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The impact of sleep and psychiatric symptoms on alcohol consequences among young adults

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HIGHLIGHTS

- One in four heavy-drinking college students reports poor sleep quality.
- More than half screen positive for a psychiatric disorder
- Sleep quality and psychiatric symptoms interact in the prediction of alcohol problems.
- Treatment of sleep and psychiatric symptoms may improve alcohol outcomes.

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ABSTRACT

Objective: Independent lines of research have documented links between psychiatric symptoms and poor sleep quality, psychiatric symptoms and alcohol use, and alcohol use and poor sleep quality. The current study examined the synergistic effect of poor sleep quality and psychiatric symptoms on alcohol-related consequences in heavy-drinking young adults.
Method: Matriculating college students reporting at least one heavy drinking episode over the first nine weeks of the semester ($N = 385$, 52% female) were categorized as experiencing 'good' ($n = 280$) versus 'poor' sleep quality ($n = 105$) and screening 'positive' ($n = 203$) or 'negative' ($n = 182$) for a psychiatric disorder. Sleep quality was assessed using the Pittsburgh Sleep Quality Index; psychiatric diagnosis was assessed using the Psychiatric Diagnostic Screening Questionnaire; and alcohol-related consequences were assessed using the Brief Young Adult Alcohol Consequences Questionnaire. General linear models were used to examine the main effects and interaction between sleep quality and psychiatric symptoms on alcohol-related consequences.
Results: Sleep quality moderated the association between psychiatric screen and alcohol-related consequences among heavy-drinking college students, such that psychiatric symptoms were associated with more alcohol-related consequences in the context of poor sleep quality.
Conclusions: The combination of poor sleep quality and psychiatric symptoms is associated with increased alcohol-related consequences among heavy-drinking college students. Given the significant interaction between these symptoms, healthcare providers are encouraged to screen for the presence of sleep and psychiatric disorders among heavy-drinking young adults and to provide empirically-supported treatments as appropriate.

Alcohol remains the most widely used psychoactive substance among young adults, with 14% of high school seniors consuming five or more drinks in a row in the past two weeks (Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2015b). This rate of drinking increases substantially as adolescents matriculate to college campuses and universities, where 35% of students report this form of heavy drinking (Johnston, O'Malley, Bachman, Schulenberg, & Miech, 2015a). Heavy drinking in adolescence predicts more frequent occurrence of health

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problems and unsafe health behaviors at 24 years (Oesterle et al., 2004). Thus, prevention of heavy alcohol use among young adults is an ongoing focus of public health efforts.

Poor sleep health (defined broadly as short sleep duration, trouble falling/staying asleep, inconsistent sleep timing, decreased alertness, or poor subjective sleep quality; see Buysse, 2014) has been identified as a risk factor for alcohol-related consequences among young adults. Poor sleep quality, in particular, has been found to moderate the association between alcohol use and related consequences, such that college students reporting worse subjective sleep quality experience more consequences as a result of alcohol consumption (Kenney, LaBrie, Hummer, & Pham, 2012; Miller, DiBello, Lust, Carey, & Carey, 2016). This association occurs not only concurrently but also prospectively, with worse sleep quality predicting more alcohol-related consequences over a five-month period (Miller et al., 2016). Trouble falling/staying asleep at 16–17 years has also been associated with greater alcohol-related problems at ages 21–22 (Wong, Robertson, & Dyson, 2015). Thus, poor sleep health seems to compound young adults' risk for alcohol-related problems, both in the short- and long-term.

Despite consistent associations between sleep and alcohol use in young adults, adolescence and young adulthood are marked by major social and developmental changes that may influence both sleep and alcohol use. Symptoms of psychiatric disorders, in particular, typically emerge between 14 and 24 years (Kessler et al., 2005) and may impact the course and duration of both substance use and sleep disorders. In regards to the association between psychiatric symptoms and alcohol use among college students, symptoms of PTSD have been associated with increased alcohol use (Radomski & Read, 2016), and those with alcohol use disorders have increased odds of mood and anxiety disorders (Dawson, Grant, Stinson, & Chou, 2005). Complex associations also exist between psychiatric symptoms and sleep: while sleep disturbance is often a symptom of psychiatric disorders, changes in sleep may also impact symptom severity and response to treatment (Krystal, 2012). Changes in sleep also seem to impact affective states that may influence the presentation of psychiatric symptoms; specifically, poor sleep quality and shortened sleep duration have been associated with decreased positive affect in adolescents and adults (Bower, Bylsma, Morris, & Rottenberg, 2010; Talbot, McGlinchey, Kaplan, Dahl, & Harvey, 2010) and increased negative affect in response to mild stress (Minkel et al., 2012). Collectively, these data suggest that alcohol use may be associated with symptoms that cut across multiple diagnoses (Roberts, Roberts, & Xing, 2007). Difficulty falling/staying asleep is one symptom that is shared across multiple psychiatric disorders, and therefore may represent a cross-diagnostic risk factor for alcohol-related problems.

While independent associations between psychiatric symptoms, poor sleep quality, and heavy alcohol use have been documented, it is unclear how the synergistic effect of these three factors may impact young people's risk for alcohol-related consequences. National surveys have found that both heavy drinking and psychiatric symptoms predict sleep disturbance among adolescents and young adults (Bruck & Astbury, 2012; Johnson & Breslau, 2001; Popovici & French, 2013; Wong et al., 2015). However, these studies were limited by use of single-item sleep measures and did not assess the joint impact of poor sleep quality and psychiatric symptoms on alcohol-related consequences. In contrast, Kenney, Lac, LaBrie, Hummer, and Pham (2013) found that poor mental health predicted concurrent alcohol-related consequences both directly and indirectly through poor sleep quality. While this model proposes poor sleep quality as a mediator of the association between psychiatric symptoms and alcohol-related consequences, it is also possible that poor sleep quality moderates this association by compounding the negative impact of psychiatric symptoms on alcohol-related consequences.

This study examined the interplay between sleep quality and psychiatric symptoms in predicting alcohol-related consequences among heavy-drinking young adult using two widely-utilized screening measures. Consistent with previous research (Bruck & Astbury, 2012; Johnson & Breslau, 2001; Kenney et al., 2012; Popovici & French, 2013; Wong et al., 2015), we expected poor sleep quality and symptoms suggestive of a psychiatric disorder to predict greater alcohol-related consequences among heavy-drinking college students. Moreover, we hypothesized that poor sleep quality would moderate the association between psychiatric symptoms and alcohol-related consequences, such that psychiatric symptoms would be associated with more alcohol-related consequences in the context of poor sleep quality.

1. Method

1.1. Participants and procedure

Data for the current study were derived from a research study examining sleep and genetics in matriculating college students (Carskadon, Sharkey, Knopik, & McGeary, 2012). First-year college students at a private university in the Northeastern United States were invited by email to participate in the trial. Participants completed an initial survey after accepting college admission. Those who participated in the initial survey were then invited to take part in Phase 2 of the study, in which participants completed online daily diaries for the first nine weeks of their first semester by logging onto the survey website with an identification number and password. Diaries assessed sleep patterns and daily activities, including daily alcohol use. At the end of those nine weeks, a link to the final online outcome survey was provided. Students received $1 for completing each diary (and small $1 bonuses for completion of three and seven consecutive diaries) and $18 for completing the final outcome survey. All procedures were approved by the Institutional Review Board.

Participants selected for the current analysis were heavy-drinking college students who completed at least 50% of daily diaries in the first nine weeks of the semester. Of the 1085 students (58% female; 55% White; $M_{age} = 18.7$, $SD = 0.5$) who provided data for the study, 11 were excluded for completing <50% of daily diaries, 48 participants did not provide sufficient data to be categorized into sleep/psychiatric symptom groups, and 641 denied at least one heavy drinking episode (defined as 4/5+ drinks on one occasion for women/men; Wechsler et al., 2002) over the first nine weeks of the semester. Thus, the final sample included 385 participants (see Table 2 for descriptive statistics). Those excluded from analyses were more likely than those included to be female, $\chi^2(1) = 8.82$, $p = 0.003$, and non-White, $\chi^2(1) = 26.30$, $p < 0.001$. They did not differ significantly in terms of age, $t(913) = 0.86$, $p = 0.39$; sleep quality, $t(958) = -0.19$, $p = 0.85$; or psychiatric symptoms, $t(957) = 0.88$, $p = 0.38$.

2. Measures

2.1. Demographic information

Participants provided information regarding their gender, age, year in school, and race/ethnicity as part of the initial survey.

2.2. Alcohol use

Participants completed nine weeks of daily diaries that included an item assessing how many alcoholic drinks (0 through 9+) they had consumed in the last 24 h (drinks per drinking day). Participants who reported heavy episodic drinking (4/5+ drinks for women/men) in the past 24 h were classified as having had a 'heavy-drinking' day. Participants who denied at least one heavy drinking day over the first nine weeks of the semester were excluded from this study.

2.3. Alcohol-related consequences

The Brief Young Adult Alcohol Consequences Questionnaire (BYAACQ) (Kahler, Hustad, Barnett, Strong, & Borsari, 2008) was

completed as part of the final outcome survey. The BYAACQ includes 24 (*yes*/*no*) items addressing alcohol-related consequences (e.g., driving after drinking too much to drive safely, waking up in an unexpected place after drinking) experienced in the past month. This scale has demonstrated sensitivity to changes in alcohol-related consequences over time (Kahler et al., 2008) and adequate internal consistency in research with college students ($\alpha = 0.89$; in this sample, $\alpha = 0.77$) (Kahler, Strong, & Read, 2005).

2.4. Psychiatric symptoms

Participants also completed the Psychiatric Diagnostic Screening Questionnaire (PDSQ; Zimmerman, 2002) as part of the final outcome survey. The PDSQ is a 125-item self-report (*yes*/*no*) measure of current symptoms for 13 DSM-IV disorders. Timeframes for items varied as a function of the disorder being assessed, ranging from past two weeks to past six months. The PDSQ has demonstrated strong psychometric properties in previous studies, with current case identification methods resulting in 90% sensitivity and 97% negative predictive power among outpatient psychiatric samples (Zimmerman & Mattia, 2001).

Participants were categorized as 'screening positive' for a psychiatric disorder (indicating that the individual is more likely than one who did not screen positive to qualify for diagnosis of that disorder) if they endorsed the established minimum number of symptoms required for any single diagnostic disorder on the PDSQ (see column 1 of Table 1). The substance and alcohol use disorder subscales were not included in screening determinations in order to avoid confounds between predictor and outcome variables. Cut-off scores, rather than total symptom counts, were used for the PDSQ in order to avoid (a) the overemphasis of symptoms (e.g., sleep disturbance) that may manifest across multiple disorders and (b) the assumption that all psychiatric symptoms impose equivalent risk, irrespective of disorder of origin.

2.5. Sleep quality

The Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989), also included in the final outcome survey, is a 19-item measure of sleep quality "on the majority of days and nights in the past month." It assesses seven components of sleep functioning: (a) subjective sleep quality (*very good* to *very bad*); (b) sleep onset latency, or minutes to fall asleep; (c) sleep duration (<5 h, 5-6 h, 6-7 h, or >7 h); (d) habitual sleep efficiency, or percent of time in bed spent sleeping (<65%, 65–74%, 75–84%, or >85%); (e) frequency of sleep disturbances such as early morning awakening, need to use the bathroom, inability to breathe comfortably, snoring, uncomfortable temperature, bad dreams, pain, or other disturbances (*not during the past month* to *three or more times per week*); (f) use of sleep medication (*not during the past month* to *three or more times per week*); and (g) daytime dysfunction. Total PSQI scores range from 0 to 21, with higher scores indicating worse sleep quality. The PSQI has demonstrated good test-retest reliability (Buysse et al., 1989) and correlates with sleep diary reports in clinical and non-clinical samples (Backhaus, Junghanns, Broocks, Riemann, & Hoghagen, 2002; Grandner, Kripke, Yoon, & Youngstedt, 2006). In this study, a cut-off score of 5 was used to distinguish between those experiencing 'good' (≤5) or 'poor' (>5) sleep quality (Backhaus et al., 2002). Among patients with primary insomnia, a PSQI total score >5 has demonstrated sensitivity of 99% and specificity of 84% (Backhaus et al., 2002).

2.6. Data screening and analysis

Data were screened for missing values, outliers, and normality prior to analysis. Outliers were defined as any value that was three standard deviations above the mean and were replaced with the value that was three standard deviations plus one above the mean (Tabachnick & Fidell, 2007). After replacing outliers for the PDSQ ($n = 5$), skewness and kurtosis estimates for all outcome and predictor variables fell within the normal range. Chi-squared and independent samples *t*-tests were performed to test equivalence of groups across demographic variables, thereby identifying important covariates for subsequent analyses (see Table 2). Using general linear models, we tested the main effects of poor sleep quality and psychiatric symptom groups as well as their interaction on alcohol-related consequences. Sleep and psychiatric symptom groups specified as fixed factors. Age, gender, and average number of drinks per drinking day were included as covariates.

3. Results

3.1. Descriptive information

Participant characteristics are depicted in Table 2, and Pearson correlation coefficients for study variables are presented in Table 3. Zero-order correlations revealed significant positive associations between alcohol-related consequences and age, drinks per drinking day, sleep quality group, and psychiatric symptom group.

3.2. Primary analyses

Parameter estimates for main effects and interactions are presented in Table 4. There was a significant main effect of sleep quality [$F(1, 378) = 12.48$, $p < 0.001$, partial $\eta^2 = 0.03$] and psychiatric symptoms [$F(1, 378) = 7.49$, $p = 0.01$, partial $\eta^2 = 0.02$] on alcohol-related consequences. However, main effects were qualified by a significant interaction between sleep quality and psychiatric symptoms on alcohol-related consequences [$F(1, 378) = 4.13$, $p = 0.04$, partial $\eta^2 = 0.01$]. Examination of estimated marginal means suggests that a positive

Table 1
Frequency of PDSQ symptoms and non-substance-related disorders endorsed by heavy-drinking first-year college students ($N = 385$).

Disorder	Number of symptoms required for a positive screen Required/total	Number of symptoms endorsed *M* (SD)	Positive screen for psychiatric disorder *n* (%)
Social phobia	4/15	3.1 (3.5)	135 (35.1)
Obsessive-compulsive disorder	1/7	0.4 (1.0)	89 (23.1)
Somatization disorder	2/5	0.5 (0.9)	53 (13.8)
Major depressive disorder	9/23	3.9 (3.6)	44 (11.4)
Generalized anxiety disorder	7/10	1.9 (2.5)	31 (8.1)
Bulimia/binge-eating disorder	7/10	1.6 (2.5)	29 (7.5)
Hypochondriasis	1/5	0.2 (0.6)	31 (8.1)
Posttraumatic stress disorder	5/13	1.0 (2.6)	27 (7.0)
Psychosis	1/6	0.1 (0.4)	29 (7.5)
Panic disorder	4/8	0.3 (1.1)	9 (2.3)
Agoraphobia	4/11	0.3 (0.9)	4 (1.0)
Total	N/A	13.3 (12.9)	203 (52.7)

Note. N/A = not applicable. PDSQ = Psychiatric Diagnostic Screening Questionnaire.

Table 2
Group differences in demographic, predictor, and outcome variables ($N = 385$).

Variable	Total sample ($N = 385$)	Good sleep quality ($n = 280$)	Poor sleep quality ($n = 105$)	χ^2/t (df)	Negative PDSQ ($n = 182$)	Positive PDSQ ($n = 203$)	χ^2/t (df)
Age in years (*SD*)	18.6 (0.4)	18.6 (0.4)	18.7 (0.5)	2.08 (383)*	18.7 (0.5)	18.6 (0.4)	1.61 (340)
Female (%)	199 (51.7)	139 (49.6)	60 (57.1)	1.72 (1)	84 (46.2)	115 (56.7)	4.23 (1)*
Race	–	–	–	4.02 (5)	–	–	4.93 (5)
Caucasian (%)	251 (65.2)	188 (67.1)	63 (60.0)	–	125 (68.7)	126 (62.1)	–
African American (%)	16 (4.2)	9 (3.2)	7 (6.7)	–	7 (3.8)	9 (4.4)	–
Asian American (%)	47 (12.2)	32 (11.4)	15 (14.3)	–	21 (11.5)	26 (12.8)	–
American Indian/Alaska Native (%)	2 (0.5)	1 (0.4)	1 (1.0)	–	0 (0.0)	2 (1.0)	–
Bi/multiracial (%)	37 (9.6)	26 (9.3)	11 (10.5)	–	13 (7.1)	24 (11.8)	–
Not reported	32 (8.3)	24 (8.6)	8 (7.6)	–	16 (8.8)	16 (7.9)	–
No. days until first drink	4.8 (6.7)	5.0 (7.1)	4.2 (5.3)	1.06 (383)	4.6 (7.4)	4.9 (5.9)	0.44 (383)
No. diaries completed (*SD*)	62.3 (8.9)	62.5 (8.8)	61.7 (9.4)	0.78 (383)	62.7 (8.8)	62.0 (9.1)	0.69 (383)
% diaries completed	88.4 (11.0)	88.5 (10.8)	87.9 (11.6)	0.48 (383)	89.1 (10.8)	87.7 (11.2)	1.28 (383)
No. heavy drinking days (*SD*)	7.5 (5.1)	7.2 (5.0)	8.2 (5.2)	1.84 (383)	7.5 (5.1)	7.5 (5.1)	0.04 (383)
% heavy drinking days (*SD*)	12.0 (8.2)	11.6 (8.2)	13.3 (8.0)	1.86 (383)	12.0 (8.3)	12.1 (8.1)	0.10 (383)
Average TST (*SD*)	7.2 (0.6)	7.3 (0.6)	7.0 (0.6)	3.38 (383)*	7.2 (0.6)	7.2 (0.6)	1.27 (383)
PSQI total score (*SD*)	4.5 (2.1)	3.5 (1.2)	7.3 (1.4)	27.27 (383)*	3.9 (1.8)	5.1 (2.2)	5.91 (381)*
PDSQ total score (*SD*)	13.3 (12.9)	11.0 (11.9)	19.5 (13.5)	5.67 (166)*	4.8 (4.1)	20.9 (13.3)	16.45 (245)*
No. PDSQ cut-offs met	1.3 (1.7)	1.0 (1.5)	1.9 (2.0)	4.44 (152)*	0.0 (0.0)	2.4 (1.7)	19.67 (202)*
BYAACQ (*SD*)	4.5 (3.5)	4.0 (3.1)	5.9 (3.9)	4.51 (158)*	3.9 (3.0)	5.1 (3.7)	3.41 (378)*

Note. BYAACQ = Brief Young Adult Alcohol Consequences Questionnaire (higher scores indicate more consequences). No. = number. PSQI = Pittsburgh Sleep Quality Index (higher scores indicate worse sleep quality). PDSQ = Psychiatric Diagnostic Screening Questionnaire (higher scores indicate more psychiatric symptoms). TST = total sleep time.
* $p < 0.05$.

psychiatric screen is associated with more alcohol-related consequences in the context of poor, but not good, sleep quality (see Fig. 1).[1]

4. Discussion

This study extends the previous literature by evaluating the influences of sleep quality and psychiatric symptoms on alcohol-related consequences among young adults who drink. Overall, our data indicate that sleep and psychiatric symptoms interact in the prediction of alcohol-related consequences among heavy-drinking college students, such that those reporting poor sleep quality within the context of a positive psychiatric screen also report more alcohol-related consequences. While the mechanisms underpinning this finding require further investigation, our data suggest that both poor sleep quality and psychiatric symptoms are required to see elevated alcohol-related consequences, at least among heavy-drinking college students. It may be that sleep quality and psychiatric symptoms are independent risk factors that work synergistically to raise the risk of consequences, perhaps via compounded deficits in attention and working memory capacity (Alhola & Polo-Kantola, 2007; Benitez & Gunstad, 2012; Moon & Jeong, 2015; Singh & Gotlib, 2014). Alternatively, the presence of both poor sleep quality and psychiatric symptoms may be a marker of shared genetic vulnerabilities that place individuals at increased risk for alcohol-related consequences.

We were surprised to find that participants reporting only one risk factor (poor sleep quality or a positive psychiatric screen) did not report significantly more alcohol-related consequences than those endorsing neither difficulty. This seems to qualify previous literature indicating the poor sleep health (Kenney et al., 2012; Miller et al., 2016) and psychiatric symptoms (Harford, Yi, Chen, & Grant, 2015) have independent effects on alcohol-related consequences. However, it is important to note that current findings are generalizable specifically to heavy-drinking college students. National data suggest that the association between drinking and psychiatric symptoms is weaker among college students than those who are not in college, perhaps due to increased access to social support and mental health treatment (Dawson et al., 2005). Similarly, rates of self-medication of psychiatric symptoms with alcohol are lower among college students than 18- to 29-year-olds who are not in college (Dawson et al., 2005). Given these data, it is possible that poor sleep quality and/or psychiatric symptoms would exert stronger independent effects on alcohol-related problems in other samples and contexts.

Given their associations with alcohol-related consequences, it is important to note that rates of poor sleep quality and psychiatric problems in the current sample were high. One in four students scored in the PSQI range indicating poor sleep quality (>5), and 36% failed to achieve the recommended minimum of 7 h of sleep per night (Watson et al., 2015). Similarly, over half of our sample screened positive for a psychiatric disorder on the PDSQ. This finding is consistent with previous studies, in which 50% of heavy-drinking college students experienced elevated levels of depression, anxiety, or mental distress (Kenney et al., 2013). However, the diagnostic categories endorsed in our sample were surprising. For example, positive screens for depression (11% in our sample vs. 16% in previous research), panic (2% vs. 24%), and generalized anxiety (8% vs. 28%) substantially lower than rates documented among heavy-drinking college students in previous research (Cranford, Eisenberg, & Serras, 2009). Conversely, positive screens for all disorders were higher than the estimated rate of occurrence in the general adult population (Zimmerman, 2002). This may be due in part to the relatively high sensitivity (90%) but low specificity (66%) of the recommended cut-offs for the PDSQ (Zimmerman & Mattia, 2001).

The prevalence of both sleep and psychiatric problems among college students in the current sample highlights the ongoing need for healthcare professionals to screen and treat these issues. Chronic mild sleep deprivation has been associated with increased sensitivity to stress (Meerlo, Sgoifo, & Suchecki, 2008), which may heighten risk for psychiatric disorders. Similarly, symptoms of anxiety and mood disorders were among the most commonly reported psychiatric symptoms endorsed in this sample. Effective treatments for all of these disorders exist, and efficacious transdiagnostic treatments have been computerized to increase the feasibility of such interventions (Newby, Tworney, Li, & Andrews, 2016); yet they are underutilized in university settings (Cranford et al., 2009). Additional efforts to implement prevention

[1] Because anxiety, mood, and trauma-related disorders have been associated with alcohol use among college students (Dawson et al., 2005; Radomski & Read, 2016), we conducted exploratory analyses including only those participants who screened positive for anxiety-, mood-, or trauma-related disorders (at the exclusion of somatization disorder, eating disorders, hypochondriasis, and psychosis). The pattern of results was consistent, in that those who reported both poor sleep quality and a positive psychiatric screen ($M = 6.30$, $SE = 0.38$) reported more alcohol-related consequences than those reporting poor sleep quality/negative screen ($M = 4.50$, $SE = 0.60$), good sleep quality/positive screen ($M = 4.36$, $SE = 0.31$), or good sleep quality/negative screen ($M = 3.92$, $SE = 0.26$). However, the interaction was no longer statistically significant [$F(1, 353) = 2.80$, $p = 0.10$, partial $\eta^2 = 0.01$].

Table 3
Descriptive statistics and zero-order correlations among study variables ($N = 385$).

		1	2	3	4	5	6	7
1	Age	–						
2	Female gender	−0.04	–					
3	White race	−0.03	−0.10	–				
4	Drinks per drinking day	−0.10	−0.34*	0.05	–			
5	Poor sleep quality (PSQI)	0.11*	−0.07	−0.07	0.06	–		
6	Positive PDSQ screen	−0.08	−0.11*	−0.07	0.03	0.23*	–	
7	BYAACQ	−0.14*	−0.01	0.04	0.30*	0.25*	0.17*	–
		M	*N*	*N*	*M*	*N*	*N*	*M*
		18.63	199	251	4.71	105	203	4.54
		SD	%	%	*SD*	%	%	*SD*
		0.44	51.7	65.2	1.53	27.3	52.7	3.45

Note. BYAACQ = Brief Young Adult Alcohol Consequences Questionnaire (higher scores indicate more consequences). PDSQ = Psychiatric Diagnostic Screening Questionnaire (0 = negative screen, 1 = positive screen). PSQI = Pittsburgh Sleep Quality Index (0 = good sleep quality, 1 = poor sleep quality).
* $p < 0.05$.

and intervention strategies for poor sleep health and psychiatric symptoms on college campuses are warranted, as screening and discussion of impairment in these areas may serve as a personally relevant entry to formal and empirically-supported treatment.

4.1. Limitations

Results of this study should be interpreted in the context of important limitations. First, college students in the current sample were primarily White, older adolescents enrolled in their first semester at a private, four-year college; therefore, findings may not generalize to more diverse samples. However, sleep and drinking patterns were consistent with those reported in other research (Kenney et al., 2012), and there is evidence that sleep (Doane, Gress-Smith, & Breitenstein, 2015) and heavy drinking patterns (Martinez, Sher, & Wood, 2014) in the first semester of college parallel those reported in subsequent semesters. Second, predictor and outcome variables were measured concurrently, precluding determination of causality in associations between sleep, psychiatric symptoms, and alcohol-related consequences. Third, all data were collected via self-report. Young adults' self-reported estimates of alcohol use (Leffingwell et al., 2013) and sleep patterns (Wolfson et al., 2003) have been correlated with objective measures of each respective behavior in previous studies; however, self-reported psychiatric symptoms in the current study likely overestimated true rates of such disorders in the general population (Zimmerman, 2002). Similarly, participants were not provided with standard drink definitions; therefore, self-reported drinking quantities use may be underestimated (Bergen-Cico & Kilmer, 2010).

The conclusions drawn from this study are also limited by the fact that we did not attempt to control for the extent to which certain psychiatric diagnoses (e.g., anxiety or depression) may be more strongly associated with both sleep and alcohol-related consequences than others (eating disorders) (Harford et al., 2015). We chose this non-specific approach to psychopathology based on findings that heavy substance use in the context of any comorbid disorder is associated with functional impairment among adolescents (Roberts et al., 2007). However, this approach assumes that various forms of psychopathology are interchangeable in their association with problematic sleep and/or drinking, which may not be the case (Harford et al., 2015).

Finally, our attempt to predict alcohol use as a function of poor sleep quality is confounded by the bidirectional relationship between sleep and alcohol use. Specifically, a moderate dose of alcohol has been found to delay sleep onset in college students who attempt to initiate sleep on the ascending limb of the breath alcohol concentration curve and accelerate sleep onset on the descending limb (Van Reen, Rupp, Acebo, Seifer, & Carskadon, 2013). Alcohol use has also been associated with later bedtimes and rise times among college students (Van Reen et al., 2016). Thus, alcohol use itself may lead to changes in sleep quality, which in turn may impact alcohol-related problems. While we attempted to account for this by controlling for drinking quantity in statistical analyses, future studies may overcome this limitation using controlled experimental or daily association research designs.

Table 4
Parameter estimates for main effects and interaction predicting alcohol-related consequences.

	B	*SE*	*t*	*p*	η_p^2
Intercept	20.00	7.04	2.84	0.01	0.02
Age	−0.92	0.37	−2.48	0.01	0.02
Female gender	0.55	0.35	1.56	0.12	0.01
Drinks per drinking day	0.68	0.11	5.99	<0.001	0.09
Good sleep quality (PSQI)	−2.18	0.46	−4.75	<0.001	0.002
Negative PDSQ screen	−1.86	0.68	−2.73	0.01	0.001
PSQI × PDSQ (0,0)	1.58	0.78	2.03	0.04	0.01

Note. Adj. = adjusted. PDSQ = Psychiatric Diagnostic Screening Questionnaire (0 = negative screen, 1 = positive screen). PSQI = Pittsburgh Sleep Quality Index (0 = good sleep quality, 1 = poor sleep quality).

5. Conclusion

Poor sleep quality and psychiatric symptoms are prevalent among college students who engage in heavy drinking. However, research documenting the interactive effects of these symptoms on alcohol-related consequences is limited. The results of this study indicate that poor sleep quality moderates the association between psychiatric

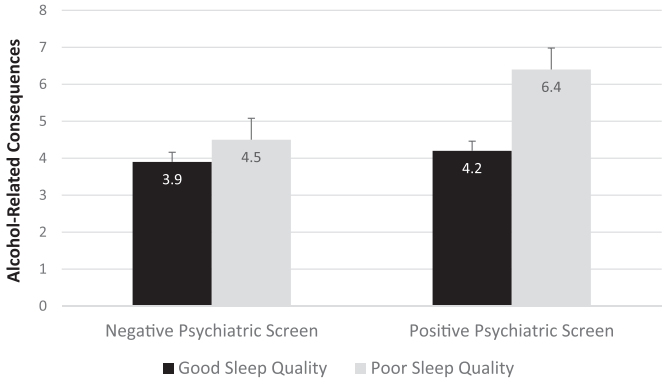

Fig. 1. Group differences in alcohol-related consequences as a function of the sleep by psychiatric symptom group interaction.

symptoms and alcohol-related consequences among heavy-drinking young adults, such that psychiatric symptoms are associated with more alcohol-related consequences in the context of poor sleep quality. Given the negative impact of the combined presentation of these symptoms, healthcare professionals are encouraged to screen and recommend treatment for sleep and psychiatric disorders among young adults presenting for alcohol-related problems.

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Contributors

Author MAC designed the study and wrote the protocol. Authors MAC, EVR, DHB, and BMR implemented the research plan, with input from RS. Author MBM conducted literature searches and provided summaries of previous research studies. Authors MBM and DHB conducted the statistical analysis. Author MBM wrote the first draft of the manuscript, and all authors (including BB and JEM) contributed to and have approved the final manuscript.

Conflict of interest

The authors have no conflicts of interest.

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