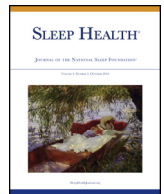




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## Calculating the contribution of sleep problems to undergraduates' academic success

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### ABSTRACT

**Objectives:** The objective of this study is to determine to what degree sleep disturbances predict academic success, relative to other known risk factors for decreased academic performance.

**Methods:** We performed regression analyses on data from the Spring 2009 American College Health Association National College Health Assessment II dataset (n=55,322 students) to isolate the relative contribution of the frequency of sleep problems in the previous week to GPA and the likelihood of withdrawing from a course. In our estimations, we also controlled for other factors that influence academic success such as demographic and academic variables, drug and alcohol use, perceived stress, and employment hours.

**Results:** Sleep disturbances were found to be a significant independent predictor of academic problems; on average, each additional day per week that a student experienced sleep problems raised the probability of dropping a course by 10% and lowered the cumulative GPA by 0.02. Factors such as stress, binge drinking, marijuana and other illicit drug use, which typically receive more attention by university administrators, had similar or relatively smaller negative associations with academic success as compared to disturbed sleep. Approximately three quarters of students surveyed reported never receiving information about sleep from their university.

**Conclusions:** Sleep education represents an underutilized opportunity for universities to maximize retention rates and academic success.

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### Introduction

Universities use predictors of college achievement to select students and allocate student support services to raise retention rates. Historically, attempts to predict academic success at the university level have focused on measures such as high school GPA and performance on standardized college admissions tests, which collectively account for only one fourth of the variance in college GPA.<sup>1–3</sup> As colleges and universities in the United States cope with record high levels of psychological distress among students,<sup>4,5</sup> the higher education community is recognizing that non-academic factors like mental health and wellbeing are intricately related to academic success.<sup>6–9</sup> In fact, a prospective study of 204 first-year students found that 56% of the variance in GPA could be predicted by a survey comprised

primarily of measures of behavioral health.<sup>10</sup> Accordingly, colleges and universities are searching for ways to improve students' wellbeing and academic success by promoting behavioral health. Although seminal studies of academic success and retention have not included sleep measures as predictor variables,<sup>11–15</sup> sleep represents a modifiable risk factor with great potential to impact success. If sleep is found to impact academic success, universities can integrate this information into budgetary decisions regarding allocation of student services.

The consensus of the scientific community is that the vast majority of adults require seven to nine hours of restorative sleep a night for optimal physical and mental health and cognitive performance.<sup>16</sup> Yet, a minority of college students regularly achieve this target.<sup>17</sup> More than two-thirds of students experience significant problems with excessive daytime sleepiness, more than a third of students fall asleep in class at least once a week,<sup>17</sup> and more than a quarter describe their sleep problems as traumatic or difficult to handle.<sup>18</sup> In college students, insufficient and poor sleep quality exacerbate physical and mental health concerns. Specifically, inadequate sleep has

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been shown to decrease their immune function, increase the expression of underlying psychological disorders (particularly anxiety and mood disorders), increase motor vehicle accident risk, and increase other risk-taking behaviors like unsafe sex and substance abuse.<sup>19–21</sup>

Multiple single-institution studies have shown that insufficient, inconsistent, and poor quality sleep are also significant and independent predictors of university students' academic performance. Taylor et al. (2013) used a prospective sleep diary approach in a large population ( $n = 867$ ) to compare unique contributions of sleep problems to GPA in context with other important academic variables including high school GPA, standardized test scores, and health variables (e.g., alcohol abuse; perceived stress; depression, and marijuana).<sup>22</sup> After high school GPA and standardized test scores, they found that the most significant predictors of academic success were total sleep time and sleep time inconsistency, with students sleeping less than six or more than nine hours a night achieving the lowest grades. Gomes, Tavares, & de Azevedo (2011) performed a multi-measure, multi-predictor study of college success from Portugal, which included measures of previous academic success, class attendance, study time, drug and alcohol habits, and lifestyle questions ( $n = 1654$ ).<sup>23</sup> Their results indicated that achieving sufficient sleep was the third most important variable in predicting end of semester grades, after previous academic achievement and class attendance. Academic success has also been found to positively correlate with consistent sleep/wakefulness schedules. In a survey of community college students ( $n = 157$ ), Eliasson et al. (2009) found that students in the highest GPA quintile had significantly earlier bedtimes and rise times than those in the lowest quintile, although total sleep time was not different between groups.<sup>24</sup> Peters, Joireman, and Ridgway (2005) demonstrated that students with higher GPAs were less likely to oversleep ( $n = 231$ ).<sup>25</sup> A prospective sleep diary and actigraphy-based study of 61 college students found that academic performance was positively correlated with sleep schedule regularity.<sup>26</sup> Achieving restorative sleep also predicts academic success; a large study of undergraduate students ( $n = 1845$ ) found that those who screened positive for possible sleep disorders were significantly more likely to be at risk for academic failure ( $GPA < 2.0$ ).<sup>27</sup>

In our study, we use data from the American College Health Association's National College Health Assessment (ACHA-NCHA) II survey<sup>28</sup> to compare the relationship sleep problems and GPA and course completion with other demographic, academic, health, and social variables. To our knowledge, this study is the first to use a multi-institution national dataset to examine whether sleep problems are a significant predictor of academic success. Because of the detail in the survey instrument, we are able to control for a multitude of health-related and demographic variables such as sexual orientation, learning disability, volunteer and work hours, serious illness, and depression/anxiety diagnosis and treatment – all factors that can influence the quantity and quality of sleep students obtain. Our objectives were to determine whether sleep disturbances independently predict academic performance and, if so, how the strength of this relationship compares to the predictive capacity other health factors.

Students already recognize the adverse effect of sleep on their academic performance. Summary statistics from the Spring 2017 ACHA-NCHA IIc survey showed that the top four self-rated impediments to undergraduate academic success are stress (34%), anxiety (26%), sleep difficulties (22%), and colds and flu (17%).<sup>18</sup> Despite the frequency of self-reported academic problems associated with sleep, the majority (73%) of students surveyed in the spring 2017 ACHA-NCHA reported never having received information about healthy sleep from their universities.<sup>18</sup> In fact, released summary statistics from the 2017 ACHA-NCHA IIc report show that sleep ranked second to last in health related topics undergraduate students report

**Table 1**

Percent of undergraduates who report receiving and being interested in receiving health information from their university

Health Topic	Received	Interested
Sexual assault prevention	84%	59%
Alcohol & other drug use	83%	36%
Stress reduction	69%	74%
Depression & anxiety	66%	64%
STD* prevention	63%	55%
Physical activity	61%	62%
Nutrition	57%	67%
Cold, flu, sore throat	55%	46%
How to help others in distress	54%	69%
Suicide prevention	53%	58%
Violence prevention	50%	53%
Pregnancy prevention	49%	45%
Relationship difficulties	45%	51%
Tobacco use	42%	33%
Grief & loss	39%	53%
Eating disorders	36%	45%
Injury prevention	36%	49%
<b>Sleep difficulties</b>	<b>27%</b>	<b>66%</b>
Problem use of internet/games	18%	29%

Data Source: Spring 2017 ACHA-NCHA IIc Undergraduate Student Reference<sup>18</sup> group questions 2A ("Have you received information on the following topics from your college or university?") and 3A ("Are you interested in receiving information on the following topics from your college or university?"); responses ranged from 47,151 to 47,723.

\* STD = sexually transmitted disease or infection.

receiving information about from their universities, despite being one of the topics students were most interested in learning about (Table 1).<sup>18</sup> Given the strong student interest in receiving information on sleep health, as well as the demonstrated and perceived impact of sleep on student success, instituting a sleep education program may potentially represent an underutilized opportunity for universities to maximize retention rates and academic success.

## Method

### Survey Instrument

We received permission from the American College Health Association to analyze data from the Spring 2009 administration of the ACHA-NCHA II, a nationally-recognized research survey that collects detailed information about thousands of graduate and undergraduate students' mental and physical health habits, illnesses, behaviors and perceptions. Over 87,000 students from 110 2-year and 4-year institutions of higher learning across the United States and abroad completed the assessment that semester. Campuses included private (37%) and public (63%) institutions in rural, town, and metropolitan locations; 19 campuses had religious affiliations and five were post-secondary minority institutions. Institutions distributed the survey by random assignment any time during the semester, however most were distributed between January and March. Surveys that were collected in the month after spring break were not included in the dataset. The overall response rate was 30%. Further details about the survey methodology, including information about validity, reliability, and generalizability, can be found on the ACHA-NCHA website.<sup>18</sup>

### Sample Construction

We only included undergraduate students in our sample who were under the age of 25 and attended a 4-year institution of higher learning in the United States. These restrictions were made for two reasons. First, the measure of academic success is not constant across levels of higher education. For instance, earning a B in graduate school is not equivalent to earning a B as an undergraduate. Second,

college students older than 25 likely have different sources of stressors and constraints on their time that influence their academic performance. This is true as well for students studying abroad in a different academic culture.

We also created a sample that only consisted of first year students, because first-year student performance is a critical indicator of future student academic success. Radcliffe, Huesman, and Kellogg (2006) have found that withdrawing from even one course in a student's first year decreases the probability of graduating within 6 years of entry by 14%.<sup>29</sup> Because retention rates are critical to the economic sustainability of colleges and universities, better understanding of what factors predict student success in the first year is a high priority for universities. In addition, poor academic performance in the first year has long-term negative effects on students' learning in future upper division courses and their overall GPA, which in part determines what graduate and professional opportunities are available. Given these restrictions, our final sample consisted of 55,322 completed student survey participants (of whom 15,090 were first year students) from 105 unique schools in the United States. (See Appendix A for more information about the sample construction.)

## Measures

The ACHA-NCHA II survey contains a variety of questions that we used to measure students' sleep problems. For simplicity, we focus our discussion on the sleep measure constructed by averaging student responses to four questions from the ACHA-NCHA II survey:

- On how many of the past 7 days, did you get enough sleep so that you felt restored when you woke up in the morning? (Question 42, reverse scored)
- In the past 7 days, how often have you...
- ...awakened too early in the morning and could not get back to sleep? (Question 44a)
- ...felt tired, dragged out, or sleepy during the day? (Question 44b)
- ...have an extremely hard time falling asleep? (Question 44d)

The authors felt these four recent retrospective questions covered distinct but not overlapping categories of sleep disturbances: insufficient or non-restorative sleep (Question 42), excessive daytime sleepiness (Question 44b), poor sleep maintenance (Question 44a) and sleep onset insomnia (Question 44d). Question 44c ("In the past 7 days, how often have you gone to bed because you could not stay awake any longer?") was not included in our constructed average because it did not describe a recognized sleep disturbance. For the duration of the paper, we will refer to this sleep measure as *Days per Week Sleep Problems*.

## Academic Success Regression Model

We performed regression analyses to isolate how much the predictor variables individually explained the variation in academic success across students. Our dependent variable is *Academic Success*. This was measured in two ways: 1) whether the student dropped a course or received an incomplete in the last 12 months (Question 45); and 2) the student's self-reported GPA (Question 63; a categorical choice where A equals 4 and D/F equals 1).

For both specifications, we use the same variables to explain variation in academic success across students. These include students' reported number of *Days per Week Sleep Problems*, as previously described. A number of student demographic characteristics are included such as age, race, and gender, as well as indicator variables for students' LGBT (lesbian, gay, bisexual or transgender identity), athletic, and international status, and whether the student lived on campus or has a physical disability. The academic related variables consist of whether a student is full-time, or has Attention Deficit/

Hyperactivity Disorder (ADHD) or another learning disability. To capture how variation in time demands and stress levels might impact academic performance, variables such as the number of self-reported major stressors in the student's life in the last year, whether the student had been in an abusive relationship in the last year, and whether the student worked or volunteered 10 plus hours per week are included.

The health-related predictor variables are BMI, having a difficult physical illness, having been diagnosed and treated for depression and/or anxiety, having been diagnosed but not treated for depression and/or anxiety, or having any other psychological diagnosis. Note that we combined the anxiety and depression diagnoses into one variable to address potential multi-collinearity issues. The high comorbidity rates (75% lifetime comorbidity of anxiety disorder with depressive disorder)<sup>30</sup> would make it difficult to separately identify these two health factors' impact on academic success. We also include students' reported alcohol and drug use impact academic success as predictor variables. Table 2 provides the summary statistics for the outcome variables (GPA and the probability of dropping a course) and the predictor variables of interest. (See Appendix A for full variable definitions.) Finally, fixed effects were estimated to capture variation in academic success that varies by colleges (i.e., the unobserved variation in sleep behavior that affects academic success that varies by college due to college-specific social/academic norms.)

We used a logistic regression specification with fixed effects to estimate the likelihood of dropping a course or receiving an incomplete. The errors are assumed to follow a standard logistic distribution. We used an Ordinary Least Squares (OLS) regression specification with

**Table 2**  
Descriptive Statistics - Full Sample

	Mean	Std. Dev.	Range
<b>Sleep</b>			
Days per week sleep problems *	2.43	1.28	0–7
<b>Academic</b>			
GPA	3.21	0.68	1–4
Drop Course*	0.05	0.23	0–1
Fulltime*	0.97	0.17	0–1
ADHD*	0.06	0.23	0–1
Learning Disability*	0.02	0.14	0–1
<b>Demographics</b>			
Men*	0.35	0.48	0–1
White*	0.76	0.43	0–1
Age	20.17	1.55	18–25
Athlete*	0.10	0.30	0–1
International*	0.07	0.25	0–1
Live On Campus*	0.48	0.50	0–1
GLBT*	0.06	0.24	0–1
Physical Disability*	0.03	0.18	0–1
<b>Stressors</b>			
Number of Stressors	2.72	2.55	0–11
Abusive Relationship*	0.11	0.31	0–1
Work 10+ Hours*	0.35	0.48	0–1
Volunteer 10+ Hours*	0.05	0.22	0–1
<b>Health</b>			
BMI	23.87	4.59	15–77
Difficult Physical Illness*	0.12	0.33	0–1
Diagnosed and treated depression and/or anxiety*	0.11	0.31	0–1
Diagnosed but untreated depression and/or anxiety*	0.03	0.17	0–1
Any other psychiatric diagnosis*	0.09	0.28	0–1
<b>Drug Use</b>			
Cigarette user*	0.07	0.25	0–1
Binge drinking episodes in last two weeks	1.04	1.74	0–10
Marijuana user*	0.17	0.38	0–1
Other drug user*	0.06	0.24	0–1
Prescription drug misuse*	0.15	0.36	0–1

Note: \* indicates dummy variables.

**Table 3**

Factors influencing whether a college student drops a course or earns an incomplete: Logit Regression with School Fixed Effects

		First-year students		All Levels	
		Coef.	Std. Err.	Coef.	Std. Err.
Sleep	Days per Week Sleep Problems	0.144	0.036 **	0.104	0.016 **
	GPA	−0.796	0.064 **	−0.786	0.030 **
Academic	Fulltime	−0.346	0.276	−0.498	0.093 **
	ADHD	0.420	0.145 **	0.392	0.064 **
Demographics	Learning disability	0.382	0.249	0.173	0.114
	Men	0.256	0.104 **	0.094	0.047 *
	White	−0.123	0.114	−0.022	0.051
	Age	0.005	0.057	0.075	0.021 **
	Athlete	−0.055	0.158	−0.187	0.082 *
	International	−0.184	0.199	0.005	0.083
	Live on campus	−0.403	0.135 **	−0.144	0.055 **
	LCBT	0.183	0.153	0.289	0.067 **
Stressors	Physical Disability	0.335	0.189	0.253	0.089 **
	Number of Stressors	0.175	0.020 **	0.181	0.009 **
	Abusive Relationship	0.049	0.128	0.173	0.053 **
	Work 10+ Hours	−0.035	0.124	−0.067	0.045
Health	Volunteer 10+ Hours	0.122	0.250	0.122	0.086
	BMI	−0.003	0.010	−0.004	0.004
	Difficult physical illness	0.412	0.121 **	0.288	0.053 **
	Diagnosed and treated depression and/or anxiety	0.824	0.136 **	0.782	0.057 **
	Diagnosed but untreated depression and/or anxiety	−0.407	0.227	0.245	0.087 **
	Any other psychiatric diagnosis	0.353	0.144 *	0.284	0.062 **
Drug Use	Cigarette user	0.398	0.146 **	0.187	0.066 **
	Binge drinking episodes in last 2 weeks	0.045	0.028	−0.030	0.012 *
	Marijuana user	0.015	0.124	0.126	0.055 *
	Other drug user	0.280	0.157	0.214	0.069 **
	Prescription drug misuse	0.142	0.122	0.145	0.052 **
# of observations		14,926–1746.1		55,272–9210.88	
Log Likelihood		LR $\chi^2(27) = 839.10$		LR $\chi^2(31) = 3958.09$	
LR Test		$P < .001$		$P < .0001$	
McFadden Pseudo R-squared Adjusted		0.18		0.17	
Nagelkerke Pseudo R-squared		0.22		0.21	

Notes: Standard errors are given in parentheses. \* and \*\* indicate significance at the 5 and 1% levels, respectively.

fixed effects to estimate GPA. These error terms were i.i.d. normally distributed with a mean of zero and variance of  $\sigma^2$ . We performed Wald tests to determine if regression coefficients are statistically different from *Days per week with sleep problems* variable, the variable of interest in this study.

## Results

Pearson correlations were calculated across the respondents' academic success, reported sleep problems, demographic variables, extracurricular involvements, health variables, and drug and alcohol use (see Supplementary Table 1). Because evidence suggests that each of these variables likely plays a role in a student's ability to achieve academic success, we included all variables in the regression analyses to avoid an omitted variable bias. Regression coefficients for these variables for dropping a course or earning an incomplete are listed in Table 3 for both samples: a) only first year students and b) all undergraduate students. Regression coefficients predicting GPA are listed in Table 4 for both samples.

To predict course completion, we ran a logistic regression. Of the 26 predictor variables included, 21 were found to be significant independent contributors to this measure of academic success for the undergraduate population. At the 1% significance level, we reject the null hypothesis that all of the coefficients in the Logistic regression for the full sample are jointly zero [LR  $\chi^2(27) = 839.10$ ,  $P < .001$ ].

To predict undergraduate GPA, we performed an OLS regression. Of the 26 predictor variables included, all but five were significant predictors of academic success. Collectively, the model explains 11.6% of the variance in GPA. At the 1% significance level, we can

reject the null hypothesis that all of the coefficients are jointly zero [ $F_{31,55186} = 215.87$ ,  $P < .001$ ].

Overall, students with more sleep disturbances in the last week had a greater incidence of academic problems, including higher rates of dropping or taking an incomplete in a course in the last 12 months (Fig. 1a) and a lower cumulative GPA (Fig. 1b). Sleep problems were found to be a significant, independent negative predictor of academic success. Table 3 presents parameter estimates from a logit regression with fixed effects for colleges. We report marginal effects to demonstrate how a change in one of the covariates influences the likelihood a college student drops a course or earns an incomplete. The number of days a student reported sleep problems in the last week was a significant predictor at the 1% level for the likelihood of dropping or earning an incomplete in a course. Each additional day per week an undergraduate student experienced sleep problems on average raised the probability of dropping a course by 10%, holding all other variables constant. When one limits the analysis to only first year students, sleep problems on average raised the probability of dropping a course by 14%, holding all other variables constant, a 40% increase as compared to the undergraduate population.<sup>i</sup>

The number of days students reported sleep problems in the last week was also a significant predictor of undergraduate students' cu-

<sup>i</sup> One might be interested in whether sleep disruption affects academic success differently for different demographic groups. We also ran the regressions allowing for interactions between sleep and three demographic variables: gender, race, and living on campus. For the GPA regressions, none of the interaction terms were statistically different from zero. For the dropping a course regressions, only living on campus interaction terms for undergraduates were statistically different for zero. Sleep problems' adverse impact on likelihood of dropping a course is statistically larger for those students who live on campus than those who live off campus.



**Table 4**  
Undergraduate GPA: OLS Regression with School Fixed Effects

		First Years		All Levels	
		Coef.	Std. Err.	Coef.	Std. Err.
Sleep	Days per Week Sleep Problems	−0.020	0.005 **	−0.021	0.002 **
	Drop Course	−0.391	0.029 **	−0.328	0.012 **
Academic	Fulltime	0.119	0.043 **	0.105	0.016 **
	ADHD	−0.198	0.024 **	−0.196	0.012 **
Demographics	Learning Disability	−0.212	0.039 **	−0.247	0.020 **
	Men	−0.066	0.012 **	−0.080	0.006 **
	White	0.220	0.014 **	0.216	0.007 **
	Age	0.002	0.008	−0.008	0.003 *
	Athlete	−0.119	0.017 **	−0.103	0.010 **
	International	0.039	0.022 **	0.063	0.011 **
	Live On Campus	0.011	0.018	0.015	0.007 *
	LGBT	0.066	0.022 **	0.055	0.011 **
	Physical Disability	0.026	0.028	−0.007	0.015
	Number of Stressors	−0.034	0.003 **	−0.028	0.001 **
Stressors	Abusive Relationship	−0.023	0.019	−0.035	0.009 **
	Work 10+ Hours	−0.049	0.015 **	−0.038	0.006 **
	Volunteer 10+ Hours	0.015	0.033	0.073	0.012 **
Health	BMI	−0.017	0.001 **	−0.016	0.001 **
	Difficult physical illness	0.088	0.019 **	0.052	0.009 **
	Diagnosed and treated depression and/or anxiety*	0.022	0.022	0.043	0.010 **
	Diagnosed but untreated depression and/or anxiety*	−0.035	0.034	−0.022	0.017
Drug Use	Any other psychiatric diagnosis	0.028	0.024	0.019	0.011
	Cigarette user	−0.170	0.025 **	−0.127	0.011 **
	Binge drinking episodes in last two weeks	−0.025	0.004 **	−0.019	0.002 **
	Marijuana user	−0.052	0.017 **	−0.038	0.008 **
	Other drug user	−0.068	0.026 **	−0.020	0.012
	Prescription drug misuse	−0.057	0.018 **	−0.071	0.008
# of observations		15,090		55,322	
R-squared		0.109		0.116	
F test		F(27,14,959) = 63.49 (Prob > F) < 0.0001		F(31,55,186) = 215.87 (Prob > F) < 0.0001	

\* and \*\* indicate significance at the 5 and 1% levels, respectively.

mulative GPA (See Table 4 for OLS regressions). For both the first year students and the entire undergraduate population, each additional day per week a student reported a sleep problem, a student's GPA dropped by 0.02, holding all other variables constant.

For the total undergraduate population, the variables that accounted for the most variance in both measures of academic success were a diagnosis of ADHD and cigarette use. Other important predictors of dropping a course were a diagnosis of depression and/or anxiety (treated), and LGBT identity. The probability of dropping a course had three additional important factors (diagnosed but untreated depression and/or anxiety, any other psychiatric diagnosis, and illicit drug use other than marijuana).

To make comparisons across predictor variables easier, Table 5 groups the unstandardized regression coefficients by size, relative to the sleep disturbance per week variable. Sleep problems were found to be equivalent to or a relatively stronger predictor of academic success than many other health problems typically promoted by campus health centers. For example, the impact of sleep problems on the probability of dropping a class, holding all other variables constant, was equivalent to marijuana and other drug use, prescription drug misuse, and having untreated depression and anxiety, and greater than that of binge drinking. For the full undergraduate sample, the estimated impact of an additional day per week with a reported sleep problem on GPA was equivalent to binge drinking and being involved in an abusive relationship. For first year students, sleep problems have a larger predictive capacity for the likelihood of dropping a course than they do for the general undergraduate population. In predicting first year students' GPA, the contribution of sleep difficulties was equivalent to binge drinking and marijuana use.

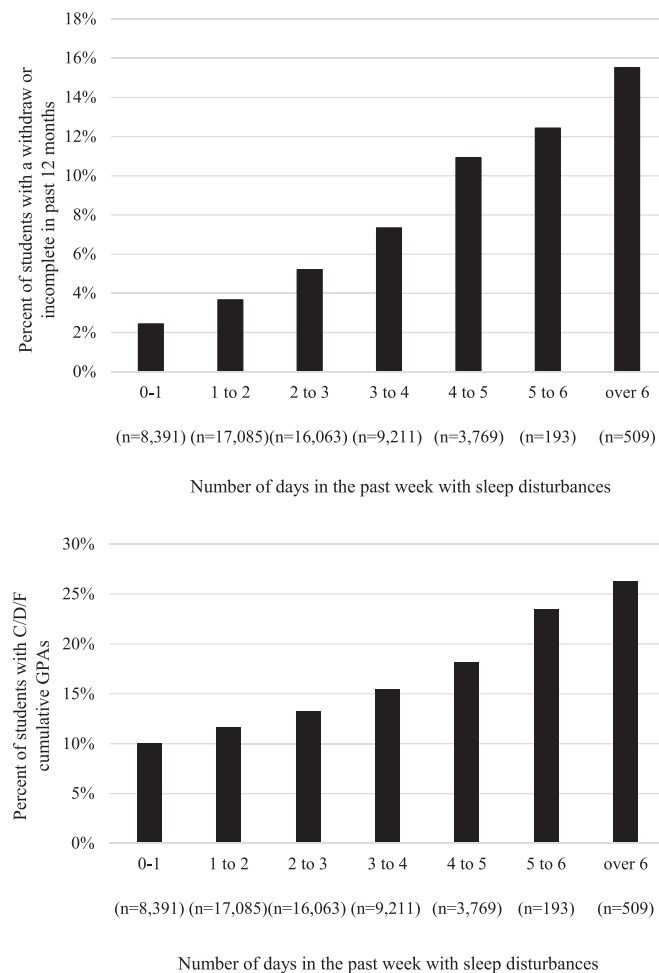
When comparing the predicted impact of these health-related variables on academic success relative to the attention universities

provide on these topics (Table 1), sleep problems emerge as the factor with the greatest calculated impact that receives the least attention. For example, whereas more than twice the number of students received information about stress reduction (69%) than sleep difficulties (27%), those factors are essentially equivalent in predicting academic success. Likewise, 83% of students report receiving information about alcohol and other drug use, but its predictive capacity for academic success is on par with or smaller than sleep difficulties.

## Discussion

### Review of Major Findings

Our findings demonstrate a strong negative relationship between sleep disturbances and academic success in undergraduate students. Our analyses showed that students reported experiencing an average of 2.4 (SD 1.28) days of sleep disturbance the week prior to being surveyed. On average, each additional day per week with sleep problems raised the probability that a first year student drops a course by 14% and lowered the GPA approximately 0.02, holding all other variables constant. Even if one views the magnitude of these figures as small, one must consider that the negative impact of poor sleep on academic success is found to be equivalent to (and under some specifications greater than) the impact of binge drinking and marijuana use. Only learning disabilities and diagnosed depression and/or anxiety, conditions for which universities already routinely provide services, have a significantly larger impact on academic success across both measures. Finally, the adverse relationship between poor sleep and the probability of dropping a class is about 40% higher for first-year students than it is for all undergraduate students. Therefore, in order to help their students succeed academically, universities



**Fig. 1.** Association between self-reported sleep problems in the last week and students' academic performance as defined by dropping or withdrawing from a course (top) and having a lower GPA (bottom).

**Table 5**

How does sleep's impact on academic performance compare to other health factors for which universities routinely provide resources?

	Drop Course		GPA	
	First year	Full sample	First year	Full sample
Impact is greater than sleep disturbance	Anxiety/ Depression-treated**	Anxiety/ Depression-treated** Other psychiatric diagnosis*	ADHD** Learning Disability* No. of stressors* Cigarette use** Rx drug misuse**	Anxiety/ Depression-treated** ADHD** Marijuana use**
Impact is on par with sleep disturbance	ADHD Other psychiatric diagnosis No. of stressors Cigarette use	Depression/ Anxiety-untreated ADHD No. of stressors In abusive relationship Cigarette use Marijuana use Rx drug misuse Other drug use Binge drinking*	Binge drinking Marijuana use Other drug use	Binge drinking In abusive relationship
Impact is less than sleep disturbance Not a significant predictor of academic success	Binge drinking*  Depression/ Anxiety-untreated Learning Disability In abusive relationship Marijuana use Other drug use	Learning Disability	Depression/ Anxiety- treated & untreated Other psychiatric diagnosis In abusive relationship	Depression/ Anxiety-untreated Other psychiatric diagnosis Other drug use

We performed Wald tests to determine if regression coefficients are statistically different from the *Days per week with sleep problems variable*. \* and \*\* indicate that coefficients are significantly different from the sleep disturbance coefficient at the 5%, and 1% levels, respectively.

could make a significant difference by effectively addressing students', particularly first-year students', sleep problems.

Our findings that link sleep problems with reductions in students' academic achievements are consistent with the many studies that have shown academic benefits from improved sleep. Sleep disordered breathing is associated with poor academic performance as measured by grades and reported behavioral problems for middle and high school students.<sup>31,32</sup> Adhering to the recommendations of numerous professional health organizations, many high schools and colleges have adopted changes to delay school start times to increase total sleep time and better align academic schedule with adolescents' biological rhythms. Following these changes in school start times, schools have reported improved attendance and academic performance,<sup>33–35</sup> as well as reductions in tardiness and disciplinary actions.<sup>36</sup> On the university level, Carrell, Maghakian, and West (2011) found that starting the school day 50 minutes later at the U. S. Air Force Academy resulted in a significant improvement in student outcomes not only for the first class, but for their classes throughout the day.<sup>37</sup> Being assigned a class during first period on average lowered normalized grade by 0.03 standard deviations. Thus, the preponderance of evidence from this and other studies suggests that sufficient, restorative sleep would have a positive and robust impact on academic performance.

### Limitations of Study

As with any study of data from a large national sample, we are limited by a number of factors inherent in the survey design. First, all measures are self-reported. We do not have independent confirmation of grades, medical diagnoses, or sleep problems. However, self-reported GPAs do tend to be fairly accurate, particularly in the A/B range),<sup>38</sup> which were the majority of students in our sample (e.g. mean grade = 3.21). Because the ACHA-NCHA II asks students to self-report their GPA not as a discrete number, but rather as a categorical choice ("mostly As, mostly Bs, mostly Cs, or mostly D/Fs"), reporting errors are likely reduced. Also, the sample is not necessarily representative of the general population; the survey responses were skewed to more female and more academically successful respondents.

Second, the ACHA-NCHAII survey asks students whether they have been diagnosed and/or treated for a mental illness in the last 12 months, but does not include standard measures of stress, depression and anxiety states, such as the Beck Depression Inventory or the Subjective Units of Distress Scale, so direct comparisons to other studies of sleep and health are limited. The coefficients on diagnosed depression/anxiety we used likely underestimate the full impact of these mental health illnesses on academic success. Far more students report experiencing extreme psychological distress (e.g., thoughts of suicide; feelings of overwhelming anxiety, or depression so intense it's difficult to function) than report having been diagnosed with or treated for a mental illness in the last year.<sup>17</sup> The adverse relationship between untreated and undiagnosed depression/anxiety and reduced academic success is likely captured by the *Stressors* variable, which is the sum of ten potential options, including 'other' that students report finding "traumatic or very difficult to handle." Thus, in our model of academic success, we can account for the impact of both treated and undiagnosed mental illness.

Third, we are limited to the survey questions, so we do not have access to key predictors of college success, such as standardized college admissions test scores, socioeconomic status, or measures of conscientiousness and self-efficacy, leading to an omitted variable bias in our estimated effect of how poor sleep affects academic success. For example, the literature has routinely found that high school GPA and standardized test scores are the biggest predictors of college GPA.<sup>3,22</sup> In addition, Taylor et al. found these two high school academic achievement factors to be highly positively correlated with

sleep problems. If sleep and (unobserved) academic ability are positively correlated, then the coefficient on sleep in our study is biased downwards and we are underestimating the negative impact of poor sleep on academic success.

Fourth, the sleep questions included in the ACHA-NCHA II did not include topics that are usually included in studies of sleep (e.g., total sleep time, circadian preference, and sleep schedule regularity), which limits direct comparisons to other studies of sleep and academic performance. Even if we had data on these sleep variables, because of the high correlations among the various sleep measures, it would have been difficult to identify separately the individual impact of each sleep measure on academic success. The survey however, does ask students the number of times in the past 7 days they had insufficient or non-restorative sleep, excessive daytime sleepiness, poor sleep maintenance, and sleep onset insomnia. We average the answers to these four questions to calculate the mean number of nights students experienced sleep disturbances in the last week. Our measure of sleep disturbance can therefore be viewed as a composite one. We cannot be certain of how representative the previous week's sleep behavior is of a student's sleep throughout the academic year. However, studies of the reliability of sleep diaries in adolescents indicate that five days recording indicate good to excellent test–retest validity for sleep duration and sleep latency,<sup>39</sup> and an 8-year comparison of mean responses of our 4 measures of sleep disruption show very little year-to-year variation (see Supplementary Table 2).

Finally, as with other studies calculating the impact of various health factors on specific outcomes, our results suffer from the multi-collinearity problem. For example, sleep problems exacerbate anxiety/depression, and anxiety/depression exasperate sleep problems.<sup>40</sup> As a result, the estimated standard errors are larger than their true values, making it more difficult to find statistical significance. Even with this multi-collinearity problem present, we were able to observe evidence that both sleep problems and anxiety/depression are significant negative predictors of academic success. Compared to other published reports,<sup>3,20,23</sup> our GPA regressions show a smaller coefficient for sleep problems. Because we control for many other health and sociocultural factors that previous studies may have misattributed to sleep (e.g., anxiety/depression, stress, drug use), we are likely calculating a more precise estimate of the impact of sleep problems per se on academic performance.

### Conclusion

Sleep education is by far the most requested and least provided health topic for college students in the United States. Here, we have demonstrated a significant negative relationship between poor sleep and both GPA and course completion. In fact, the strength of the association between poor sleep and academic success is on par with or exceeds that of other health factors for which universities routinely provide services. Given these results, university administrators may consider increasing the amount of resources devoted to educating students on the importance of sleep and improving their sleep hygiene.

Beyond its pronounced relevance to course completion and GPA, poor sleep is also physically and mentally costly to students. Inadequate and nonrestorative sleep increases accident frequency, drug use, health care utilization, and depression and anxiety symptoms.<sup>20,41</sup> As such, addressing sleep problems early in a student's college career would likely lead to improved wellness across a number of clinically relevant measures.

### Disclosure Statement:

All authors report that there are no competing financial interests regarding this paper.

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## Appendix A

### Sample Construction

31,783 observations were dropped from the original sample to obtain our final sample. Eighty-seven percent of these observations (27,792) were dropped because the observations did not match the selection criteria used to construct the sample (i.e., student is over 25, is not an undergraduate, or does not attend a US institution that offers at least a bachelor's degree). An additional 789 observations were dropped because either GPA information was unavailable (e.g., school does give out grades or the student does have a GPA yet) or because this information was not reported. The remaining 3,202 observations were dropped because participants had incomplete responses to any of the other predictor variables.

### Variable Definitions

#### Academic Variables:

*GPA* – is a self-reported approximate of grade point average. It is a discrete variable that takes on the value of 4 for an A and value of 1 for a D/F.

*Drop Course* – is a dummy variable that equals 1 if the student dropped a course or earned an incomplete and zero otherwise.

*Live on Campus* – is a dummy variable that equals 1 if the student lives on campus and zero otherwise.

*Fulltime* – is a dummy variable that equals 1 if the student attends college fulltime and zero otherwise.

*ADHD* – is a dummy variable that equals 1 if the student has been diagnosed with ADHD and zero otherwise.

*Learning Disability* – is a dummy variable that equals 1 if the student has been diagnosed with a learning disability other than ADHD and zero otherwise.

#### Demographic Variables:

*Men* – is a dummy variable that equals 1 if the student is a male and zero otherwise.

*White* – is a dummy variable that equals 1 if the student is White and zero otherwise.

*Age* – is the age of the student.

*Athlete* – is a dummy variable that equals 1 if the student is a varsity athlete and zero otherwise.

*International* – is a dummy variable that equals 1 if the student is an international student and zero otherwise.

*GLBT* – is a dummy variable that equals 1 if the student reports they identify as gay/lesbian, bisexual, or unsure and zero otherwise.

*Physical Disability* – is a dummy variable that equals 1 if the student reported having a physical disability and zero otherwise.

#### Stressor Variables:

*Number of Stressors* – is the number of 11 areas of the student's life that has been traumatic or very difficult for the student to handle. (The areas include the following options: academics, career related issues, death of a family member or friend, family problems, intimate relationships, other relationships, finances, health problem of a family member or partner, personal appearance, personal health issue, and other.)

*Abusive Relationship* – is a dummy variable that equals 1 if the student reports he or she is in a verbally, sexually, or physical abusive relationship in the past 12 months and zero otherwise.

*Work 10+ hours* – is a dummy variable that equals 1 if the student works 10+ hours per week and zero otherwise.

*Volunteer 10+ hours* – is a dummy variable that equals 1 if the student volunteer 10+ hours per week and zero otherwise.

#### Health Variables:

*Diagnosed depression and/or anxiety* – is a dummy variable that equals 1 if the student has been diagnosed and treated for depression and/or anxiety in the last 12 months and zero otherwise.

*Diagnosed but untreated depression and/or anxiety* – is a dummy variable that equals 1 if the student has been diagnosed for depression and/or anxiety in the last 12 months but has not been treated and zero otherwise.

*Any psychiatric diagnosis* – is a dummy variable that equals 1 if the student has been diagnosed or treated by a professional in the last 12 months for a psychiatric concern and zero otherwise. (Survey question 31 but did not include insomnia, other sleep problems, depression/anxiety, or substance abuse).

*BMI* – variable constructed using the student's reported height and weight.

*Difficult Physical Illness* – is a dummy variable that equals 1 if the student has been diagnosed or treated by a professional for physical illness and reported that they had a personal health issue that was traumatic or difficult to handle and zero otherwise.

#### Drug Use Variables:

*Cigarette User* – is a dummy variable that equals 1 if the student smokes cigarettes at least 20 out of the last 30 days and zero otherwise.

*Number of Binge Drinking* – equals the number of times in the past two weeks the student drank five or more drinks of alcohol at one sitting.

*Marijuana User* – is a dummy variable that equals 1 if the student has smoked marijuana at least once in the past 30 days and zero otherwise.

*Other drug user* – is a dummy variable that equals 1 if the student has taken other drugs (crack, sedatives, ecstasy, inhalants, etc.) at least once in the past 30 days and zero otherwise.

*Illegal Prescription User* – is a dummy variable that equals 1 if the student has taken a prescription drug that was not prescribed in the last 12 months.

## Appendix B. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.sleh.2018.07.002>.

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