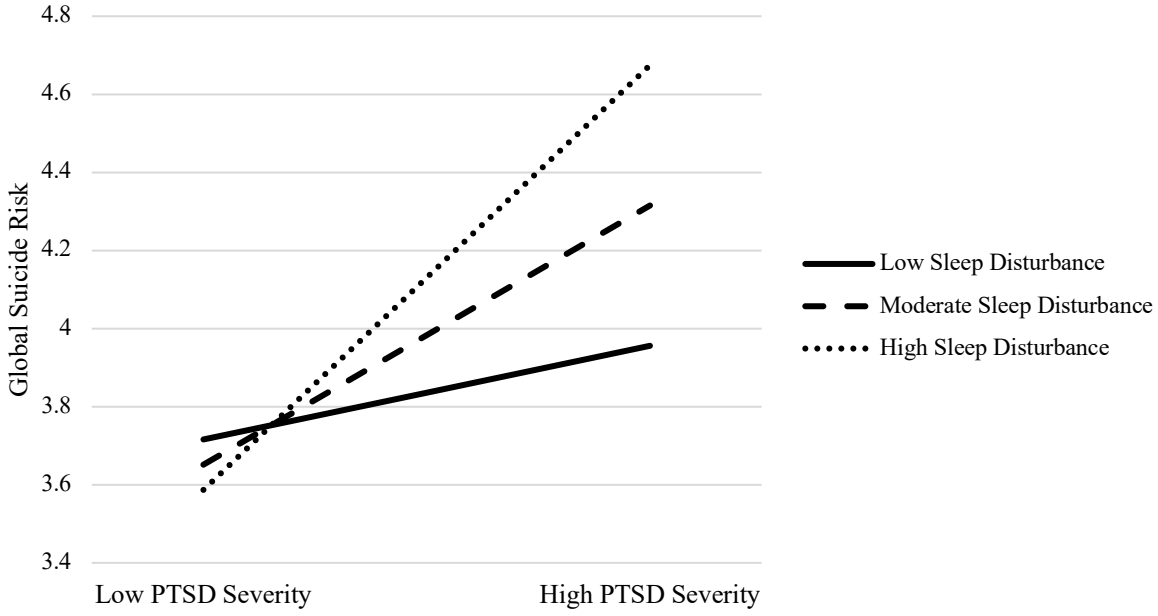


Figure 2.2

Interaction of PTSD symptom severity and PSQI sleep efficiency on global suicide risk.

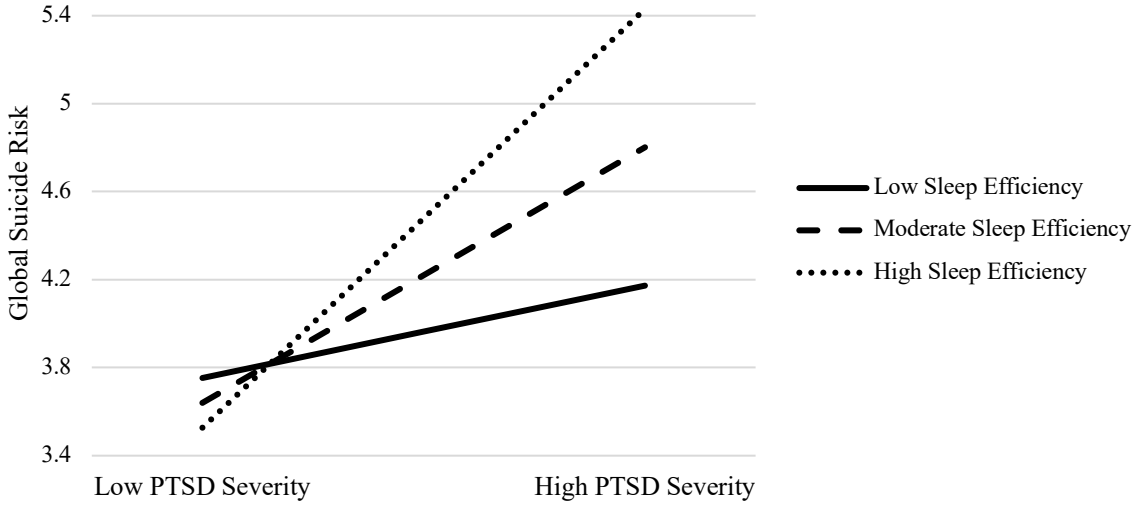


Figure 2.3

Interaction of PTSD symptom severity and PSQI perceived sleep quality on global suicide risk.

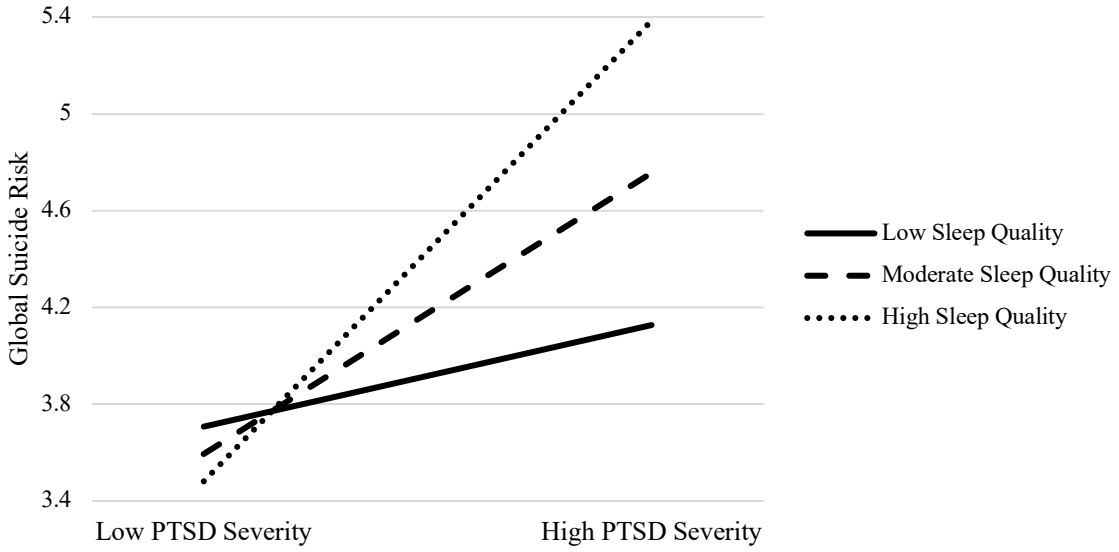


Figure 2.4

Interaction of PTSD symptom severity and PSQI daily disturbances on global suicide risk.