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ORIGINAL ARTICLE

# Sleep Disturbance Among Firefighters: Understanding Associations with Alcohol Use and Distress Tolerance

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## Abstract

Sleep disturbance is related to a variety of health issues and represents a prominent occupational concern among firefighters. Two potential predictors relevant to disturbed sleep are alcohol use and distress tolerance, which refers to the perceived ability to withstand negative emotional states. Main and interactive effects of alcohol use and distress tolerance on sleep disturbance were examined, after controlling for the covariates of service years and occupational stress. Participants included 652 firefighters (93.7% male; 77.9% white; Mage = 38.4 years), of whom 23.5% screened positive for hazardous alcohol use and 48.6% for disturbed sleep. Results indicated that higher alcohol misuse and lower distress tolerance were each significantly associated with greater sleep disturbance. Distress tolerance moderated the association between alcohol misuse and sleep disturbance, and the total model accounted for 28% of variance. Results indicate that firefighters with higher levels of hazardous alcohol use and lower levels of distress tolerance may exhibit higher levels of sleep disturbance.

**Keywords** Sleep · Distress tolerance · Alcohol · Firefighters

Sleep disturbance is related to significant medical and psychiatric comorbidity (Breslau et al. 1996; Dragioti et al. 2018; Katz and McHorney 1998; Klingaman et al. 2017; Kuppermann et al. 1995), reduced quality of life (Dragioti et al. 2018), and impaired job performance (Kuppermann et al. 1995; Reynolds et al. 2017; Rosekind et al. 2010). Further, sleep deprivation can lead to symptoms such as fatigue, inattention, decreased cognitive speed, and impaired memory (Goel et al. 2013). Firefighters are a population especially at risk of experiencing chronic sleep disturbances, including acute and chronic sleep deficiency and disruption of circadian rhythm, due to extended work schedules and frequent work-related stress (Beaton and Murphy 1993; Regehr et al. 2005).

Current estimates suggest that 51–59% of firefighters experience sleep-related disturbances (Carey et al. 2011; Vargas de Barros et al. 2013), a significantly higher rate than the general population (Ohayon 2002). Sleep disturbances are associated with poor psychological and physical well-being among firefighters (Vargas de Barros et al. 2013) and research has shown reductions in workplace injuries and work loss due to disability among firefighters who receive psychoeducation-based sleep intervention (Sullivan et al. 2017). Sleep disturbances refer to a wide variety of concerns, and factor analytic studies of well-established self-report sleep indices have settled on three overarching facets, including sleep efficiency, perceived sleep quality, and daily disturbances (Casement et al. 2012; Cole et al. 2006; Mariman et al. 2012; Tomfohr et al. 2013). Given the prevalence of sleep-related concerns and problems among firefighters, it is imperative to better understand health behaviors and psychological factors that relate to these facets of sleep disturbance in order to inform evidence-based, specialized interventions for this vulnerable population.

One factor relevant to disturbed sleep is alcohol use. Extant research has demonstrated that firefighters are at-risk with regard to alcohol misuse and alcohol use disorder (AUD; Boxer and Wild 1993; Carey et al. 2011; Haddock et al. 2012; Jones 2017; North et al. 2002; Tomaka et al. 2017), with approximately one-half of firefighters endorsing excessive alcohol use (i.e., 3 or more drinks; Haddock et al.

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2015) and one-third reporting heavy episodic drinking (i.e., 5 or more drinks; Haddock et al. 2015; Piazza-Gardner et al. 2014). Overall, lifetime AUD prevalence rates of 47% have been documented among firefighters (North et al. 2002), in comparison to 29.1% lifetime AUD prevalence in the general population (Grant et al. 2015). The association between alcohol use and sleep disturbance is bidirectional, with sleep disturbances predictive of increased alcohol use (Taylor et al. 2003; Wong et al. 2004), and alcohol use predictive of increased sleep disturbance (e.g., changes in sleep pattern, poorer sleep quality, daytime sleepiness; Colrain et al. 2014; Hartwell et al. 2015; Mahfoud et al. 2009; Roehrs and Roth 2001). Notably, while using alcohol to mitigate sleep difficulties is commonly cited as a reason that individuals initiate and continue regular alcohol use (Johnson et al. 1998), alcohol use is known to worsen sleep quality via increased sleep fragmentation (Colrain et al. 2014). Indeed, the prevalence of sleep problems has been reported to be high as high as 72% among individuals with AUD (Foster et al. 1998). Among firefighters, specifically, available research has demonstrated positive bivariate correlations between alcohol use and sleep disturbance (Carey et al. 2011; Vargas de Barros et al. 2013; Yun et al. 2015). Given the clinically pertinent associations between sleep disturbance and alcohol use, it is important to identify relevant cognitive-affective factors that are targetable via intervention.

Distress tolerance, defined as the perceived ability to tolerate negative or aversive emotional states (Leyro and Bernstein 2010), is a promising transdiagnostic cognitive-affective factor with relevance to both alcohol use and sleep disturbance. Low levels of distress tolerance have been associated with elevated symptom severity of various psychological disturbances, namely anxiety, mood, and substance use disorders (e.g., Leyro and Bernstein 2010). More specifically, empirical studies have demonstrated associations between distress tolerance and alcohol use across undergraduate (e.g., Buckner et al. 2007; Holzhauer et al. 2017), community adult (e.g., Gorka et al. 2012; Vujanovic et al. 2011), and substance use treatment populations (Bornovalova et al. 2012). Across studies, individuals with lower perceived and actual/behavioral abilities to tolerate negative emotional states are more likely to endorse greater levels of alcohol use. While extant research on the relation between sleep quality and distress tolerance is more limited, emerging research has demonstrated links between low distress tolerance and lower perceived sleep quality among military veterans (Short et al. 2016) and inadequate sleep and unintentionally falling asleep among homeless individuals (Reitzel et al. 2017). Furthermore, there is a clear theoretical link between sleep disturbances and distress tolerance. Specifically, those with poor sleep quality may be susceptible to more frequent and intense negative affect (Minkel et al. 2012; Zohar et al. 2005), and those with low distress tolerance may have difficulty regulating emotional responses (Mauss et al. 2013; Yoo et al. 2007), thus amplifying sleep disturbances further.

Theoretically, alcohol users who perceive themselves as less able to withstand negative emotional states may be especially likely to manifest sleep disturbances, even after controlling for general stress. Alcohol use has been demonstrated to worsen sleep quality, particularly when consumed in relatively large quantities or over long durations (Colrain et al. 2014), and to increase sleep loss consequences (e.g., fatigue, sleepiness, and depression; Voinescu and Orăşan 2014). Individuals with low distress tolerance, specifically, may perceive themselves as unable to handle negative emotions and, in reaction, may be more likely to engage in maladaptive behaviors (e.g., increased alcohol use) and/or endure adverse health behaviors (e.g., sleep disturbance) as a result (Brown et al. 2005; Zvolensky et al. 2009). Thus, low distress tolerance among firefighters may amplify the alcohol use—sleep disturbance association. Firefighters with low distress tolerance may be especially likely to report alcohol use and sleep disturbance as a result of insufficient perceived or actual resources to withstand emotional distress, generally, and the stress associated with their occupation, specifically. Conversely, heightened distress tolerance may help firefighters to cope more effectively with negative emotionality, resulting in lower levels of sleep disturbance and alcohol consumption, as has been found in other samples of substance users (e.g., Abrantes et al. 2008; Ali et al. 2017; Howell et al. 2010; Vujanovic et al. 2015). Two published studies to date (Bartlett et al. 2018; Stanley et al. 2018), based upon the same sample as that used for the current investigation, have examined distress tolerance in firefighters. These studies have found that firefighters reported greater perceived distress tolerance as compared to community adult populations, but that low levels of distress tolerance were related to deleterious psychological symptoms, including occupational stress, posttraumatic stress, and suicide risk. Taken together, firefighters with low distress tolerance may be especially likely to report increased sleep disturbances, and therefore, heightened distress tolerance may moderate, or exacerbate, the association between elevated alcohol use and sleep disturbance in firefighters, even after controlling for occupational stress and years in the fire service.

Overall, there is a paucity of research examining cognitive-affective factors and mental health correlates among firefighters. No study to date has focused on better understanding relations among alcohol use, distress tolerance, and sleep disturbances among firefighters, in one overarching model. Further, no study to date has examined specific aspects of sleep disturbance (e.g., sleep efficiency, perceived sleep quality, and daily disturbances) among firefighters. The relatively sparse extant

literature has been based upon small samples (e.g., McGillis et al. 2017; Meyer et al. 2012; Murphy et al. 1999) or on specific sub-samples of firefighters (e.g., Arbona and Schwartz 2016; Harvey et al. 2016; Lee et al. 2014). Thus, the present study represents a unique contribution that extends the literature base through an examination of relations among alcohol use, distress tolerance, and sleep disturbances in a large sample of urban firefighters. First, it was hypothesized that higher levels of alcohol misuse and lower levels of distress tolerance would be associated with greater global sleep disturbance severity. Second, it was expected that distress tolerance would significantly moderate (or exacerbate) the association between greater alcohol use and greater global sleep disturbance symptoms. These effects were expected above and beyond the covariates of years in the fire department and occupational stress. These covariates were selected due to statistically significant associations with alcohol use outcomes in past work among first responders (e.g., Meyer et al. 2012; Murphy et al. 1999; Paulus et al. 2017; Piazza-Gardner et al. 2014). Finally, exploratory analyses were conducted to examine the proposed model with regard to three specific components of global sleep disturbance (i.e., sleep efficiency, perceived sleep quality, and daily disturbances) as outcomes.

## Methods

### Participants

This study is a secondary analysis of data from a larger project examining stress and health-related behaviors among firefighters (e.g., Bartlett et al. 2018; Boffa et al. 2018; Paulus et al. 2018; Stanley et al. 2018). The present investigation is distinct from, and not redundant with prior published works from the database. The overall sample included 652 professional firefighters (93.7% male; *M*age = 38.4, *SD* = 8.6) at a fire department in a large metropolitan area in the southern United States. See Table 1 for participant characteristics. Of note, firefighters in this particular department are simultaneously trained to perform both emergency medical services and fire suppression services. To be included in the study, participants must have: been 18 years of age or older, been a current firefighter, and consented to participation and completion of all online questionnaires. Furthermore, participants must have reported drinking alcohol on at least a "monthly or less" basis, which was used as a screener to determine ever alcohol use. Exclusionary criteria were comprised of inability or unwillingness to provide informed consent for the completion of the online questionnaires. Please see "Procedures" section for more information.

**Table 1** Participant characteristics

| | Participants ($n = 652$) |
|---|---|
| Age (years) | 38.4 (8.6) |
| Sex | |
| Male | 93.7% (611) |
| Female | 5.5% (36) |
| Transgender | 0.8% (5) |
| Race | |
| White | 77.9% (508) |
| Hispanic/Latino | 26.4% (172) |
| African American | 10.9% (71) |
| Asian | 1.4% (9) |
| American Indian or Alaskan Native | 1.8% (12) |
| Other | 8.0% (52) |
| Education | |
| GED/equivalent | 0.8% (5) |
| High school graduate | 8.1% (53) |
| Some college | 46.9% (306) |
| College graduate | 44.2% (288) |
| Relationship status | |
| Married | 68.1% (444) |
| Living with a partner | 5.1% (33) |
| Single | 18.9% (123) |
| Divorced | 7.7% (50) |
| Widowed | 0.3% (2) |
| Fire department tenure | 13.1 (8.8) |
| Alcohol use[a] | |
| Drinks monthly or less | 28.4% (185) |
| Drinks 2–4 times a month | 30.5% (199) |
| Drinks 2–3 times a week | 28.4% (185) |
| Drinks 4 or more times a week | 12.7% (83) |
| Hazardous alcohol use (AUDIT ≥ 8) | 23.5% (153) |
| Sleep disturbance[b] | |
| Disturbed Sleep (PSQI Total ≥ 5) | 48.6% (317) |
| Distress tolerance[c] | |
| Distress tolerance (sum total) | 61.5 (12.4) |
| Distress tolerance (average item total) | 4.10 (0.8) |

Values are mean (standard deviation) or N (%), as appropriate

[a]Information on alcohol use obtained from the Alcohol Use Disorders Identification Test (AUDIT) questionnaire

[b]Information on disturbed sleep obtained from the Pittsburgh Sleep Quality Index (PSQI)

[c]Information on distress tolerance obtained from the Distress Tolerance Scale (DTS)

### Measures

#### Demographic Questionnaire

Participants were asked to self-report demographic information including sociodemographic factors, firefighter service history, and military service history. In the current study, the

demographic questionnaire was used to describe the sample, with years of service in the fire department utilized as a covariate in the current model.

### Alcohol Use Disorders Identification Test (AUDIT; Saunders et al. 1993)

The AUDIT is an extensively validated 10-item, Likert-style screening instrument that was developed by the World Health Organization and designed to identify individuals presenting with alcohol problems within the past year (Newcombe et al. 2005; Saunders et al. 1993). Total scores range from 0 to 40, and the generally accepted cut-off to identify potentially hazardous alcohol intake is 8. The AUDIT has demonstrated good psychometric properties (Bohn et al. 1995; Garcia Carretero et al. 2016; Selin 2003). The AUDIT has demonstrated high sensitivity and specificity for detecting probability of alcohol dependence and hazardous or harmful drinking (sensitivity = 32–96%, specificity = 84–96%) (Barry and Fleming 1993; Saunders et al. 1993; Schmidt et al. 1995). In the present study, internal consistency for the total AUDIT score (α = .85) was good. The AUDIT total score was used as a predictor in the current analyses.

### Distress Tolerance Scale (DTS; Simons and Gaher 2005)

The DTS is a 15-item self-report measure that evaluates the extent to which respondents believe they can experience and withstand distressing emotional states, rated on a 5-point scale (1 = *strongly agree* to 5 = *strongly disagree*). The DTS contains four subscales: Tolerance (e.g., "I can't handle feeling distressed or upset"), Appraisal (e.g., "Being distressed or upset is always a major ordeal for me"), Absorption (e.g., "When I feel distressed or upset, I cannot help but concentrate on how bad the distress actually feels"), and Regulation (e.g., "I'll do anything to stop feeling distressed or upset"). Total scores range from 15 to 75, with higher values indicating greater levels of emotional DT (e.g., higher perceived ability to withstand distressing emotional states). The DTS demonstrates good psychometric properties (Simons and Gaher 2005). For the current study, the DTS total score was used to represent the overall level of DT, as consistent with past literature (Simons and Gaher 2005; Vujanovic et al. 2013). In the current sample, internal consistency for the total DTS score was excellent (α = .92). For the purposes of this study, the DTS total score was used as a predictor variable.

### Pittsburgh Sleep Quality Index (PSQI; Buysse et al. 1989)

The PSQI is a 19-item self-report measure of sleep disturbances during the previous month. Component scores are summed to create a total "global" sleep score that ranges from 0 to 21, with higher scores indicating increased sleep disturbance (Fig. 1). The PSQI demonstrates strong test–retest reliability as well as convergent and discriminant validity, based on recent meta-analytic evidence (Mollayeva et al. 2016). Factor analyses of the PSQI have demonstrated support for a 3-factor model, which includes sleep efficiency (sleep duration and sleep efficiency variables), perceived sleep quality (subjective sleep quality, sleep latency, and sleep medication variables), and daily disturbances (sleep disturbances and daytime dysfunctions variables; Casement et al. 2012; Cole et al. 2006; Mariman et al. 2012; Tomfohr et al. 2013). For each of these factors (i.e., sleep

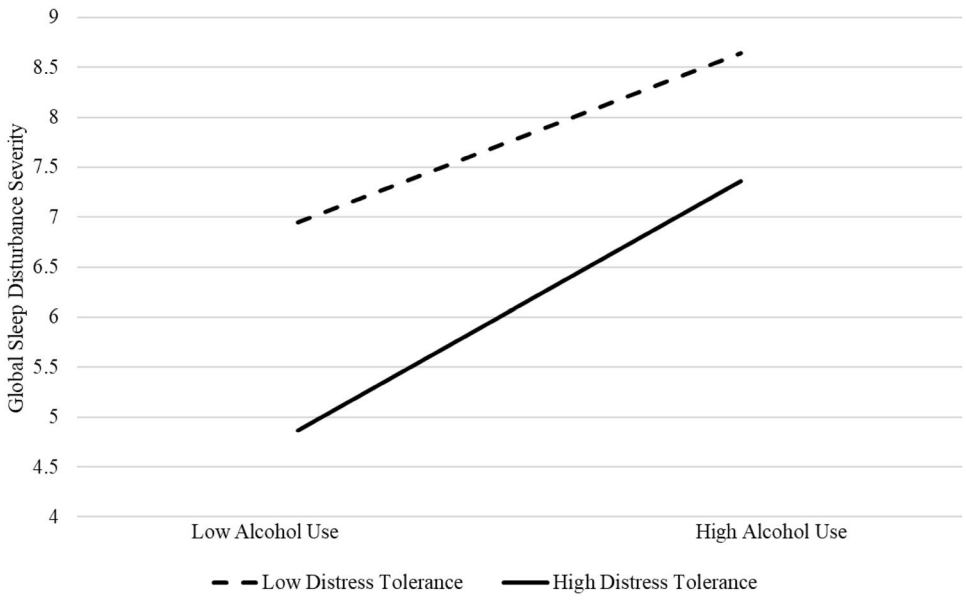


**Fig. 1** Interaction of alcohol use severity with distress tolerance in predicting global sleep disturbance. Full scale range of the PSQI is 0–21

efficiency, perceived sleep quality, and daily disturbances), higher scores indicate increased sleep disturbance. In the present study, internal consistency of the PSQI global sleep disturbance score was acceptable ($\alpha = .74$). The component scores, evidenced lower internal consistency for sleep efficiency ($\alpha = .53$), perceived sleep quality ($\alpha = .58$), and daily disturbances ($\alpha = .66$). The PSQI global sleep disturbance score was used as the primary outcome variable in the current analysis. The three component scores, based upon the 3-factor model of the PSQI, were used as exploratory analysis outcomes.

#### Sources of Occupational Stress (SOOS-14; Kimbrel et al. 2011)

The SOOS-14 is a revised 14-item self-report measure used to assess occupational stress, defined as the harmful physical and emotional responses that occur when the requirements of the job do not match the capabilities, resources, or needs of the worker. Items are scored on a 5-point Likert-style scale from 1 (*Not at all bothered*) to 5 (*Extremely bothered*). Total scores range from 14 to 70, with higher scores indicating greater levels of occupational stress. The SOOS-14 has exhibited good factor structure and validity coefficients across independent samples of firefighters (Kimbrel et al. 2011). Internal consistency of the SOOS-14 for the current sample was excellent ($\alpha = .91$). Extant research has demonstrated positive correlations between occupational stress and negative affect ($r$'s = .33–.57), generally (e.g., Decker and Borgen 1993; Falco et al. 2013; Fogarty et al. 1999), as well as specific mental health concerns (e.g., posttraumatic stress, depression and substance abuse; Kimbrel et al. 2011). The SOOS-14 total score was used as a covariate to account for occupational stress in the current study.

### Procedures

All firefighters were recruited for participation in an online, survey-based study through a large urban fire department in the southern United States. A fire department-wide email was sent to all firefighters, notifying them of the opportunity to complete an online research survey about stress and health behaviors among firefighters for one continuing education (CE) credit and a chance to win one of several raffle prizes (e.g., movie tickets, restaurant gift certificates). 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. Firefighters who elected to participate were given the option to discontinue participation at any time without penalty. The total amount of time required for participation in this study was estimated at 45–60 min. The study has been approved by all relevant institutional review boards.

### Analytic Plan

Descriptive statistics, bivariate correlations, and study hypotheses were tested using IBM SPSS 24.0. First, descriptive statistics and bivariate correlations among all study variables were examined. List-wise deletion was utilized for missing data. Specifically, among 11% of participants, data were missing for two open-ended items on the PSQI, which are necessary for computing the total score and the sleep efficiency subscale; no other missing data on relevant variables was noted. Second, a hierarchical regression analysis was conducted. Years in the fire department (demographics questionnaire) and occupational stress severity (SOOS-14 total score) were entered as covariates (step one). Next, predictors were mean-centered with alcohol use severity (AUDIT total score) and distress tolerance (DTS total score) were entered as predictors (step two). Finally, the interaction term of alcohol use severity and distress tolerance were entered (step three). The outcome variable was global sleep disturbance (PSQI total score). Post hoc analyses were conducted to examine the impact of the proposed models on three specific sleep outcomes, including sleep efficiency, perceived sleep quality, and daily disturbances (see the "Measures" section above for descriptions of each). Given the exploratory nature of these analyses, a Bonferonni correction was applied to control for Type I error ($\alpha = .05/3 = .016$).

## Results

### Descriptive Statistics

Distributions for study variables approximated normality (skewness < |2.25|; George and Mallery 2003) and any missing values were assumed to be missing at random. Examination of collinearity diagnostics revealed no evidence of excess collinearity among predictors [variance inflation index (VIF) < 1.07]. Bivariate correlations for study variables are presented in Table 2. Alcohol use severity was significantly and negatively associated with distress tolerance and significantly and positively associated with global sleep disturbance, sleep efficiency, perceived sleep quality, and daily disturbances. Distress tolerance was also negatively associated with global sleep disturbance, sleep efficiency, perceived sleep quality, and daily disturbances. Occupational stress severity was significantly and positively correlated with alcohol use severity and global sleep disturbance, sleep

**Table 2** Bivariate correlations of study variables

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Mean | SD |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Years of service | – | – | – | – | – | – | – | – | 13.12 | 8.75 |
| 2. Occupational Stress | .07 | – | – | – | – | – | – | – | 25.35 | 10.01 |
| 3. Alcohol use severity | −.04 | .27** | – | – | – | – | – | – | 5.58 | 5.04 |
| 4. Distress tolerance | .01 | −.20** | −.20** | – | – | – | – | – | 61.52 | 12.36 |
| 5. Global sleep disturbance | .02 | .47** | .30** | −.23** | – | – | – | – | 6.08 | 3.76 |
| 6. Sleep efficiency | −.06 | .20** | .15** | −.14** | .73** | – | – | – | 1.92 | 1.56 |
| 7. Perceived sleep quality | .02 | .41** | .27** | −.21** | .87** | .41** | – | – | 2.60 | 1.95 |
| 8. Daily disturbances | .10* | .52** | .30** | −.22** | .75** | .31** | .57** | – | 1.56 | 1.23 |

N = 652; Years in the fire service = demographic measures; Occupational stress = Sources of Occupational Stress Scale (SOOS-14) total score (Kimbrel et al. 2011); Alcohol use severity = Alcohol Use Disorders Identification Test (AUDIT) total score (Saunders et al. 1993); Distress tolerance = Distress Tolerance Scale (DTS) total score (Simons and Gaher 2005); Global sleep disturbance = Pittsburgh Sleep Quality Index (PSQI) total score (Buysse et al. 1989); Sleep efficiency, perceived sleep quality, and daily disturbances are derived from the PSQI (Buysse et al. 1989)

**p < .01

efficiency, perceived sleep quality, and daily disturbances; and significantly and negatively correlated with distress tolerance. Finally, years of service within the fire department was not significantly correlated with occupational stress severity, alcohol use, distress tolerance, global sleep disturbance, sleep efficiency, or perceived sleep quality; and significantly and positively correlated with daily disturbances.

### Hierarchical Regression Analyses

A hierarchical regression analysis was conducted. Please see Table 3 for a summary of results. At step 1, the covariate of years of service in the fire department was not significantly associated with global sleep disturbance. However, occupational stress was significantly associated with global sleep disturbance. At step 2, alcohol use severity and distress tolerance were significantly associated with global sleep disturbance, after controlling for covariates. Finally, at step 3, the interactive effect of alcohol use severity and distress tolerance was significantly associated with global sleep disturbance, after controlling for main effects and covariates, contributing 1% of variance above the 27% of variance accounted for in steps 1 and 2.

Notably, the models were conducted without excluding participants based on lifetime alcohol use. The models were also run with posttraumatic stress as a covariate instead of occupational stress. The pattern of results and magnitude of effects reported above remained consistent.

### Post-Hoc Exploratory Analyses

Please see Table 3 for a summary of results of exploratory analyses. First, sleep efficiency was examined as an outcome. At step 1, the covariate of years of service in the fire department was not significantly associated with sleep efficiency, but occupational stress was significantly associated with sleep efficiency. At step 2, alcohol use severity and distress tolerance were not significantly associated with sleep efficiency given the Bonferroni correction. The interactive effect of alcohol use severity and distress tolerance at step 3 was also not significantly associated with sleep efficiency.

Second, perceived sleep quality was examined as an outcome. At step 1, years of service in the fire department was not significantly associated with perceived sleep quality, but occupational stress was significantly associated with perceived sleep quality. At step 2, alcohol use severity and distress tolerance were significantly associated with perceived sleep quality. However, the interactive effect of alcohol use severity and distress tolerance was not significantly associated with perceived sleep quality given the Bonferroni correction.

Third, daily disturbances were examined as an outcome. At step 1, years of service in the fire department was not significantly associated with daily disturbances, but occupational stress was significantly associated with daily disturbances. At step 2, alcohol use severity and distress tolerance were significantly associated with daily disturbances. At step 3, the interactive effect of alcohol use severity and distress tolerance was significantly associated with daily disturbances.

## Discussion

The current study examined the main and interactive effects of alcohol use and distress tolerance with regard to sleep disturbance among firefighters, an important aspect of health behavior relevant to a variety of psychiatric and medical conditions (Breslau et al. 1996; Dragioti et al. 2018; Katz

**Table 3** Hierarchical regression results: sleep disturbance

| | $\Delta R^2$ | β[a] | SE | $sr^2$ | *p* |
|---|---|---|---|---|---|
| Main outcome: sleep disturbance | | | | | |
| Level 1 | .22 | | | | .000 |
| Years of service[b] | | −.01 | .02 | .00 | .707 |
| Occupational stress[c] | | .47 | .01 | .22 | .000 |
| Level 2 | .05 | | | | .000 |
| Alcohol use severity[d] | | .17 | .03 | .03 | .000 |
| Distress tolerance[e] | | −.12 | .01 | .02 | .001 |
| Level 3 | .01 | | | | .002 |
| Interaction[f] | | −.11 | .00 | .01 | .002 |
| Post Hoc outcome: sleep efficiency | | | | | |
| Level 1 | .05 | | | | .000 |
| Years of service[b] | | −.07 | .01 | .01 | .062 |
| Occupational stress[c] | | .21 | .01 | .04 | .000 |
| Level 2 | .02 | | | | .005 |
| Alcohol use severity[d] | | .08 | .01 | .01 | .041 |
| Distress tolerance[e] | | −.09 | .01 | .09 | .029 |
| Level 3 | .00 | | | | .376 |
| Interaction[f] | | −.04 | .00 | .01 | .376 |
| Post Hoc outcome: perceived sleep quality | | | | | |
| Level 1 | .17 | | | | .000 |
| Years of service[b] | | −.01 | .01 | .00 | .888 |
| Occupational stress[c] | | .41 | .01 | .17 | .000 |
| Level 2 | .04 | | | | .000 |
| Alcohol use severity[d] | | .16 | .01 | .03 | .000 |
| Distress tolerance[e] | | −.11 | .01 | .01 | .004 |
| Level 3 | .01 | | | | .024 |
| Interaction[f] | | −.08 | .00 | .01 | .024 |
| Post Hoc outcome: daily disturbances | | | | | |
| Level 1 | .27 | | | | .000 |
| Years of service[b] | | .06 | .01 | .00 | .079 |
| Occupational stress[c] | | .51 | .00 | .27 | .000 |
| Level 2 | .04 | | | | .000 |
| Alcohol use severity[d] | | .17 | .01 | .04 | .000 |
| Distress tolerance[e] | | −.09 | .00 | .01 | .006 |
| Level 3 | .02 | | | | .000 |
| Interaction[f] | | −.15 | .00 | .03 | .000 |

[a]β = standardized beta

[b]Years of service = demographic measures

[c]Occupational stress = Sources of Occupational Stress Scale (SOOS-14) total score (Kimbrel et al. 2011)

[d]Alcohol use severity = Alcohol Use Disorders Identification Test (AUDIT) total score (Saunders et al. 1993)

[e]Distress tolerance = Distress Tolerance Scale (DTS) total score (Simons and Gaher 2005)

[f]Interactive term of alcohol use severity and distress tolerance

and McHorney 1998; Klingaman et al. 2017; Kuppermann et al. 1995). Results were consistent with hypotheses, and our proposed model accounted for 28% of variance in global sleep disturbance. The findings for the current study are informative given the relative dearth of information regarding behavioral and cognitive affective underpinnings of sleep disturbance within this vulnerable population.

First, the current study demonstrated a significant incremental effect of alcohol use severity on global sleep disturbance among firefighters, above and beyond the covariates of years in the department and occupational stress. Furthermore, post hoc analyses revealed significant incremental effects of alcohol use severity on perceived sleep quality and daily disturbances, but not sleep efficiency. Results are reflective of the well-established empirical literature demonstrating that alcohol use may contribute to various aspects of impaired sleep (e.g., changes in sleep pattern, poorer sleep quality, daytime sleepiness; Colrain et al. 2014; Hartwell et al. 2015; Mahfoud et al. 2009; Roehrs and Roth 2001). While there was not a statistically significant effect for sleep efficiency (i.e., the proportion of time in bed spent sleeping), this particular aspect of sleep is notably subject to multiple external influences among firefighters, including shared sleeping quarters, dispatch alarms, etc. Future work may incorporate more objective measures of sleep efficiency beyond self-report, as self-report of sleep duration has been shown to correlate poorly with objective measures of sleep (e.g., Girschik et al. 2012).

Second, distress tolerance was incrementally associated with global sleep disturbance among firefighters, after accounting for covariates. Exploratory analyses demonstrated that these effects were consistent for perceived sleep quality and daily disturbances, but not sleep efficiency. Thus, firefighters with low distress tolerance may be especially apt to manifest lower subjective sleep quality and higher daytime fatigue, but not lower sleep productivity. Theoretically, firefighters with low distress tolerance may have difficulty regulating negative emotional states (Mauss et al. 2013; Yoo et al. 2007), thus amplifying their propensity for sleep disturbances due to heightened emotional arousal. These results indicate that distress tolerance may not have as great an impact on subjective sleep efficiency, and future work may compare the relative effect of perceived versus behaviorally indexed distress tolerance, as well as more objective measures of sleep efficiency, to further explore this association. It is also important for future work to test this theoretical postulation through experimental methodologies to ascertain whether the documented association between distress tolerance and sleep disturbance is accounted for, or exacerbated, by emotion regulation difficulties. Furthermore, this finding is theoretically consistent with emerging work demonstrating associations between low distress tolerance and increased sleep disturbance (Reitzel et al. 2017; Short et al. 2016). These findings might suggest that distress tolerance skills may be beneficial to improving interventions for sleep disturbance in this unique population. Indeed, individuals with heightened distress tolerance may self-select into the

firefighting profession; conversely, distress tolerance levels may change over time as a result of the chronically stressful nature of the occupation. Longitudinal investigations examining the role of distress tolerance in terms of predicting risk and resilience among firefighters are imperative, as such empirical efforts have potential to inform specialized distress tolerance interventions for firefighters.

Third, distress tolerance significantly moderated the association between greater alcohol use and greater global sleep disturbance symptoms, above and beyond the effects of covariates and main effects. The interactive effect contributed 1% of unique variance to the model, above and beyond the 27% of variance accounted for by covariates and main effects. Further, post hoc exploratory analyses demonstrated that distress tolerance moderated the association between alcohol use severity and daily disturbances, contributing 2% of unique variance. This indicates that firefighters in the current sample with higher levels of alcohol use and lower distress tolerance are more likely to report greater global sleep disturbance and increased sleep-related daily disturbances. However, there was not a significant interaction of alcohol use severity and distress tolerance on sleep efficiency or perceived sleep quality. While these findings may be partially due to error inherent in self-report of sleep (e.g., Girschik et al. 2012), it indicates that distress tolerance does not moderate the relationship between alcohol use severity and sleep efficiency or perceived sleep quality in the current sample. Overall, alcohol use severity is related to increased sleep disturbance, and this association is markedly stronger when firefighter's levels of distress tolerance are low.

Notably, occupational stress was most robustly related to global sleep disturbance, as compared to either alcohol use severity or distress tolerance, underscoring its clinical relevance with regard to sleep among firefighters. Occupational stress also was significantly related to perceived sleep quality and daily disturbances. These findings are consistent with past research showing increased levels of occupational stress are significantly related to increased sleep disturbance (Akerstedt et al. 2002; Lusa et al. 2002). As firefighters with increased occupational stress are more likely to experience increased sleep disturbance, efforts to reduce job-related stress in the fire service may help to improve sleep quality and thus improve occupational stress among this vulnerable population.

This study contributes to the growing literature documenting associations between increased alcohol use and various facets of sleep disturbance in firefighters (Carey et al. 2011; Vargas de Barros et al. 2013; Yun et al. 2015). Notably, effect sizes were small and warrant replication with more generalizable samples of firefighters. Nevertheless, these results might be clinically important. Replications and extensions of this work may increase the effectiveness of emerging interventions seeking to improve sleep quality among firefighters (Sullivan et al. 2017). Given that firefighters are at risk of chronic sleep disturbance (Carey et al. 2011; Vargas de Barros et al. 2013), specialized intervention programs for firefighters might consider including a discussion of the health impact of sleep disturbance, education regarding associations between alcohol use and sleep disturbance, an emphasis on building distress tolerance skills to enhance emotional coping and thus improve sleep quality and reduce alcohol use, and screening (and appropriate referrals) for problematic alcohol use.

Beyond the primary aims of the study, additional findings are worthy of note. First, number of years in the fire service was not significantly related to study variables with the exception of a significant positive association with daily disturbances, indicating that daily disturbances (e.g., daytime fatigue, lack of enthusiasm) may increase with years in the fire service. Notably, the number of years in the fire service was not significantly associated with alcohol use severity, which is in contrast to extant research among firefighters demonstrating significant associations between years in the fire department and probable alcohol dependence (e.g., Meyer et al. 2012; Paulus et al. 2017). These findings may indicate that firefighters in the current sample with more years of experience are not as likely to utilize alcohol. Alternatively, firefighters who engage in increased alcohol use may not continue working in the fire service over time. Second, approximately 23.5% of firefighters met clinical cut-off levels for hazardous alcohol use, which is similar to the prevalence of hazardous alcohol use across various samples of firefighters (e.g., Jones 2017; Paulus et al. 2017). In addition, 48.6% of firefighters endorsed clinically significant levels of disturbed sleep, which is a rate consistent with other firefighter samples (Carey et al. 2011; Vargas de Barros et al. 2013).

While interpreting the results of this study, several limitations are worthy of note. First, this study utilized a cross-sectional design, and thus, no inferences regarding causality among variables can be inferred. It is imperative that future work integrate longitudinal and experimental designs in order to better understand the relations among alcohol use, distress tolerance, and sleep disturbance among firefighters. Second, while the self-report methodology facilitated the screening of a large sample of firefighters, effects of method variance and reporting bias cannot be ruled out. Future research may benefit from employing multimodal measures (i.e., self-report and behavioral indices) of distress tolerance and experimental measures of sleep disturbance (e.g., actigraphy, polysomnography) to better distill relations between perceived and behaviorally-indexed distress tolerance associations with sleep disturbance. Relatedly, under-reporting of sensitive topics cannot be ruled out. Firefighters in the current study, specifically, were all career (versus volunteer)

firefighters and certain psychiatric symptoms (e.g., alcohol use) may have been underreported due to fears of job-related repercussions (Hom et al. 2016; Stanley et al. 2017). Third, while this study controlled for the effects of years in the fire department and occupational stress, which were selected due to their relevance to the variables under study (e.g., Meyer et al. 2012; Murphy et al. 1999; Paulus et al. 2017; Piazza-Gardner et al. 2014), it did not control for affective symptoms or psychiatric disorders. Future work may incorporate assessment of psychiatric disorders to evaluate how such symptoms may interplay with distress tolerance, alcohol use, and sleep disturbance. Finally, alcohol and sleep variables within the current study were assessed according to different timeframes (past year and past month, respectively). Given the acute physiological effects of alcohol upon sleep, it is possible that recent alcohol use may have more robust associations with sleep, a line of work that should be examined by future research. Overall, replication and extension of this work among larger, more representative populations of firefighters is necessary in order to draw more definitive conclusions regarding the clinical significance of the variables under study.

The current examination also had several strengths. Notably, the current study examined a large sample from a unique population that is highly understudied with regard to substance use (e.g., alcohol use) and health behaviors (e.g., sleep disturbance). Further, this study examined a novel model with regard to substance use, cognitive affective factors, and health behaviors. Future research should build upon these preliminary findings by investigating these associations among various samples of firefighters and with the inclusion of more objective measures of sleep disturbance. Research examining factors that impact the association between alcohol and sleep among firefighters, a vulnerable population in need of increased empirical attention, may inform interventions to reduce the burden of sleep disturbance within the fire service and improve overall safety.

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## Compliance with Ethical Standards

**Conflict of Interest** Lia J. Smith, Brooke A. Bartlett, Jana K. Tran, Matthew W. Gallagher, Candice Alfano, and Anka A. Vujanovic declare that they have no conflict of interest.

**Ethical Approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the University of Houston, Houston Fire Department, and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed Consent** Informed consent was obtained from all individual participants included in the study.

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