ABSTRACT

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| Title of Thesis: | SLEEP, ALCOHOL, AND CANNABIS USE IN COLLEGE STUDENT DRINKERS WITH AND WITHOUT ADHD |
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**Background:** Heavy drinking college students are at risk for experiencing poor sleep and negative alcohol-and cannabis-related consequences. College students with attention-deficit/hyperactivity disorder (ADHD) are uniquely vulnerable to both poor sleep and negative consequences from alcohol and cannabis use. Thus, it is critical to consider relations between ADHD, sleep and alcohol-related negative consequences together in a single study. In the present study, we examined: (1) the associations among ADHD status, sleep and alcohol- and cannabis-related consequences; (2) the independent and interactive effects of sleep and ADHD on negative alcohol-related consequences. Finally, we explored the independent and interactive effects of sleep and ADHD on negative cannabis-related consequences. **Method:** College student drinkers with (*n*=51) and without (*n*=50) ADHD completed a 2-hour assessment that included measures of sleep quality, alcohol and cannabis use, and alcohol/cannabis-related negative consequences. Analyses utilized a series of hierarchical linear regression models to examine study aims. **Results:** College student drinkers with ADHD reported significantly worse sleep

quality relative to non-ADHD student drinkers. Students with ADHD also experienced more negative alcohol-related consequences, relative to student drinkers without ADHD. When ADHD and sleep quality were included in the model together, ADHD—but not sleep quality—was independently associated with negative alcohol consequences, but not negative cannabis consequences. There were no moderating effects of ADHD on the associations among sleep and negative consequences resulting from either alcohol or cannabis use. **Conclusion:** This is the first study to examine sleep quality in college students with and without ADHD engaging in heavy drinking, as well as the first to examine the independent and interactive effects of sleep and ADHD on alcohol- and cannabis-related consequences. Results demonstrated that college drinkers with ADHD are particularly vulnerable to experiencing poor sleep and negative consequences from their alcohol and cannabis use, compared to their heavy drinking peers without ADHD. Future, larger scale studies should consider longitudinal effects as well as underlying mechanisms of risk.

# SLEEP, ALCOHOL, AND CANNABIS USE IN COLLEGE STUDENT DRINKERS WITH AND WITHOUT ADHD

by

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# Introduction

## *Problem Alcohol Use in College*

College is a critical developmental period when students' autonomy increases as they are learning to navigate new responsibilities and their social lives. Higher education is a time for students to test their independence, explore identities and interests, and form new peer groups without much, if any, scaffolding from caregivers. As students transition into college, many will engage in alcohol and cannabis use, which are the most commonly used substances on college campuses and are often easily accessible and embedded in the social scene (Schulenberg et al., 2021). Indeed, over 60% of college students reported drinking alcohol and 39% reported binge drinking in the past month; 20% of college students engaged in cannabis use in the past month (Welsh et al., 2019).

Unfortunately, alcohol use during the college years has the potential to lead to negative consequences, including high-risk behaviors (e.g., alcohol-related aggression, attempted suicide, sexual assault, property damage, impaired driving), academic struggles, health consequences, less favorable career outcomes and greater psychiatric impairment (Buckner et al., 2010; Jennison, 2004; Welsh et al., 2019). The potential for negative alcohol-related consequences is high among college student drinkers (Henry Weschler et al, 1994; Hingson et al., 2017; Jennison, 2004; Lipari & Jean-Francois, 2016; Welsh et al., 2019). For college students, at least one negative consequence resulted on 33% of the days on which they consumed alcohol (Lee et al., 2020). These alcohol- related negative consequences are particularly

concerning given they also increase the risk of progression to alcohol use disorder (AUD; Debenham et al., 2019).

Similarly, cannabis use is common among college student drinkers with initiation peaking in emerging adulthood. Like alcohol, cannabis use is associated with a host of potential negative consequences for college students (Buckner et al., 2010; Kosterman et al., 2000). For students that reported cannabis use in the past month, 90.8% reported one or more negative consequences from their cannabis use (Pearson et al., 2017). Some of the most common consequences endorsed were 49.2% reporting driving while impaired, 45% saying/doing embarrassing things, and 44.7% feeling tired and sluggish the day after use. Since the college student population is at high-risk for experiencing negative alcohol- and cannabis-related consequences, further research examining this population is critical.

### *ADHD, Alcohol Use and Cannabis Use*

Because alcohol and cannabis use are prevalent and normalized in emerging adulthood and can lead to serious negative consequences, identifying *which* college students are most vulnerable for experiencing negative consequences from alcohol and cannabis use in college is of utmost importance. The college transition may be particularly difficult for students with attention-deficit/hyperactivity disorder (ADHD), a neurodevelopmental disorder characterized by age-inappropriate symptoms of inattention and/or hyperactivity-impulsivity. These symptoms are thought to, in part, be due to poor self-regulation (Brocki et al., 2017). Self-regulation is defined as autonomous goal-directed behavior over time to achieve a future consequence (Barkley, 2011). Research shows that college students with ADHD

report worse self-ratings of academic abilities, psychosocial functioning, school engagement, substance use and emotional difficulties than their peers without ADHD (DuPaul et al., 2015). Both alcohol and cannabis use may exacerbate risk for such maladaptive outcomes in this population.

College students with ADHD show significantly higher rates of hazardous alcohol use (i.e., more likely to endorse drinking 4 or more times/week and binge drinking episodes) and higher rates of alcohol-related problems than their peers (Mochrie et al., 2020; Baker et al., 2012; Blase et al., 2009; Rooney et al., 2012). Furthermore, some work has shown that students with ADHD also experience worse impairment as a result of their alcohol use, even when they retrospectively report consuming the same average quantity of alcohol as their peers (Rooney et al., 2012, 2015).

Additionally, a meta-analysis examining ADHD and cannabis use showed that young adults with ADHD are around three times more likely to have used cannabis in their lifetime and 1.5 times more likely to be diagnosed with cannabis use disorder (CUD) than individuals without ADHD (Lee et al., 2011). Howard and colleagues (2020) also found that childhood ADHD symptoms are associated with more frequent cannabis use in adolescence and young adulthood, in part due to their earlier initiation of use. Lastly, a daily diary study examining young adult (ages 19-25) cannabis use across 14 days indicated that negative consequences from cannabis use are higher for those with greater past-6-months ADHD symptoms, compared to those with less severe ADHD symptoms in the past 6 months (Goldstein et al., 2021). Taken together, these findings suggest that ADHD is a risk factor for negative consequences

from alcohol and cannabis use; however, extant literature has yet to explore what consequences look like for students with ADHD when additional risk factors, like sleep quality, are introduced.

*Sleep Quality and Alcohol and Cannabis Use in Students with and without ADHD*

Sleep is critical to examine within the college context among drinkers with and without ADHD because of the ubiquity of sleep problems in young adulthood. In a large multi-site study examining 7,626 college students across six universities, 62% of participants met criteria for poor sleep (i.e., score >5 on Pittsburgh Sleep Quality Index; PSQI), demonstrating that sleep difficulties are very common for emerging adults (Becker et al., 2018). Having good overall sleep quality is essential during this developmental period, as sleep problems (i.e., disturbed sleep continuity, insufficient sleep duration, hypersomnia) are associated with increased internalizing symptoms, and emotion dysregulation in adolescents and college students (Hasler et al., 2015). This research highlights the prevalence of sleep problems in college students.

Furthermore, sleep plays an important role in alcohol use and related problems for college students. Sleep and circadian disruption may alter reward functioning in emerging adult brains (increased risk-taking and reward sensitivity), which in turn, can predict problem alcohol use (Hasler et al., 2015). Moreover, a cross-sectional study of 388 adolescents showed that individuals reporting higher levels of sleep problems also reported higher levels of risk-taking behaviors, including substance use (O'Brien & Mindell, 2005; Taylor & Bramoweth, 2010). These findings suggest that in addition to the prevalence of sleep problems in college

students, sleep problems are associated with alcohol use specifically and warrant further examination in a college sample of heavy drinkers.

Although alcohol use affects sleep by interfering with sleep homeostasis, it is also true that worse sleep can contribute to problem alcohol use and thus, theoretical models considering sleep as a predictor—rather than only an outcome—are needed as well (Thakkar et al., 2015). In a study of 704 adolescents, self-reports of alcohol use and sleep measures were collected longitudinally to examine the bidirectional relation between sleep and hazardous substance use (Pasch et al., 2012). Results showed that sleep patterns (weekend sleep delay/weekend oversleep) and duration predicted later alcohol use. Furthermore, cross-sectional research has shown that college students with worse overall sleep quality on the PSQI consumed more alcohol and were twice as likely to use alcohol as a sleep aid than their better sleeping peers (Lund et al., 2010; Orzech et al., 2011). In addition, research suggests that sleep may act as a buffer for alcohol-related negative consequences among college students. For example, in a study of 261 college students, global sleep quality was assessed using the PSQI and alcohol-related negative consequences were measured using the Rutgers Alcohol Problem Index (RAPI; Kenney et al., 2012). Results from this study indicated that better global sleep quality was associated with fewer alcohol-related negative consequences in college students (Kenney et al., 2012). These results suggest that sleep quality may act as a potential contributing factor to alcohol-related negative consequences, rather than only an outcome of alcohol use only, and research examining both sleep and alcohol use should acknowledge the likely bidirectional effects between sleep and alcohol use when discussing conclusions. And importantly,

sleep quality has never been examined in conjunction with ADHD to determine the associations with negative alcohol-related consequences.

In addition to an association between alcohol use and sleep, research has also linked sleep difficulties with cannabis use (McKnight-Eily et al., 2011). McKnight-Eily and colleagues (2011) found in a study of over 12,000 high school students in the United States that shorter sleep duration was associated with more cannabis use, after controlling for demographic variables. Additionally, greater past month cannabis use has been associated with sleep alterations, which include reduced slow wave sleep and rapid eye movement sleep (SWS & REM: critical for deep, restorative sleep; Jacobus et al., 2009). Cannabis use appears to have a complicated relation with sleep for college students, as previous literature has shown that using cannabis to assist with sleep is related to increased problem use and worse sleep efficiency (Drazdowski et al., 2021). Thus, there are established associations between sleep and cannabis use, however, the association between sleep problems and negative cannabis use consequences and have yet to be explored in conjunction with ADHD.

As students transition to college, there is a reduction in caregiver monitoring and structure around their daily routines. This may result in routines—like sleep—being disrupted and dysregulated. Good overall sleep quality requires regulating one's bed and wake times and management of one's daily schedule to allow for sufficient sleep duration. Because good sleep quality in the college context requires strong self-regulatory skills, students with ADHD, who typically struggle with self-regulated behaviors, are at risk for experiencing worse overall sleep quality than their peers. In fact, Becker and colleagues (2018) found that college students with ADHD

have worse sleep quality, increased daytime dysfunction and greater sleep disturbances. Further, the association among sleep and alcohol- and cannabis-related problems may be stronger for drinkers with ADHD relative to students without ADHD, given the aforementioned self-regulation difficulties. However, sleep quality, ADHD, and negative alcohol- and cannabis-related consequences have not been studied together to date.

*Present Study*

Research has called for the additional examination of factors that could explain risk for substance use in students with ADHD (Molina & Pelham, 2003). Currently, we do not understand the shared difficulty of sleep dysregulation for both students with ADHD and for heavy-drinking college students. Understanding potential differences in sleep dysregulation and negative consequences from alcohol and cannabis use among college students with and without ADHD is essential for identifying and intervening with students at greatest risk. The present study is the first to examine if heavy drinking college students with ADHD differ in their sleep quality from their heavy drinking peers without ADHD. Additionally, this is the first study to examine if sleep quality and negative consequences from alcohol and cannabis use are exacerbated for students with ADHD (i.e., if ADHD moderates the association between sleep quality and negative alcohol- and cannabis-related consequences).

The current cross-sectional study employed a sample of heavy drinkers to examine: 1) differences among participants with and without ADHD in overall sleep quality and negative alcohol- and cannabis-related consequences, and the relation between sleep quality and negative alcohol- and cannabis-related consequences; 2)

independent and interactive effects of sleep and ADHD status on negative alcohol-related consequences. In addition, we explored the independent and interactive effects of sleep and ADHD status on negative cannabis-related consequences in the subset of our sample that uses cannabis.

We hypothesized that those with ADHD would report worse overall sleep quality and more negative consequences from their alcohol and cannabis use. We also predicted that sleep would be associated with alcohol-related negative consequences, such that worse sleep would predict more consequences and this association would be stronger for (i.e., moderated by) those with ADHD. It is possible that students with ADHD—since self-regulation difficulties, poor sleep quality, and consequences from alcohol and cannabis use are already elevated—are more sensitive to the effects of sleep on substance use consequences than their peers without ADHD. Finally, we hypothesized, in exploratory analysis with a subset of the sample, that those with ADHD would report more negative consequences from their cannabis use. We also predicted that sleep would be associated with cannabis-related negative consequences, such that worse sleep would predict more consequences and this association would be stronger for (i.e., moderated by) those with ADHD.

# Methods

## *Participants*

Participants were 101 ($n$ = 49 females) full-time college student drinkers with ($n$ = 51) and without ADHD ($n$ = 50) between the ages of 18 and 22 years old recruited from the University of Maryland, College Park. Recruitment consisted of

campus listservs and flyers posted within the University Counseling, Accessibility and Disability support services and throughout campus. Recruitment flyers included a brief study description, "to examine college drinking behaviors and lifestyle choices." Participants in the cannabis only subsample were 52 ($n$ = 28 females) college student drinkers with ($n$ = 34) and without ADHD ($n$ = 18).

Students in the comparison group were eligible to participate if they: (1) had < 3 current DSM-5 symptoms of ADHD, (2) reported no history of ADHD in childhood, and (3) had never been prescribed medication to treat ADHD. Participants in both groups were required to: (1) report drinking an average of three or more days a week in the past two weeks, with no plans to changing their alcohol use during the study period, (2) report at least 1 binge drinking episode in the last two weeks (defined by consuming 4+/5+ alcoholic drinks in two hours or less for females and males, respectively) (3) report problem drinking on the Alcohol Use Disorder Identification Test (AUDIT; Saunders et al., 1993), defined by a score of 7 or greater for males or 5 or greater for females (DeMartini & Carey, 2012); (4) be a full-time undergraduate student at University of Maryland College Park, and (5) be between the ages of 18-22 years old. Additionally, those in the cannabis subsample were required to use cannabis at least once in the past month. Exclusion criteria for the study included individuals currently receiving treatment for alcohol and/or drug use, evidence of current suicidal ideation or behaviors beyond study team management, conditions requiring immediate and/or intensive treatment outside of the capability of the current study resources (e.g., bipolar disorder, psychosis, schizophrenia).

## *Procedure*

The Institutional Review Board at University of Maryland College Park approved this study. The present study is a secondary analysis of a larger substance use study. After answering the screening survey, participants who met initial eligibility were scheduled to speak with study personnel over the phone, where initial eligibility was confirmed, and a baseline assessment was scheduled. To determine ADHD group membership, participants completed structured clinical interviews assessing DSM-V symptoms during childhood and present day, and questionnaires via Qualtrics at their baseline assessment (American Psychiatric Association, 2013). If participants did not meet eligibility during this baseline process, they were excluded and compensated for their participation ($n$=4).[1]

## *Measures*

### *ADHD Measure*

**Adult ADHD Clinical Diagnostic Scale (ACDS; Kessler et al., 2010)** is a semi-structured clinical interview used to assess childhood (before the age of 12) and current (past year) ADHD symptoms for eligibility and group status (ADHD vs. non-ADHD). Masters- and doctoral-level students administered the interview ($n$=3), all of whom had prior training and experience in assessment and treatment of ADHD. Assessors were trained and met a reliability criterion ($k$ > 0.80). A licensed clinical

[1] Participants did not meet full diagnostic criteria for ADHD but had greater than 3 reported symptoms of ADHD to be included in the comparison group.

psychologist with expertise in assessment and treatment of ADHD reviewed the cases and provided supervision.

*Sleep Measure*

**The Pittsburgh Sleep Quality Index (PSQI)** includes 9 items that assess seven well- validated components of sleep: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, use of sleep medication, and daytime dysfunction. A total PSQI score was calculated in the current study, with higher scores reflecting poorer sleep over the past month. Scores ≤5 used to classify participants as "good sleepers", with scores >5 used to classify participants as "poor sleepers" (i.e., clinically significant sleep problems). The PSQI is internally consistent, is reliable across four weeks, correlates with other measures of sleep disturbance and daily diaries of sleep activity, and has been frequently used with college students (Becker et al., 2014, 2018a; Buysse et al., 1989; Carpenter & Andrykowski, 1998; Dietch et al., 2016).

*Alcohol and Cannabis Use*

**The Alcohol Use Disorders Identification Test** (AUDIT; Saunders et al., 1993) is a 10-item questionnaire screening for high-risk drinkers by measuring domains including alcohol consumption, drinking behavior and dependence, and alcohol-related problems in the past year. The AUDIT was used for eligibility screening in the present study. A higher total AUDIT score indicates higher levels of engagement in risky alcohol use (Babor et al., 2001). Demartini & Carey (2012) suggest that appropriate cut-offs for identifying at risk college drinkers was 7 for

males and 5 for females. These cutoffs were used to determine inclusion for our study. The AUDIT has been shown as both valid and reliable in college students (Kokotailo et al., 2004; Park et al., 2009).

**The Daily Drinking Questionnaire** (DDQ; Collins et al., 1985) asks participants how many drinks they consumed in a typical week in the past month. For each day, participants list the number of drinks consumed for each day and how many hours it took to consume the drinks. The questionnaire included a reference for standard drink quantities to facilitate accurate reporting: "(1 drink = 12 fl oz/can of regular beer = 8-9 fl oz of malt liquor = 5 fl oz of wine = 1.5 fl oz shot of liquor)."

**The Brief Young Adult Alcohol Consumption Questionnaire 30 Day** (BYAACQ; Read et al., 2006) is a 24-item questionnaire that measures the total number of alcohol-related negative consequences in the past 30 days. Individuals are asked to select 'yes' (1) or 'no' (0) to indicate whether the item describes something that happened to them in the past 30 days. The numerical responses (0 or 1) are totaled, with a larger number indicating more negative consequences. The B-YAACQ 30 Day is both reliable and valid as it has been used in samples of college students (Kahler et al., 2008), including college students with ADHD (Meinzer et al., 2021; Oddo et al., 2021).

**Brief Marijuana Consequences Questionnaire** (B-MACQ; Simons et al., 2012) is a 21-item questionnaire that was administered to participants who indicated they used cannabis one or more times in the past month (n = 52). The list of items asks participants to indicate "Yes" or "No" for each of the various consequences. Example items include, "The quality of my work or schoolwork has suffered because

of my cannabis use," "I have driven a car when I was high," "I have neglected obligations to family, work, or school because of my cannabis use," and "I have lost motivation to do things because of my cannabis use." A total sum score was calculated ranging from 0-21, where 21 indicates all consequences were incurred for that participant in the last month. The B-MACQ has been shown to be a valid and reliable measure in college student samples (Bravo et al., 2019).

*Analytic Overview*

IBM SPSS Statistics Version 28.0 statistical software was used for all analyses (IBM Corp., 2019). Descriptive statistics are presented in Table 1, separately for participants with and without ADHD and separately for the cannabis-only subsample in Table 1a. Additionally, bivariate correlations among key study variables are presented in Table 2, broken down between the full sample and cannabis-only sample. All models included sex (male/female) as a theoretically derived covariate, given documented sex differences in alcohol and cannabis use (Benton et al., 2004, 2006; Johnston et al., 1998). Additionally, in all models evaluating alcohol-related negative consequences, we included a covariate capturing typical drinks on a given week in the past month. In all models evaluating cannabis-related negative consequences, number of days using cannabis in the past month was included as a covariate. Both typical drinks on a given week and number of days using cannabis in the past month were included as covariates to account for the fact the students who use more alcohol and cannabis will have more negative consequences from their use. Therefore, the present study aims are designed to examine effects of ADHD and sleep

on negative alcohol- and cannabis-related consequences, above and beyond amount of alcohol and cannabis consumed.

To evaluate the associations among ADHD, overall sleep quality (PSQI), and alcohol-related negative consequences (BYAACQ), we conducted multiple linear regressions. To evaluate the interactive effects of sleep quality and ADHD on alcohol-related negative consequences, we used the PROCESS macro in SPSS (Model 3; Hayes, 2018). To explore the associations among ADHD, overall sleep quality, and negative cannabis-related consequences (B-MACQ) using the cannabis sub-sample, we conducted multiple linear regressions. To examine the interactive effects of sleep quality and ADHD on cannabis-related negative consequences, we used the PROCESS macro in SPSS (Model 3; Hayes, 2018).

# Results

Prior to conducting analyses, data were checked for assumptions and missingness. Only one data point among all study variables was identified as missing (one participant in the full sample did not have a sleep quality score but reported on drinking variables). Results from Little's MCAR test revealed the assumption that this data point was missing at random ($\chi 2$ (1) =.685, $p$ = 0.408). Assumptions for data independence, linearity, homoscedasticity, multicollinearity, and normally distributed residuals were all sufficiently met for analyses. No significant outliers were detected in the data.

*Descriptive Statistics*

Descriptive statistics and bivariate correlations for all study variables are shown in Table 1 (full sample)-1a (cannabis using sample) and Table 2, respectively. Bivariate associations are also reported for the cannabis users subsample ($n$=52) in the shaded portion of Table 2.

*Aim 1: ADHD Group Differences in Sleep Quality and Alcohol- and Cannabis-Related Consequences; Associations between Sleep Quality and Alcohol- and Cannabis-Related Consequences*

***Full Sample Analyses***

Multiple linear regression analyses revealed significant ADHD group differences in the full sample. A multiple linear regression model revealed there was a significant effect of ADHD group status on overall sleep quality (PSQI), after controlling for sex and number of drinks in the past month (DDQ), $F(1,96) = 5.79$, $p < .001$, $R^2=.153$. Participants with ADHD also reported significantly worse overall sleep quality ($M = 7.63$) than those without ADHD ($M = 5.37$), ($b = 2.35$, $p < .001$). Additionally, multiple linear regression model revealed there was a significant effect of ADHD group status on negative alcohol-related consequences after controlling for sex and typical number of drinks in the past month, $F(1,97) = 14.57$, $p < .001$, $R^2=.331$. Participants with ADHD had significantly more alcohol-related negative consequences than those without ADHD, ($b = 2.37$, $p < .01$). A separate multiple linear regression model revealed there was a significant effect of sleep quality on negative alcohol-related consequences (BYAACQ) after controlling for sex and number of drinks in the past month (DDQ), $F(1,96) = 13.99$, $p < .001$, $R^2=.304$.

Participants with worse sleep quality reported significantly more alcohol-related negative consequences than those with higher sleep quality, ($b$ = .366, $p$ < .01).

***Cannabis Subsample Analyses***

Similarly, in the cannabis subsample, multiple linear regression models showed a significant group difference in sleep quality after controlling for sex and number of days using cannabis, F(1,48) = 3.05, $p$ < .05, $R^2$=.16. Participants with ADHD reported significantly worse overall sleep quality than those without ADHD, ($b$ = 2.39, $p$ < .05). However, separate multiple linear regression models failed to find a significant association between ADHD and negative cannabis-related consequences in the subsample after controlling for sex and number of days using cannabis ($b$ = 1.11, $p$ = .331). Similarly, separate multiple linear regression models failed to find a significant association between sleep quality and negative cannabis-related consequences in the subsample. Worse overall sleep quality scores were not significantly associated with cannabis-related consequences ($b$ = .133, $p$ = .425).[2]

*Aim 2: Independent and Interactive effects of ADHD and Sleep Quality on Negative Alcohol-Related Consequences*

See Table 3 for model results on independent and interactive effects. ADHD ($b$ = .177, $p$ < .05) significantly predicted—but overall sleep quality did not significantly predict ($b$ = .256, $p$ = .06)—negative alcohol-related consequences when entered into the same multiple linear regression model, above and beyond the effects of sex and average number of drinks, F(2,95) = 11.98, $p$ < .001, $R^2$=.335.

[2] Analyses were conducted with and without covariates and no changes in results were found. Therefore, only the proposed analyses with covariates are reported.

When the interaction term between overall sleep quality and ADHD was entered into the model, no significant interaction between sleep quality and ADHD predicting negative alcohol-related consequences was found, ($b$ = .37, $p$ = .21).

*Aim 3: Independent and Interactive effects of ADHD and Sleep Quality on Negative Cannabis-Related Consequences*

Neither ADHD ($b$ = .9, $p$ = .46) nor overall sleep quality ($b$ = .09, $p$ = .62) significantly predicted negative cannabis-related consequences when entered into the same multiple linear regression model, above and beyond the effects of sex and average number of days using cannabis. See Table 3 for model results on independent and interactive effects.

When the interaction term between overall sleep quality and ADHD was entered into the model, no significant interaction between sleep quality and ADHD predicting negative cannabis-related consequences was found, ($b$ = -.31, $p$ = .5).

# Discussion

Alcohol and cannabis use are prevalent among college students; subsequently, many college students experience severe negative alcohol- and cannabis-related consequences (Welsh et al., 2019; Bonner et al., 2017; Littlefield et al., 2009; Skidmore, et al., 2016). A priority for researchers is identifying *which* college student drinkers are most vulnerable to experiencing negative consequences, with a particular focus on modifiable risk factors that can be targeted in treatment. Known risk factors for experiencing more substance-related negative consequences include both poor sleep and ADHD, yet these risk factors have yet to be studied together in the same

model or within heavy drinking samples of college students, thus limiting generalizability to high-risk samples. The present study represents an important step in examining sleep quality among heavy drinking college students with and without ADHD, as well as associations among sleep quality and ADHD with negative alcohol- and cannabis-related consequences in the same model. Results show elevated risk for sleep and alcohol and cannabis use consequences among students with ADHD, compared to heavy drinking peers without ADHD.

Findings revealed that, on average, college drinkers with ADHD reported significantly worse sleep quality than college drinkers without ADHD, even after controlling for sex and number of drinks. This association also remained in the cannabis subsample analyses. These results may suggest that there are unique effects of having ADHD on sleep quality among college drinkers. It is likely that college drinkers with ADHD already experience worse sleep quality because of struggles with self-regulation around their behaviors and sleep routines, and the addition of alcohol use likely further exacerbates difficulties with self-regulation strategies around sleep more so than alcohol use does for college drinkers without ADHD. For example, consuming alcohol in college may lead to later bedtimes on average for everyone, but drinkers with ADHD may be going above and beyond these late bedtimes to extremely late hours. Alternatively, the effects of poor overall sleep quality may be especially detrimental for students with ADHD. These findings align with prior work showing that college students with ADHD are already at risk for experiencing sleep dysregulation and that alcohol use disrupts sleep—and when these factors are combined (as in our study) poor sleep quality is exacerbated even further

(Becker, Jarrett, et al., 2018; Pasch et al., 2012). Further, these findings underscore the potential benefit of targeting sleep in interventions for college drinkers with ADHD. Recent research demonstrated the efficacy of a sleep intervention in young adult drinkers and suggests a focus on leveraging other health concerns like sleep provides an innovative solution for treatment that young adult drinkers may find more approachable (Fucito et al., 2017).

Analyses also revealed that, on average, college drinkers with ADHD reported significantly more negative alcohol-related consequences than college drinkers without ADHD, even after controlling for sex and number of drinks. Additionally, we did not find any significant difference in the number of drinks between students with and without ADHD. These findings are consistent with prior work demonstrating that college students with ADHD report significantly more consequences from drinking, but not a significantly different number of drinks consumed (Rooney et al., 2012). Although this finding replicated prior work, the current study also extends the literature by replicating this relation in a sample selected on the basis of heavy drinking. These findings are also critical because they may signal that there are unique underlying processes that heavy drinkers with ADHD are engaging in that lead to more severe consequences from alcohol use and this cannot be better explained by the amount of alcohol consumed in a typical week. For example, students with ADHD may not consume more alcohol during an average week than their peers without ADHD but could engage in alcohol use at riskier times (e.g., later times into the night or night before an exam), engage in fewer protective behavioral

strategies (e.g., drinking water before bed or between drinks), and therefore, experience more negative related consequences from their alcohol use.

Outside of finding that ADHD significantly predicts worse sleep quality in the cannabis subsample, no other significant ADHD group differences were found. It is likely that this subsample *(N* = 52; give n for each group) was quite underpowered to detect moderate group differences if there were any because this subsample included cannabis and alcohol users with all relatively poor sleep quality and frequent negative cannabis-related consequences. However, this preliminary examination of sleep, ADHD and cannabis-related consequences may set up future longitudinal research that can increase within-person power for analyses and explore in more detail *how* cannabis is being used for heavy-drinking college students with and without ADHD. Furthermore, many college students—particularly those with ADHD—report using cannabis to aid in sleeping and become dependent on cannabis to fall asleep (Goldstein et al., 2021). Therefore, college students with ADHD that use cannabis for sleep routinely, may actually report better sleep associated with their cannabis use. Thus, this pattern of cannabis use may wash out any opposite effect of students who report associations between poor sleep and cannabis-related negative consequences. Future research may consider examining chronic and dependent cannabis users separately from infrequent or social cannabis user and incorporate intensive longitudinal study designs (e.g., daily dairies and/or ecological momentary assessment) to parse out associations over time.

Results of this study showed that ADHD, but not overall sleep quality, was significantly associated with negative alcohol-related consequences when included in

the same model together, above and beyond sex and drinking quantity. It is likely that the sample was too small to detect small to moderate independent associations between sleep and negative alcohol-related consequences, however, post-hoc power analyses confirmed the full sample size was sufficient to detect medium ($f^2 = .15$) effect sizes. Regardless, having ADHD placed college drinkers at higher risk for experiencing negative alcohol-related consequences, and the mechanism behind this relation awaits further investigation using larger samples and longitudinal designs.

For the parallel model of negative cannabis-related consequences, significant independent associations were not found, likely due to low power. Future research is also still needed to explore how these independent effects look within and between students with and without ADHD.

Finally, contrary to expectations, our results demonstrated no significant moderating effects of ADHD on the relation between sleep and negative alcohol- or cannabis-related consequences. It is possible that a mediation model may better capture relations between ADHD, sleep and substance-related negative consequences. For example, it is possible that ADHD predicts worse sleep quality, which in turn, predicts more substance use consequences. Future longitudinal research is needed to examine if sleep is the mechanism that explains, at least partially, why students with ADHD experience more substance-related negative consequences.

There are some important limitations to consider. First, the present study was cross-sectional and we could therefore not examine temporal associations between these variables. Because of the bidirectional nature of sleep and substance use, future longitudinal research can disentangle how sleep may act as both a predictor and

outcome for college students with ADHD and is still needed (Pasch et al., 2012). Furthermore, the present study sample was relatively small *(N* = 101, *N* = 52 for cannabis subsample) and was underpowered to detect small to moderate effect sizes for interactions. The sample was also relatively limited in racial/ethnic diversity and therefore generalization to other racial and ethnic groups and more rural areas is limited. Future work should focus on recruiting more diverse samples, including a range of gender and sexual orientation identities, racial/ethnic identities, and socioeconomic status. The present study was limited by nature of some of the used measures. For example, the sleep quality measure reported on overall sleep quality for the past month and may have failed to capture daily variations or an accurate representation of objective sleep scores in the present sample as this measure is not significantly associated with objective sleep measures (Buysse et al., 1989). It is possible that heavy drinking college students, especially those with ADHD, have poor insight into their actual sleeping habits and quality of sleep or are underreporting consequences from their alcohol and cannabis use. Extant research has demonstrated an issue with under-reporting substance use and consequences, particularly within contexts where it is illegal (e.g., underage drinking), stigmatized or there is a perceived risk in reporting (e.g., academic consequences; Hunt et al., 2015). While participants were informed their answers would be kept confidential in the present study, the perceived risk for accurately reporting likely still exists in this population. Future research is needed that should consider either objective sleep tracking (e.g., actigraphy/polysomnography) and/or daily sleep dairies that capture day-to-day sleep variability that better correlate with objective sleep measures. Furthermore, data

collection occurred during the COVID-19 pandemic, which may have impacted sleep-wake regularity with virtual classes. Lastly, the present study did not account for other symptoms of psychopathology in the reported model; internalizing symptoms that are associated with both sleep and ADHD (e.g., depression) should be considered in future models (Becker, Jarrett, et al., 2018).

These results have identified a particularly high-risk group for experiencing the colliding effects of both ADHD and alcohol use on overall sleep quality. For perspective, the clinical cut-off on the sleep measure used in the present study (PSQI) is a score of greater than 5 for poor sleepers (Becker et al., 2018a), and both the ADHD group (*M*=7.63 on PSQI) and without ADHD group (*M*=5.37 on PSQI) were above the threshold considered clinically poor sleepers. Thus, college drinkers with ADHD report clinically meaningful elevations of poor sleep, which is more pronounced than the clinically elevated sleep problems of heavy drinkers without ADHD. Future research examining a more detailed analysis of daily bedtimes, and when students stop drinking at night, could help elucidate why drinkers with ADHD are suffering from worse sleep than their heavy drinking peers without ADHD.

Future research is also needed to continue to explore what is driving the association between ADHD and negative alcohol-related consequences. It is possible that students with ADHD are not drinking different amounts overall but the *way* they drink or the context surrounding drinking looks different. For example, students with ADHD may engage in drinking at times that are more harmful even if they are not drinking more (e.g., drinking the night before an exam versus drinking on a weekend or drinking later into the evening and therefore, disrupting sleep further). Research

that incorporates more fine-grained methodologies (e.g., daily diaries) to examine specific alcohol use behaviors is critical for better understanding these relations and for examining the mechanisms behind heavy drinkers with ADHD and the subsequent negative alcohol-related consequences they incur.

If follow up research confirms sleep as a mechanism for why students with ADHD experience more negative alcohol-related consequences, sleep interventions could be a potentially effective way to in triage care for heavy drinking college students with ADHD. Many sleep interventions may exclude participants if they are actively engaging in substance use, and therefore, there may be a portion of the population not receiving intervention that is at high-risk for negative alcohol- and sleep-related consequences. It stands to reason that students with ADHD engaging in heavy drinking may not respond as effectively to organizational skills and time management (OST) interventions, homework and planning focused interventions (HOPS) or other common treatment modalities for students with ADHD before their daily sleep difficulties are being addressed (Langberg et al., 2012). Some existing sleep interventions have been adopted for use with adolescents with ADHD and preliminary research shows promising results in these interventions efficacy (Becker et al., 2022). However, these sleep interventions have yet to include heavy drinking participants. In light of the present study findings, future work should also consider how these sleep interventions targeted for students with ADHD can be extended to college students and specifically and how to incorporate strategies to minimize effects of alcohol use for this population. Research continuing to focus on understanding sleep in the context of both ADHD and substance use is critical, especially as the

present study findings demonstrated that poor sleep is associated with more negative alcohol-related consequences.

Because of the pervasiveness of college substance use and the severity of associated negative outcomes, it is imperative that research identifies *which* students are most at risk for experiencing these consequences and what factors may lead to negative alcohol- and cannabis related consequences. The present study underscores the elevated risk heavy college drinkers with ADHD face from alcohol use. On average, college drinkers with ADHD experience more alcohol-related negative consequences and worse sleep quality than their heavy drinking peers without ADHD. The present study is the first to examine sleep quality and negative alcohol- and cannabis-related consequences in a heavy drinking college sample with and without ADHD. Future research that incorporates longitudinal and daily diary methodologies can elucidate the potential mechanisms behind the risk college drinkers with ADHD face and generate further areas for targeted interventions. The ability to examine causality and capture daily variability in sleep are critical next steps in better understanding the mechanisms of risk that heavy drinkers with ADHD face.

# List of Tables

**Table 1.**

*Demographics table, full sample (N = 101).*

| Variable | ADHD | Non-ADHD Controls | Total |
|---|---|---|---|
| **Participant Demographics** | N (%) | N (%) | N (%) |
| Sex | | | |
| Female | 22 (43.1) | 27 (54.0) | 49 (48.5) |
| Male | 29 (56.9) | 23 (46.0) | 52 (51.5) |
| Racial/Ethnic Identification | | | |
| Asian | 4 (7.8) | 3 (6.0) | 7 (6.9) |
| Black or African American | 3 (5.9) | 4 (8.0) | 7 (6.9) |
| Hispanic/Latino | 7 (13.7) | 5 (10.0) | 12 (11.9) |
| White (non-Hispanic/Latino) | 36 (70.6) | 33 (66.0) | 69 (68.3) |
| > 1 Race | 1 (2.0) | 5 (10.0) | 6 (5.9) |
| Age | | | |
| 18 | 6 (11.8) | 5 (10.0) | 11 (10.9) |
| 19 | 14 (27.5) | 6 (12.0) | 20 (19.8) |
| 20 | 16 (31.4) | 11 (22.0) | 27 (26.7) |
| 21 | 12 (23.5) | 24 (48.0) | 36 (35.6) |
| 22 | 3 (5.9) | 4 (8.0) | 7 (6.9) |
| **Current Alcohol Use Disorder** | 34 (66.7) | 30 (60.0) | 64 (63.4) |
| **Previous ADHD Diagnosis** | 34 (66.7) | N/A | N/A |

*Note.* ADHD (Attention-Deficit/Hyperactivity Disorder)

**Table 1a.**

*Demographics table cannabis subsample (N = 52).*

| Variable | ADHD | Non-ADHD Controls | Total |
|---|---|---|---|
| **Participant Demographics** | N (%) | N (%) | N (%) |
| Sex | | | |
| Female* | 15 (44.1) | 13 (72.2) | 28 (53.8) |
| Male* | 19 (55.9) | 5 (27.7) | 24 (46.2) |
| Racial/Ethnic Identification | | | |
| Asian | 4 (11.8) | 2 (10.5) | 6 (11.5) |
| Black or African American | 1 (2.9) | 2 (10.5) | 3 (5.8) |
| Hispanic/Latino | 6 (17.6) | 1 (5.3) | 7 (13.5) |
| White (non-Hispanic/Latino) | 28 (82.4) | 14 (73.7) | 45 (86.5) |
| > 1 Race | 0 (0.0) | 1 (5.3) | 1 (1.9) |
| Age | | | |
| 18 | 4 (11.8) | 3 (15.8) | 6 (11.5) |
| 19 | 9 (26.5) | 2 (10.5) | 11 (21.2) |
| 20 | 9 (26.5) | 4 (21.1) | 13 (25.0) |
| 21 | 10 (29.4) | 9 (47.4) | 19 (36.5) |
| 22 | 2 (5.9) | 1 (5.3) | 3 (5.8) |
| **Current Alcohol Use Disorder** | 23 (67.6) | 13 (68.4) | 35 (67.3) |
| **Previous ADHD Diagnosis** | 19 (55.9) | N/A | N/A |

*Note*.* = $p < 0.05$. ADHD (Attention-Deficit/Hyperactivity Disorder)

**Table 2.**

*Descriptive Statistics and Bivariate Correlation Coefficients for Overall Sleep Quality (PSQI), Drinking (# of drinks in typical week), Alcohol Related Negative Consequences (BYAACQ), Cannabis Use (# of days using Cannabis in past month), Cannabis Related Negative Consequences (BMCQ), ADHD, and Sex*

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1. Sleep Quality | | -0.14 | 0.260** | 0.089 | .011 | .370** | -.086 |
| 2. Drinking Past Month | -.039 | | .416** | .120 | .200 | .132 | .418** |
| 3. Alcohol Consequences | .290* | .434** | | .242* | .248 | .292** | -.070 |
| 4. Cannabis Use | -.041 | .260 | .143 | | .551** | .307** | .013 |
| 5. Cannabis Consequences | .011 | .200 | .248 | .551** | | .280* | .362** |
| 6. ADHD | .268 | .159 | .067 | .217 | .280* | | .109 |
| 7. Sex | -.207 | .378** | -.099 | .182 | .362** | .285* | |
| Mean (SD): Control | 5.37(2.3) | 17.84(8.8) | 6.44(4.1) | 3.86(7.5) | 2.28(3.6) | - | - |
| Range: Control | 1-10 | 4-51 | 0-17 | 0-27 | 0-14 | - | - |
| Mean (SD): ADHD | 7.63(3.3) | 20.57(11.6) | 9.12(4.7) | 9.88(11) | 4.94(4.8) | - | - |
| Range: ADHD | 1-16 | 6-60 | 2-22 | 0-30 | 0-17 | - | - |

*Note.* Upper triangle represents full sample (*n*=101) correlations and lower shaded triangle represents cannabis users only (*N*=52) sample correlations. ADHD (Attention-Deficit/Hyperactivity Disorder)

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

**Table 3.**

*Independent Effects of ADHD and Overall Sleep Quality (PSQI) on Alcohol/Cannabis Related Negative Consequences (BYAACQ/BMCQ)*

| **Step and variable** | *df* | β | SE | t | $R^2$ | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| **Alcohol Consequences** | (2,95) | | | | .355 | .09 |
| Step 1: | | | | | | |
| Drinks in typical week | | 0.24 | .04 | 5.56** | | |
| Sex | | -2.7 | .89 | -3.04** | | |
| Step 2: | | | | | | |
| Sleep Quality | | .256 | .137 | .188† | | |
| ADHD | | 1.77 | .839 | 2.10* | | |
| **Step 3:** | (5,94) | | | | .35 | .01 |
| Sleep Quality X ADHD | | .37 | .29 | 1.25 | | |
| **Cannabis Consequences** | (2,47) | | | | .393 | .015 |
| Step 1: | | | | | | |
| Sex | | 2.52 | 1.04 | 2.42* | | |
| Cannabis use days in past month | | .225 | .051 | 4.41** | | |
| Step 2: | | | | | | |
| Sleep Quality | | .900 | 1.21 | .74 | | |
| ADHD | | .087 | .178 | .49 | | |
| **Step 3:** | (5,46) | | | | .40 | .01 |
| Sleep Quality X ADHD | | -.31 | .45 | -.68 | | |

*Note.* For the ease of visual presentation both hierarchical models are included in the above table, but models were each run separately during analyses. Cannabis consequences was run with the subsample (*N*=52). Step 3 in each model was run using the PROCESS macro.

*$p$<.05, **$p$<.01, † = .06

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