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Variations in Sleep Characteristics and Sleep-Related Impairment in At-Risk College Drinkers: A Latent Profile Analysis

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Abstract

Objective—Sleep disturbance and heavy drinking increase risk of negative consequences in college students. Limited research exists on how they act synergistically, and the overall nature of sleep and sleep-related impairment in college student drinkers is poorly understood. A latent profile analysis was conducted on the sleep characteristics and daytime sleep-related consequences of college student drinkers who were at-risk based on Alcohol Use Disorders Identification Test – Consumption scores.

Methods—Participants ($N = 312$, mean age = 18.90 (0.97) years) consumed a mean (SD) of 20.93 (13.04) drinks per week. Scores on the ten items of the Sleep/Wake Behavior Problems Scale (SWPS) were the class indicators.

Results—Four classes best described the sleep and sleep-related consequences of at-risk college drinkers. Classes represented different gradients and types of sleep patterns and sleep-related impairment; nearly half the sample reported late bedtimes and daytime consequences of insufficient sleep. Subsequent validation analyses indicated that these classes were directly correspondent with severity of alcohol consumption, alcohol-related consequences illicit substance use, and perceived health.

Conclusions—These findings indicate the presence of significant heterogeneity in college drinkers' sleep patterns and experiences of sleep-related impairment. Class differences significantly impact the level of alcohol and drug use and the consequences members experience. Greater alcohol use and sleep/wake problems are associated with increased risk for negative consequences for certain classes. These results suggest that college drinking interventions could benefit from the incorporation of sleep-related content and the value in adding brief alcohol assessments and interventions to other college health treatments.

Keywords

sleep; sleep-related impairment; college drinking; alcohol-related consequences; latent profile analysis

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Sleep disturbance is common among college students. Approximately 70% of college students report disturbances in sleep including poor sleep quality, insufficient sleep, and irregular sleep patterns (Lund, Reider, Whiting & Prichard, 2010). Only 29% of college students report getting at least 8 hours of sleep per night, below the 7–9 hours recommended for young adults (Bonnet & Arand, 2012), and 20% report staying up all night at least monthly (Lund et al., 2010). College students' irregular sleep patterns are often characterized by short sleep duration on weekdays but longer sleep duration and delayed bedtimes and waketimes on weekends (Machado, Varella, & Andrade, 1998). These sleep patterns may stem from biological shifts in circadian rhythms that emerge during adolescence, as well as the unique environment and corresponding pressures of college life (Orzech, Salafsky, & Hamilton, 2011).

Of particular importance to understanding sleep disturbance are the excessive rates of alcohol consumption on college campuses. Nearly half of all students report heavy drinking in the past month (five or more drinks on one occasion for a male; four or more drinks for a female) (Substance Abuse and Mental Health Services Administration [SAMHSA], 2006). Recent findings indicate a significant association between sleep and alcohol consumption in young adults. Specifically, college students with higher alcohol consumption and drinking frequency report lower sleep duration, more sleep on weekends than weekdays, and greater delays between weekday and weekend bedtimes than their peers who report less drinking (Singleton & Wolfson, 2009). Correspondingly, sleep patterns and sleep-related problems have effects on alcohol use. Poorer sleep quality, shorter sleep duration, and greater sleep pattern variability among college students have been associated with increased alcohol use (Cf. Orzech et al., 2011). Sleep disturbed college students are also more likely to drink to induce sleep than students with less sleep disturbance (Lund et al., 2010).

The interaction between alcohol use and sleep is particularly important for college students. Both are risk factors for accidents, including motor vehicle accidents, the leading cause of death in this age group (Brooks, Girgenti, & Mills, 2009; Center for Disease Control (CDC), 2008; Hingson, Zha & Weitzman, 2009). Heavy drinking is also linked to a wide-range of alcohol-related consequences, including academic, relational, and legal problems (Park, 2004), and unprotected sex (Hingson, Zha & Weitzman, 2009). Preliminary research suggests that the two combined may exert additive effects on risk of harm. College students who report heavy drinking and poor sleep quality experience more alcohol-related consequences than their heavy drinking counterparts who report better sleep quality (Kenney, LaBrie, Hummer, & Pham, 2012). There is limited research, however, on how alcohol and sleep problems may act synergistically. The specific nature of the sleep characteristics that increases risk of harm from drinking is also unclear.

Little is also known about whether sleep patterns and sleep-related impairment vary in presentation among college students. There are numerous ways in which these symptoms can exist (e.g. total sleep time, difficulty falling asleep, sleep pattern variability, type of sleep-related impairment). Most studies use top-down methods that rely on scale-specific cut-off scores and broadly categorize participants into “good” or “poor” sleeper on the basis of substantive domains of assessment. Though these approaches have utility, they may not identify meaningful differences (Walrath et al., 2004).

Empirical approaches provide an alternative method to characterize variation in symptom presentations. Constructs are assessed with dimensional measures; scores co-vary on the basis of individual symptom presentation over the set of measures. They have numerous statistical and theoretical advantages, including increased power from utilizing continuous variables rather than dichotomous ones. Bottom-up approaches, like latent class analysis (LCA), therefore provide a distinct perspective on the characterization of symptom variation and can help to advance the understanding of how sleep patterns and problems vary across individuals (Doss & Weisz, 2006).

This study utilized a person-centered, latent variable approach to classify at-risk college drinkers into optimal group categories on the basis of common sleep characteristics and sleep-related impairment. Rather than grouping based on predetermined cut-off scores, latent classes identify groups based on observed response patterns (Nylund, Bellmore, Nishina & Graham, 2007a). Traditional LCA uses categorical observed variables as indicator variables. Latent profile analysis (LPA), which was used in this study, uses continuous variable indicators. Both are similar to cluster analysis. LPA assumes that a latent categorical variable determines class membership. Classes may differ on dimensions of sleep and sleep-related impairment, frequency of problems, or both (Nylund et al., 2007a). For example, some college students may experience only late bedtimes while others may experience nearly all problems. LPA, then, provides a way to group individuals on the basis of shared characteristics that distinguish them from members of other groups.

LPA has benefits over cluster analysis. Due to the lack of clear benchmarks or statistics to determine the best number of classes, final class enumeration in cluster analysis can be arbitrary. LPA is probabilistic; models can be replicated with independent samples and can take uncertainty of membership, or error, into account, whereas cluster analysis cannot (Muthén & Muthén, 2000). Fit statistics have been developed for LPA that can be used to assess model fit and decide on the final number of classes (Nylund et al., 2007a). Class membership is determined probabilistically. Accordingly, LPA has outperformed cluster analysis in Monte Carlo simulation studies (Walrath et al., 2004).

This study used LPA to examine the self-reported sleep characteristics and sleep-related impairment in a sample of at-risk college drinkers (i.e., hazardous drinkers whose consumption places them at risk for experiencing negative consequences from drinking). Heavy drinking among college students has been deemed the number one public health problem in college students (Wechsler, Lee, Kuo, Seibring, Nelson, & Lee, 2002), and in 2007, the U.S. Surgeon General issued a *Call to Action* to reduce underage drinking, highlighting college student drinking (U.S. Department of Health and Human Services). Indeed, it is these heavy drinking episodes, and not drinking overall, that are associated with a variety of alcohol-related consequences (Hingson, Zha, & Weitzman, 2009; Park, 2004). As a result, colleges and universities have sought to increase treatment services. Yet, despite high rates of alcohol use among college students, they are unlikely to seek specialty treatment for problems with alcohol (Blanco et al., 2008). Thus, college treatment services cannot rely on self-identification, and as a result, many on-campus services rely on screening tools to identify at-risk drinkers. Students who screen positive on a screening assessment can then be referred for preventative or other types of care. Describing classes of

sleep disturbance in at-risk drinkers could, then, provide a novel target for college student alcohol interventions. Our goals were: (a) to determine the number and types of classes that best summarize the self-report sleep characteristics and sleep-related impairment data and (b) to validate the identified classes by examining intra-class differences on self-reported alcohol consumption, alcohol-related consequences, drug use and health. We hypothesized that students who reported the most severe levels of sleep-related impairment and delays in sleep schedules would also report more drinking and alcohol-related consequences. Exploratory analyses investigated the relationships among sleep class, drug use and perceived health status.

Method

Participants and Procedure

Participants aged 18–25 were recruited from the psychology subject pool at a private, northeastern university over one academic year. University institutional review board approval was obtained; all participants signed written consent forms before completing study assessments. In exchange for participation, participants received credit toward their research requirement for the class. A total of 584 participants completed assessments. Of those, five participants were removed from analysis either because their ages were outside of range ($n = 2$) or because they were not students in introductory psychology ($n = 3$). Additionally, a total of 32 participants failed to complete the Sleep/Wake Behavior Problems Scale, which is the primary outcome, and as a result were removed from analysis. Therefore, a total of 547 participants were considered for analysis.

Of the 547 participants with complete data, only current, at-risk drinkers ($N = 312$) were included in this data analysis. At-risk drinkers, or hazardous drinkers, are drinkers whose consumption places them at risk for experiencing negative consequences from drinking. A 2004 survey of 747 colleges and universities indicated that all engaged in some type of alcohol prevention programming; 90% provide counseling and treatment for students and nearly as many provide prevention programs for at-risk groups (Wechsler, Seibring, Liu, & Ahl, 2004). Colleges and universities are, therefore, seeing at-risk drinkers in counseling settings, but may not be aware of how sleep problems may interact with their students' alcohol use. Thus, we wanted specifically to address this interaction for students most likely to be seen in alcohol prevention programs and examine the type of sleep characteristics and sleep-related impairment that may place them at risk for alcohol-related consequences.

An at-risk drinker was defined as screening positive for at-risk drinking on the Alcohol Use Disorders Identification Test – Consumption (AUDIT-C; cf. Bush, Kivlahan, McDonnell, Fihn, & Bradley, 1998). The AUDIT is a well-validated and effective screening tool for the range of alcohol problems in adults and young adults across a wide-variety of clinical settings (see Cook, Chung, Kelly, & Clark, 2005). The AUDIT-C, the first three consumption items of the AUDIT, performs better than the AUDIT in screening at-risk drinking (e.g. at least seven drinks in a typical week and/or at least four heavy drinking episodes (five or more drinks on one occasion for a male; four or more drinks for a female) (SAMHSA, 2006) in the previous month for a female; at least 14 drinks in a typical week and/or at least four heavy drinking episodes in the previous month for a male, per NIAAA

definitions) in female college students and performs equivalently in male students (DeMartini & Carey, 2012). The recommended cut-off scores on the AUDIT-C for college students are 7 for males and 5 for females (DeMartini & Carey, 2012). Based on this criterion, 235 participants (128 males; 107 females) were identified as low-risk and were removed. The final sample included 312 at-risk college student drinkers. Because at-risk status was determined in the data analysis phase of the study, participants received no recommendations regarding their drinking patterns.

Participants completed assessments in on-campus classrooms and provided written consent to complete the study. Participants completed assessments in small and large group sessions of between five and 98 participants. Participant assessments were coded with a randomly generated, subject-specific identification code.

Measures: Class Indicators

Sleep Characteristics and Sleep-Related Impairment—Sleep patterns and sleep-related problems were assessed with the Sleep/Wake Behavior Problems Scale (SWPS; Carskadon, Seifer, & Acebo, 1991; Wolfson & Carskadon, 1998), a 10-item measure of the frequency of sleep problems and indicators of erratic sleep patterns over the past two weeks among adolescents and young adults (coefficient alpha for the current sample was 0.70.) Items are scored from 1 (never) to 5 (everyday/night) and include being late to class because of oversleeping, needing multiple reminders to get up in the morning, difficulty falling asleep, and late bedtimes. In a study of 3,120 adolescents ages 13–19, individuals with adequate sleep habits (i.e., higher total school-night sleep, smaller difference between weekend-night bedtime and week-day bedtime) had significantly lower sleep/wake behavior problems ($M = 18.48$, $SD = 6.63$) than individuals with inadequate sleep habits ($M = 22.17$, $SD = 7.01$) (Wolfson & Carskadon, 1998). Higher SWPS scores are also associated with circadian rhythm preference for evening, greater daytime sleepiness, more emotional problems, and greater risk-taking behavior, including alcohol, tobacco and drug use (DeMartini & Carey, 2009; Giannotti, Cortesi, Sebastiani, & Ottaviano, 2002; O'Brien & Mindell, 2005; Wolfson & Carskadon, 1998). Thus, the SPWS provides an adequate measure of sleep characteristics and problems and is related to a variety of risk-taking behaviors, and specifically to increased alcohol use.

Measures: Clinical Characteristics

Alcohol use patterns—For all assessments, a standard drink was defined as a 12-oz. beer, a 5-oz. glass of wine, or a 1.5-oz. shot of hard liquor either straight or in a mixed drink, all equivalent to approximately 0.6oz. or 14g of pure alcohol (NIAAA, 2010). Measures covered the month prior to and including the day of the assessment. The Daily Drinking Questionnaire (DDQ; Collins, Parks, & Marlatt, 1985) used a 7-day grid to assess typical week drinking. To determine the total number of drinks participants consumed during a typical week, we summed the total number of drinks reported on the 7-day grid. The frequency of heavy drinking episodes, or binge drinking episodes, was assessed via a single self-report item. Participants were asked to indicate how many binge episodes they had in the past 30 days. A binge episode was defined as the consumption of 5 or more drinks in one drinking occasion for men and 4 or more drinks for women.

Brief Young Adult Alcohol Consequences Questionnaire (BYAACQ; Kahler, Strong, & Read, 2005)—The BYAACQ is a 24-item self-report measure to assess alcohol-related problems. Items are specifically tailored for a collegiate population and include driving while intoxicated, unplanned sexual activity, and waking up in unexpected places after drinking. Participants indicated whether or not they had experienced each of the items in the 30 days prior to assessment. To determine the total number of problems each participant experienced, items were summed to create a total score. Coefficient alpha for the current sample was 0.84.

Drug use and health—Participants provided information about lifetime illicit substance use and perceived health status. Drug use history was assessed with a checklist of illicit drugs for the participants to indicate which ones they had used in their lifetime. To determine the total number of substances used, items were summed to create a total score. Perceived health status was assessed with a single item from the Short Form 12 Health Survey (Ware, Kosinski & Keller, 1996). Participants were asked to rate their perception of their health over the previous month on a 1 (poor) to 5 (excellent) Likert scale.

Data Analytic Plan

The goal of LPA is to categorize people into latent classes using observed indicators and then to identify indicators that best distinguish the classes. A series of five latent profile analyses (LPAs) were conducted to identify similar patterns in sleep symptoms. Models with one through five classes were fit. The single class model was fit first. Subsequent models added one additional class until no improvement in fit was observed. Analyses were conducted using Mplus 7.11 (Muthén & Muthén, 2011).

After running the first round of 1- through 5-class LPA models, additional assessments of the SWPS items were conducted. Within each class, the items were examined to determine whether they were normally distributed. When specific items (e.g. items 1, 2, 3, and 5) were determined to be significantly skewed due to floor effects, those items were subsequently modeled as categorical variables, rather than continuous variables, to model more accurately the shape of their distributions. All categorical response categories were included (e.g. Never through Always) so as to retain the variability of the responses; items were not, therefore, dichotomized, which would have resulted in a loss of variability. Thus, we ran a second round of 1- through 5-class models with items 1–3 and 5 modeled as categorical variables and items 4 and 6–10 modeled as continuous variables. Again, the single class model was fit first. Subsequent models added one additional class until no improvement in fit was observed.

Model fit indices—As in other types of latent variable modeling, there are numerous model fit indices that could be used to examine model fit. We chose evaluative model fit statistics based on a combination of the recommendations from a Monte Carlo study that determined the most appropriate fit indices for LPA and other mixture models (Nylund, Asparouhov, & Muthén, 2007b) and substantive theory to determine the best fitting model. More weight was given to the Bootstrapped Parametric Likelihood Ratio Test (BLRT; McLachlan & Peel, 2000), because the BLRT was a very consistent indicator of the number

of classes and performed better than the other well-performing likelihood test, the Lo-Mendell-Rubin (Lo, Mendell, & Rubin, 2001) (Nylund et al., 2007b). The BLRT resamples data to represent better the true distribution and tests for model improvement in each successive model (e.g. the k class model) over a model with one fewer class (e.g. the $k - 1$ class model). It allows significance testing of the difference between the k and the $k - 1$ class models. Specifically, the BLRT estimates the log likelihood difference distribution to obtain a p value that indicates if the $k - 1$ class is rejected for the k class model (Nylund et al., 2007b).

Next, we used the Bayesian information criterion (BIC; Schwartz, 1978) and the sample-size-adjusted BIC (saBIC; Sclove, 1987). The saBIC maximizes the likelihood ratio statistic while rewarding model parsimony. Low values indicate better fit, and when running a series of models, the model with the lowest saBIC is preferred (Muthén & Muthén, 2000). Third, we used entropy values, which provide an index of model classification quality. Values closer to, or equal to, 1.0 indicate better classification quality. There is no cutoff value for determining whether an entropy value is too low; however, values greater than 0.80 are considered to have adequate classification quality (Jung & Wickrama, 2008).

Class difference tests—We also considered the models' usefulness to differentiate participants on variables of interest. We were interested in a model that could be used to differentiate levels of alcohol consumption, alcohol-related problems, illicit substance use and perceived health. Wald tests of mean equality determined whether the latent classes reported different levels of alcohol consumption, problems, drug use, and health (Asparouhov, 2007). Wald tests use chi-square (χ^2) to compare latent groups with a posterior probability based multiple imputation strategy. These analyses are conducted simultaneously with the main model testing. They allow consideration of the probabilistic class membership of participants to control error (Asparouhov, 2007). Error is similarly controlled by conducting these tests simultaneously to the overall model. Thus, our final model selection was based on model fit indices, parsimony, and the substantive interpretability of the model to differentiate participants on these *a priori* target variables. Additionally, once the final model was determined, it was re-run to assess differences among classes in demographic variables. Again, Wald tests of mean equality were conducted simultaneously with the model using the posterior probability based multiple imputation strategy to minimize error in this testing.

This method of testing is also known as the pseudo-class method. It allows the independent evaluation of the relationship between the latent class variable and the predictor, auxiliary variables. The class model is estimated first, then the latent class variable is multiply imputed from the posterior distribution obtained by the LPA model, and then the imputed class variables are analyzed with the auxiliary variables using multiple imputation (Asparouhov & Muthén, 2013). Simulation studies have revealed that this technique works well when the class separation is large (e.g. entropy is large) and that other methods, including most likely class membership regression and probability-weighted regression produce biased estimates (Clark & Muthén, 2009).

Missing data—Missing data is handled in Mplus with maximum likelihood (ML) estimation under the assumption that data are missing at random. ML is considered a best practice method for the treatment of missing data (Schafer & Graham, 2002). As noted previously, 32 participants failed to complete the SWPS and were removed from data analyses due to missing data on the latent class indicators. Of the 312 remaining subjects, the covariance coverage, or the missingness on each model indicator, for all variables ranged from 0.974 to 1.0. These values well exceed the minimum thresholds for establishing adequate coverage (e.g. 0.10; Muthén & Muthén, 2011).

Results

Participant Characteristics

On average, participants were mostly male (57%; $n = 177$), freshmen (54%, $n = 169$), and Caucasian (86%, $n = 265$). The mean age of the sample was 18.90 ($SD = 0.97$) years of age. Demographic characteristics of this sample are consistent with past research conducted with similar samples at this university (cf. DeMartini & Carey, 2012).

Participants consumed an average of 20.93 ($SD = 13.04$) drinks in a typical week and reported a mean AUDIT-C score of 8.13 ($SD = 1.60$). Participants reported an average score of 7.17 ($SD = 4.66$) on the BYAACQ, indicating that most experienced approximately 7 alcohol-related problems in the prior month. Male participants consumed significantly more drinks ($M = 25.06$, $SD = 13.44$) in a typical week than females ($M = 15.51$, $SD = 10.27$) ($t(310) = 6.86$, $p < 0.001$). Males also had significantly higher AUDIT-C scores ($M = 8.77$, $SD = 1.21$) than females ($M = 7.29$, $SD = 1.66$) ($t(310) = 9.14$, $p < 0.001$). Despite the difference in consumption, males and females reported equivalent numbers of alcohol-related problems ($t(309) = 0.40$, $p = 0.69$).

Participants reported an average score of 24.26 ($SD = 5.93$) on the SWPS. Table 1 provides the means and standard deviations for all items of the SWPS. Males reported an average of 24.41 ($SD = 6.07$) on the SWPS, and females reported an average of 24.06 ($SD = 5.76$). This difference was not significant ($t(310) = 0.51$, $p = 0.61$).

Identification and Description of Latent Sleep Classes

The series of LPA models were compared using model fit indices and substantive interpretability. Fit indices for the models are presented in Table 2. The four-class solution emerged as the best fit for the data, as evidenced by the BIC and saBIC values and by the p values for the BLRT. The five-class model would not converge. The BLRT, which provides a bootstrapped validation procedure, confirmed that the four-class model had significantly better fit than the three-class model (log likelihood -4009.34 , $p < 0.001$). The latent class probability for the most likely latent class membership by latent class discrimination also had good fit. Near-1.00 values in the diagonal and near-0.00 values in the off-diagonal indicated a good representation of participant reports of sleep disturbance; participants were clearly distinguished among latent classes.

The four-class model created the following groups: (1) a group that reported *sleepiness* (S, $n = 33$, 11%); (2) a large group that reported *sleepiness and late bedtimes* (SL, $n = 132$, 42%);

(3) a group that reported *sleepiness and late bedtimes with consequences* (SLC, $n = 88$, 28%); and (4) a group that reported *sleepiness, late bedtimes, and sleep disturbance with consequences* (SLDC, $n = 58$, 19%). Table 1 presents means on the continuous SWPS items by latent class and the probabilities of responding “Never” on the categorical items by latent class; Table 3 presents the demographic characteristics of the four latent classes. Means and proportions were visually inspected to determine which within-class items were the highest. As indicated in Table 1, the S class had the lowest mean scores and the lowest probability of sleep-related consequences on nearly all items. The S class had a within-class high mean on feeling tired/sleepy. In contrast, the SL group had within-class high means on feeling tired/sleepy and staying up until at least 3:00am, indicating that this class is experiencing more late bedtimes. Two classes, the SLC and the SLDC, reported within-class high means on staying up until 3:00am, feeling tired/sleepy, sleeping past noon, and needing multiple reminders to get up in the morning, indicating more delays in bedtimes and waketimes and greater sleep-related impairment. In addition to elevations on those items, the SLDC class had high within-class means on difficulty falling asleep and difficulty staying awake and the highest probability of sleep-related consequences (i.e. falling asleep more often in class and/or arriving late to class because of oversleeping) indicating that this class of participants has the highest level of late bedtimes and waketimes and sleep-related impairment and is experiencing symptoms of sleep disturbance.

As described above, Wald tests conducted simultaneously to the LPA model using the pseudo-class method investigated whether there were any differences by class on total SWPS scale scores (see Table 1) and demographic characteristics (see Table 3). The overall test for differences among the classes on SWPS total score was significant ($\chi^2(3) = 379.94$, $p < 0.001$). Results indicated that all classes were significantly different from all other classes (all $ps < 0.001$). The S class had a significantly lower score [$M = 17.49$, $SE = 0.59$] than all other classes (all $ps < 0.001$). The SL class had the next lowest overall score [$M = 21.69$, $SE = 0.35$] and was significantly lower than the SLC and SLDC classes ($ps < 0.001$). The SLC class [$M = 25.09$, $SE = 0.37$] was significantly lower than the SLDC class [$M = 32.77$, $SE = 0.60$] ($p < 0.001$). The SLDC class had a significantly higher mean sleep score than all other classes (all $ps < 0.001$). Classes were equivalent on all demographic variables except Caucasian race. The overall test for differences among the classes on Caucasian race was significant ($\chi^2(3) = 14.35$, $p < 0.01$). The S class had significantly more Caucasian participants than the SL ($p < 0.01$) and SLDC ($p < 0.01$) classes.

Class Comparison of Drinking and Alcohol-Related Problems

We conducted Wald tests to determine if the latent classes in the four-class model were different on total drinks in a typical week, binge drinking frequency, BYAACQ scores, lifetime total number of illicit substances used, and perceived health. Table 4 contains the class means on each variable. Table 4 contains the results of the Wald tests. On total drinks in a typical week, the overall test was significant ($\chi^2(3) = 28.32$, $p < 0.001$). All class comparisons were significant except for the comparison between the SL and the SLC class. The SLDC class [$M = 26.12$, $SE = 2.16$] reported significantly greater total drinks in a typical week than all other classes (all $ps < 0.05$). The S class [$M = 13.87$, $SE = 1.47$] had significantly lower total drinks than all other classes (all $ps < 0.01$). A similar pattern

emerged on binge drinking frequency. The overall test was significant ($\chi^2(3) = 20.97, p < 0.001$). The SLDC class reported a higher frequency [$M = 9.52, SE = 0.68$] than all other classes (all $ps < 0.05$). The S class [$M = 5.44, SE = 0.66$] had a lower frequency of binge drinking than all other classes except the SLC class [$M = 7.50, SE = 0.49$] ($\chi^2(1) = 0.34, p = 0.56$). Therefore, on measures of alcohol consumption, the SLDC class drank significantly more and drank heavily more frequently than all other classes. The S class reported the lowest levels of alcohol consumption.

There was a significant overall difference among the classes on alcohol-related consequences ($\chi^2(3) = 26.16, p < 0.001$). The SLDC class [$M = 9.96, SE = 0.70$] had significantly more consequences than all other classes (all $ps < 0.001$). All other class comparisons were not significant. There was also a significant overall effect on illicit drug use ($\chi^2(3) = 11.44, p < 0.05$). The SLDC class [$M = 2.85, SE = 0.31$] reported significantly more lifetime drugs used than the SL class [$M = 1.93, SE = 0.17$] ($\chi^2(1) = 6.79, p < 0.01$) and the S class [$M = 1.54, SE = 0.26$] ($\chi^2(1) = 10.42, p < 0.01$). All other class comparisons were not significant. Therefore, the class that reported the most sleep problems and sleep-related consequences reported the most lifetime drugs used. No overall effects were seen on perceived health. Two significant pairwise comparisons emerged. The SLDC class reported lower perceived health [$M = 2.24, SE = 0.14$] than the SL class [$M = 2.60, SE = 0.08$] ($\chi^2(1) = 4.91, p < 0.05$) and the SLC class [$M = 2.61, SE = 0.11$] ($\chi^2(1) = 4.02, p < 0.05$). All other pairwise comparisons were not significant. Overall, therefore, the class with the greatest number of sleep problems and daytime sleep-related consequences reported the highest level of alcohol use, alcohol-related consequences, number of lifetime drugs used, and the lowest perceived health ratings.

Examination of Low-Risk Drinkers: Exploratory Analyses

To examine whether low-risk drinkers had similar sleep characteristics and sleep-related consequences as at-risk drinkers, we conducted an additional series of one- through five-class of LPA models on the low-risk drinkers ($n = 235$). The models were compared using the same model fit indices described above and substantive interpretability. A four-class solution best fit the data (BIC = 6507.37; saBIC = 6212.60; BLRT $p = 0.001$; Entropy = 0.877). Examination of the pattern of SWPS item means within each class indicated that these four classes were similar to those of the at-risk drinkers with the exception of Class 3. Class 1 ($n = 68, 29\%$) was similar to our previous S class, reporting only sleepiness [Total SWPS $M = 16.58 (SE = 0.37)$]. Class 2 ($n = 79, 34\%$) was similar to our previous SL class, reporting elevations on staying awake until 3:00am and feeling tired/sleepy, as well as an elevation on sleeping past noon [Total SWPS $M = 23.04 (SE = 0.40)$]. Class 3 ($n = 50, 21\%$) reported elevations on staying up until 3:00am, feeling tired/sleepy, having difficulty falling asleep, and falling asleep in morning and afternoon classes. This class is similar to the previous SLC class but participants in this group report different sleep-related consequences [Total SWPS $M = 24.42 (SE = 0.55)$]. Class 4 ($n = 38, 16\%$) was similar to the previous SLDC class with elevations and increased risk of sleep-related consequences on all items [Total SWPS $M = 31.71 (SE = 0.70)$]. Additional information about these results can be obtained from the first author.

Low-Risk Drinker Comparison of Drinking and Problems

In contrast to our results from the at-risk drinkers, the low-risk drinkers have equivalent overall levels of typical week drinking ($\chi^2(3) = 4.92, p = 0.18$) and alcohol-related consequences ($\chi^2(3) = 5.71, p = 0.13$). Pairwise testing indicated no differences among any classes on drinking and only one difference on alcohol-related consequences. On consequences, Class 1 [$M = 1.84, SE = 0.33$] had significantly fewer consequences than Class 3 [$M = 3.26, SE = 0.52$]. It is notable that, unlike the weekly drinking levels in the at-risk drinkers, the means for each class on drinks per week are under the recommended moderate weekly drinking level for women (e.g. < 7 drinks per week) (NIAAA, 2010).

Discussion

Overall, at-risk college student drinkers reported moderate sleep/wake problems. Their average Sleep Wake Problems Scale score exceeded that of adolescents with insufficient sleep identified in prior research (Wolfson & Carskadon, 1998). Additional analyses showed four classes best described the self-reported sleep characteristics and sleep-related impairment experienced by at-risk college student drinkers. Nearly half of participants in the sample, 47% ($n = 146$), were assigned to classes that experienced sleepiness, late bedtimes, and daytime sleep-related consequences. All four classes reported a high level of daytime sleepiness indicating that all classes may experience insufficient sleep. These results are consistent with past research indicating the ubiquity of sleep debt and sleep-related consequences in college students (see Orzech et al., 2011). The most common class, SL (42%, $n = 132$), reported sleepiness and late bedtimes. The other most common class, SLC (28%, $n = 88$), reported sleepiness, late bed and waketimes, and needing multiple reminders to get up in the morning. The third most common class, SLDC (19%, $n = 58$), reported the problems noted in the other two classes as well as difficulty falling asleep at night, difficulty staying awake, falling asleep more often in class and/or arriving late to class because of oversleeping. The fourth and smallest class, S (11%, $n = 33$) only reported sleepiness. Overall, our results indicate that sleep/wake problems are especially common in at-risk college student drinkers but that different students experience different gradients and types of problems.

Latent class membership was significantly related to alcohol consumption, alcohol-related consequences, and lifetime illicit substance use. The group that experienced sleep disturbance and the highest level of sleep-related impairment had the highest levels of alcohol consumption, alcohol-related consequences, illicit substance use and the lowest perceived health. Conversely, the group that only reported sleepiness had the lowest values on these indices. Validation by rates of alcohol consumption, alcohol-related problems, as well as illicit substance use and perceived health provides some evidence of the utility of the classes identified in this study. Specifically, the results suggest not only statistical differences but also important clinical differences in the sleep patterns and sleep-related impairment in at-risk college drinkers. Among college student drinkers who experience sleep disturbance and an increased probability of sleep-related impairment, alcohol consumption is particularly associated with the experience of alcohol-related consequences.

The finding that different gradients and types of sleep characteristics and sleep-related impairment are associated with different rates of alcohol consumption, illicit substance use, and alcohol-related consequences is of particular interest. It has long been established that college students who engage in frequent heavy episodic drinking are more likely to experience serious health and other consequences of their drinking than other students (Park, 2004). Numerous factors have been shown to impact this relationship (see Wechsler & Nelson, 2008). The results of this study suggest that sleep may be another important factor. The effects of chronic, heavy alcohol use on sleep are well documented including reduced sleep duration, greater sleep fragmentation, and increased sleep onset latency (Roehrs & Roth, 2001), all of which reduce daytime functioning. The combination of heavy drinking and high levels of sleep debt and sleep-related impairment may confer greater risk of harm for several reasons. First, sleep deprivation and alcohol both have negative effects on cognitive functioning and psychomotor performance (Roehrs et al., 2003); together, they may act synergistically. Second, many individuals do not accurately perceive their level of impairment from alcohol and/or sleepiness. Because of this, they may put themselves at greater risk by engaging in behaviors that are dangerous under these conditions (Barrett et al., 2003). Therefore, sleep may be an important variable for targeting and tailoring alcohol interventions for at-risk college drinkers and vice versa.

Thirdly and of particular note, insufficient sleep and late bedtimes at this age may be related to neurobiological mechanisms that increase risk taking. In a study of adolescents, larger weekday-weekend differences in sleep timing were associated with reduced activation in cortical and subcortical reward-related brain regions (Hasler et al., 2012). Adolescents might compensate for this reduced neural sensitivity in reward centers by engaging in reward-seeking behavior (Hasler et al., 2012). College students with high sleep pattern delay may not only engage in heavy drinking but also other rewarding behaviors (e.g. illicit substance use) that place them at greater risk for alcohol-related consequences. Future studies should investigate the potential mechanisms by which certain sleep characteristics and sleep-related problems promote greater alcohol-related harm.

These findings should be considered in light of study limitations. First, we cannot make causal interpretations about the directional relationship between sleep characteristics/sleep-related impairment and alcohol use and consequences due to cross-sectional data. Our results are, however, consistent with research showing that the interaction of alcohol consumption and poor sleep quality is associated with increased alcohol-related problems (e.g. Kenney et al., 2012). The combination of alcohol consumption and sleep deprivation has been shown to have effects on cognition and alertness, even when one problem alone produced no effect (Peeke, Callaway, Jones, Stone, & Doyle, 1980). Thus despite the cross-sectional nature of these data, our results suggest that alcohol-related harm and sleep/wake problems are associated among college at-risk drinkers. Future research could consider assessing these classes of sleep patterns over time to determine better the temporal association between sleep characteristics, sleep-related impairment, alcohol use, and alcohol-related consequences. Similarly, future research could also consider utilizing multiple assessments of the SWPS to examine the stability of these classes over time. Second, our study may not be representative of all manifestations of sleep characteristics/sleep-related consequences in college students. Though our sample size was large and

representative of the demographic characteristics of the university, it is possible that specific sleep patterns and/or problems were not represented. The overall rate of sleep/wake problems reported, however, is consistent with the prevalence of sleep disturbance in college students (see Lund et al., 2010). Third, these data are self-report, with no collateral verification or biological assessment of alcohol consumption. Overall, studies have supported the reliability and validity of self-report data on alcohol use in college students (e.g. Borsari & Muellerleile, 2009). Fourth, we did not collect data on other medication use or the presence of other mental and medical disorders that could impact sleep. The inclusion of these constructs in the model could help to better explain the association of the sleep classes with our auxiliary variables. Importantly, however, the classes themselves would not be impacted by the inclusion of these additional variables, because class modeling is done without consideration of auxiliary variables. Fifth, we utilized a gross estimate of illicit substance use rather than a detailed assessment of recent frequency. This allowed us to establish the relationship between the sleep classes and substance use in a general fashion. Future research should consider examining the relationship of these sleep classes with a more fine-grained substance use assessment. Sixth, the SWPS is not a comprehensive assessment of daytime sleep-related consequences. As such, we cannot speculate beyond the three consequences assessed here about the rate or range of consequences experienced by college students.

In summary, at-risk college student drinkers display different sleep patterns and types of sleep-related impairment. Classes of sleep symptoms are related to differences in alcohol consumption, alcohol-related problems and illicit substance use. At-risk drinkers with sleep disturbance and the greatest number of sleep-related consequences report more alcohol use and alcohol-related problems than all other classes. These findings suggest that there could be synergistic effects of alcohol and alcohol-related harm on sleep and/or synergistic effects of alcohol and sleep on alcohol-related problems. Harm reduction interventions for college drinking could, therefore, benefit from the incorporation of brief sleep assessments and interventions to improve students' sleep for several reasons. College students may use alcohol to self-medicate sleep disturbance (Brower, 2003). Sleep disturbance predicts poor alcohol treatment outcomes among individuals with alcohol use disorders (Brower, 2003). Moreover, as these results indicate, sleep disturbance may be associated with increased risk of negative consequences of alcohol consumption in this cohort. By the same token, sleep and other health interventions for college students could benefit from the inclusion of brief alcohol assessments and interventions. The negative effects of chronic, heavy alcohol use on sleep are well-documented (Ebrahim, Shapiro, Williams, & Fenwick, 2013; Roehrs & Roth, 2001). Likewise, there may be specific associations between heavy alcohol use and sleep-related impairment among college students.

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Table 1

Sleep Wake Behavior Problems Scale (SWPS) Means and Probabilities by Item for the Whole Sample ($n = 312$) and by Sleep Latent Profile Membership

	Whole Sample ($n = 312$)	Sleepiness ($S, n = 33$)	Sleepiness & Late Bedtimes (SL, $n = 132$)	Sleepiness & Late Bedtimes with Consequences (SLC, $n = 88$)	Sleepiness, Late Bedtimes, & Sleep Disturbance with Consequences (SLDC, $n = 58$)
<i>Categorical Items ("Never" probability, SE)</i>					
Arrived late to class because you overslept	0.56 (0.03)	0.83 (0.07)	0.68 (0.03)	0.56 (0.07)	0.15 (0.08)
Fallen asleep in AM class	0.61 (0.03)	0.62 (0.09)	0.68 (0.04)	0.72 (0.08)	0.24 (0.11)
Fallen asleep in PM class	0.71 (0.03)	0.79 (0.10)	0.75 (0.04)	0.82 (0.08)	0.39 (0.12)
Stayed up all night	0.69 (0.03)	0.90 (0.06)	0.70 (0.04)	0.79 (0.06)	0.41 (0.10)
<i>Continuous Items (mean, SE)</i>					
Stayed up until at least 3:00am	3.60 (0.06)	1.44 (0.17)	3.81 (0.06)	3.63 (0.14)	4.31 (0.11)
Slept past noon	2.82 (0.07)	1.71 (0.21)	2.69 (0.11)	2.99 (0.17)	3.46 (0.17)
Felt tired, dragged out, or sleepy during the day	3.73 (0.05)	3.36 (0.19)	3.59 (0.08)	3.85 (0.09)	4.06 (0.09)
Needed more than one reminder to get up in the morning	2.54 (0.09)	1.32 (0.09)	1.18 (0.04)	4.00 (0.12)	4.09 (0.19)
Had an extremely hard time falling asleep	2.63 (0.07)	2.53 (0.22)	2.42 (0.11)	2.74 (0.17)	3.01 (0.22)
Gone to bed because you just could not stay awake any longer	2.39 (0.07)	1.87 (0.21)	2.10 (0.10)	2.39 (0.15)	3.34 (0.21)
Total SWPS Score	24.26 (0.34)	17.49 (0.59) ^d	21.69 (0.35) ^d	25.09 (0.37) ^d	32.77 (0.60) ^d

Note. S = Sleepiness; SL = Sleepiness and Late Bedtimes; SLC = Sleepiness and Late Bedtimes with Consequences; SLDC = Sleepiness, Delayed Bedtimes, and Sleep Disturbance with Consequences

*** Overall chi-square tests significant at $p < 0.001$

^a = Class is significantly different than all other classes

Table 2

Model Fit Indices for 1- to 5-Class Solutions of Sleep Behavior Problems

Model	BIC	Adjusted BIC	BLRT _p	Entropy
1-class solution	8645.74	8556.94	—	—
2-class solution	8418.28	8256.53	0.00	0.961
3-class solution	7925.26	7538.31	0.00	0.864
4-class solution	8458.94	8151.29	0.00	0.901
5-class solution	model did not converge			

Note. BIC = Bayesian Information Criterion; LMR = Lo-Mendell Rubin; BLRT = Bootstrapped Parametric Likelihood Ratio Test

Table 3

Demographics of Sleep Latent Profiles

	Sleepiness (S, <i>n</i> = 33)	Sleepiness & Late Bedtimes (SL, <i>n</i> = 132)	Sleepiness & Late Bedtimes with Consequences (SLC, <i>n</i> = 88)	Sleepiness, Late Bedtimes, & Sleep Disturbance with Consequences (SLDC, <i>n</i> = 58)
Age, mean (SD)	18.82 (1.04)	18.95 (0.90)	18.90 (1.06)	18.84 (0.98)
Gender				
Male, <i>n</i> (%)	12 (36%)	78 (59%)	53 (58%)	34 (62%)
Female, <i>n</i> (%)	21 (64%)	54 (41%)	39 (42%)	21 (38%)
Freshmen, <i>n</i> (%)	19 (58%)	68 (52%)	52 (54%)	30 (55%)
Caucasian, <i>n</i> (%) ^a	32 (97%)	112 (85%)	81 (88%)	40 (73%)
Hispanic, <i>n</i> (%)	1 (3%)	7 (5%)	5 (5%)	8 (15%)

Note. S = Sleepiness; SL = Sleepiness and Late Bedtimes; SLC = Sleepiness and Late Bedtimes with Consequences; SLDC = Sleepiness, Delayed Bedtimes, and Sleep Disturbance with Consequences

^aThere was a significant overall difference ($p < 0.01$) in the number of Caucasians by class. The S class had a significantly higher proportion of Caucasians than the SL ($p < 0.01$) and SLDC ($p < 0.01$) classes. All other class comparisons were not significant.

Table 4

Means Scores on Typical Week Drinking, Alcohol-Related Consequences, Drug Use, and Perceived Health by Latent Profile

	Drinks/Typical Week	Binge Frequency	BYAACQ	Illicit Drug Use	Perceived Health
	<i>M (SE)</i>	<i>M (SE)</i>	<i>M (SE)</i>	<i>M (SE)</i>	<i>M (SE)</i>
S Class	13.87 (1.47)	5.44 (0.66)	5.50 (0.71)	1.53 (0.26)	2.66 (0.18)
SL Class	21.07 (1.15)	7.88 (0.42)	6.56 (0.41)	1.93 (0.17)	2.60 (0.08)
SLC Class	19.99 (1.23)	7.50 (0.49)	6.88 (0.47)	2.18 (0.23)	2.61 (0.11)
SLDC Class	26.12 (2.16)	9.53 (0.68)	9.96 (0.70)	2.85 (0.31)	2.25 (0.14)
Class Comparisons	<i>a, b, c, d, e, f</i>	<i>a, b, c, d, e, f</i>	<i>a, c, d, f</i>	<i>a, c, d,</i>	<i>c, f</i>

Note. BYAACQ = Brief Young Adult Alcohol Consequences; S = Sleepiness; SL = Sleepiness and Late Bedtimes; SLC = Sleepiness and Late Bedtimes with Consequences; SLDC = Sleepiness, Late Bedtimes, and Sleep Disturbance with Consequences. All Class Comparison tests different at $p < 0.05$.

a = significant overall chi-square test

b = significant difference between S vs. SL classes

c = significant difference between SL vs. SLDC classes

d = significant difference between S vs. SLDC classes

e = significant difference between S vs. SLC classes

f = significant difference between SLC vs. SLDC classes