



Consequences of inadequate sleep during the college years: Sleep deprivation, grade point average, and college graduation



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ABSTRACT

Sleep deprivation can have substantial consequences for college learning and achievement. However, prior studies on this topic are limited due to the reliance on small and convenience samples, the use of cross-sectional data, inadequate control for confounders, and the lack of outcome data from official school records. The present study used two waves of longitudinal data from the U.S. Wabash National Study (N = 3549) to examine the relationships between sleep deprivation and school-record grade point average (GPA) and college graduation. Random-effects and fixed-effects models were used to link sleep deprivation and GPA. Logistic regression was used to link sleep deprivation during the college years and college graduation. Results from the random-effects and fixed-effects models suggest that chronic sleep deprivation is associated with lower GPA. Students who experienced sleep deprivation from their freshman to senior years had a lower chance of graduation than students who were not sleep deprived. Furthermore, sleep deprivation during students' senior year was found to be more consequential for college graduation than sleep deprivation during their freshman year. Findings suggest that the ramifications of chronic sleep deprivation extend beyond short-term GPA; sleep deprivation predicts the likelihood of obtaining a college degree.

1. Introduction

Entering college changes many adolescents' sleep patterns. Living away from home for the first time requires college students to learn to manage their own schedules. Demands on students' time for learning, socializing, and employment coupled with stress from coursework, financial conditions, or social relationships may interfere with sleep habits and alter sleep duration (Galambos et al., 2009; Galambos et al., 2011). In fact, studies report alarming rates of insufficient sleep among college students. In a survey at a large university, Lund and colleagues (Lund et al., 2010) find that up to 70% of college students are sleep deprived, defined as obtaining inadequate sleep to support adequate daytime alertness (Hershner and Chervin, 2014). Various studies using convenience samples from different countries also show a high prevalence of inadequate sleep (Buboltz Jr et al., 2001; Tsai and Li, 2004).

Sleep deprivation, particularly chronic sleep deprivation, has numerous negative consequences. The human body requires a long period of sleep every night in order to grow muscle, repair tissue, and synthesize hormones; these vital physiological processes maintain mood, memory, and cognitive function (National Sleep Foundation, 2006). For

adolescents, the college years are when they gain critical knowledge, skills, and credentials to become successfully employed and contribute to society (Hout, 2012). When sleep deprivation occurs during the college years, it presents an obstacle to maximizing individuals' success during this critical time.

Sleep deprivation affects college outcomes through multiple mechanisms. First, sleep deprivation negatively affects learning and memory through its influences on brain and cognitive processes (Hershner and Chervin, 2014). Memory formation is dependent on sleep states. In particular, memory formation is hypothesized to be prompted by slow-wave sleep and consolidated by REM sleep (i.e., rapid eye movement sleep) (Hershner and Chervin, 2014; Stickgold, 2005). Although experimental results have not yet fully explained the biological mechanisms that link different stages of sleep to memory formation, there is convincing evidence that sleep reduction does compromise cognition and memory (Singleton and Wolfson, 2009). As such, from the neuropsychological perspective, sleep-deprived students tend to learn material less efficiently, which could lead to a lower grade point average (GPA).

Second, sleep deprivation leads to disorder in everyday life.

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Inadequate sleep reduces daytime alertness and energy, making students less likely to follow predetermined daily schedules for coursework and activities because they feel fatigued. Sleep-deprived college students may also be more likely to fall asleep during a lecture or to skip a class (Orzech et al., 2011). The disorderliness in daily life that comes from sleep deprivation can lower academic performance, which is most likely reflected in students' GPA.

As such, in the short run, sleep deprivation may lower students' GPA. However, over time, the negative impacts of sleep deprivation can compound and accumulate, resulting in a longer-term outcome of fewer credits earned. In turn, earning fewer credits can reduce the probability of receiving a college degree.

Despite the strong theoretical support for how sleep deprivation negatively affects GPA and college graduation, the empirical evidence is not conclusive. Studies that manipulate students' sleep at different education levels do reveal negative effects on short-term school performance (Curcio et al., 2006; Pilcher and Walters, 1997), but the results from observational studies remain sparse and vary. For example, many studies using convenience samples find a correlation between short sleep duration and lower GPA (Gilbert and Weaver, 2010; Kelly et al., 2001). Using data from a Portuguese university, Gomes and colleagues (Gomes et al., 2011) find an association between sleep deprivation and term GPA. And, a recent study shows that inadequate sleep remains a predictor of academic performance when the researchers control for other confounders (Taylor et al., 2013). However, some studies find no association between inadequate sleep and GPA. In a survey of 414 students, Howell, Jahrig, and Powell (Howell et al., 2004) find no association between sleep deprivation and college GPA. Another recent study performed by Nihayah and colleagues (Nihayah et al., 2011) also shows that sleep hours are not correlated with GPA. Thus, it remains unclear whether sleep deprivation predicts lower academic achievement.

A closer look at the existing studies suggests they are limited in several aspects, which likely leads to the mixed results. First, most prior studies rely on small convenience samples that select participants from introductory classes. These studies also do not consider potential confounders that may overestimate the impact of inadequate sleep on academic outcomes. Second, extant studies rely on self-reported academic outcomes such as GPA, but it has been well documented that students tend to overreport GPA (Zimmerman et al., 2002), which may result in underestimating the impact of sleep deprivation. Third, by focusing on GPA, these studies examine only the short-term education consequences and overlook a critical long-term outcome for college students: college graduation. It is safe to assume that all students want to earn a degree, and governments and policy makers all use graduation as a key indicator in evaluating academic programs and services (Lumina Foundation, 2006). As such, studies that excluding college graduation from the analysis provide only a partial picture of the consequences of sleep on academic achievement. Finally, most studies provide only a snapshot of the consequences of sleep for student achievement at one time point during the college years; no study has used large-scale longitudinal data from a probability sample of the general population of college students (Shochat et al., 2014).

These limitations of the existing literature leave many questions unanswered about sleep deprivation and academic outcomes. For example, are there times when sleep deprivation is more consequential than others? And, how does long-term sleep deprivation throughout the college years affect educational achievement? Answering these critical questions requires an analysis of longitudinal data. The present study aims to address these questions by providing a detailed analysis of the association between sleep deprivation and academic outcomes using a large sample of longitudinal data from U.S. college students.

2. Methods

2.1. Data

This study used data from the Wabash National Study of Liberal Arts Education (WNS), a longitudinal study that aims to understand the role of liberal arts education in youth development and learning. The WNS started with a brief pilot survey of a random sample of 17,000 freshmen selected from 49 different 2-year and 4-year institutions. Approximately 4500 freshmen were first contacted in the fall semester of 2006, approximately 3400 freshmen were first contacted in the fall of 2007, and another 9600 freshmen were first contacted in the fall of 2008. Students who remained at the same institutions and agreed to participate in the study again were also interviewed in the spring semester of their freshman year and the spring semester of their senior year. In addition to demographic characteristics and academic performance, the second and third waves of the WNS collected a wealth of information about students' college experiences, including their health behaviors in college, college experience, peer relationships, and health outcomes. The study thus collected three waves of data for three cohorts of freshman: (i.e., 2006–2010, 2007–2011, and 2008–2012). More information about the design of the WNS and the data collection process can be found in Loes, Pascarella, and Umbach (Loes et al., 2012).

In the final analytical sample, we used data only from wave 2 (i.e., spring of freshman year) and wave 3 (i.e., spring of senior year). We excluded data from wave 1 (i.e., the fall of freshman year) because information on financial aid and college experience was not collected in that wave. For the purpose of this study, we excluded community colleges from the final sample and excluded students with missing values for the outcome variables. In total, the study relied on a sample of 3549 students with GPA information from schools and a sample of 3870 students with graduation records from schools.

2.2. Measure of sleep deprivation

Waves 1 and 2 of the WNS included a question about college students' experience of sleep deprivation. The question asked "How often do you feel that you are 'sleep deprived' (i.e., don't get enough sleep to function effectively)?" The answer categories included never, seldom, occasionally, frequently, and almost always. This question reflects a key aspect of chronic sleep deprivation (Hershner and Chervin, 2014). Because chronic sleep deprivation in youth generates a lot of public health concern (Curcio et al., 2006), the responses on this question were recoded into a dichotomous variable of chronic sleep deprivation, with "frequently" and "almost always" coded as 1 and others coded as 0.

2.3. Officially reported academic outcomes

The present study focuses on two objective indicators of academic outcomes: GPA and graduation. In each wave, the WNS survey team obtained the student's end-of-semester GPA from the school. For graduation, the WNS survey team recorded whether the respondent graduated and obtained a degree at the end of the 4th year. Similarly, this information was directly obtained from school records. Compared to self-reported grades, these measures enable us to better estimate the impact of sleep deprivation on college student outcomes.

2.4. Covariates

In the analysis we controlled for the following demographic variables: age, gender, race, and ethnicity. We included a binary indicator of whether the respondent is an international student and whether the respondent has a dependent. To assess respondents' family socio-economic background, we used the highest level of parental education and baseline family income.

Health behaviors and personal characteristics included students'

self-rated health, current smoking status, binge drinking (defined as consuming five or more drinks in one sitting) at least once per week, frequency of physical exercise, a self-autonomy scale, and a purpose in life scale.

The questions about college experience captured key aspects of students' college life, such as the receipt of financial aid, academic engagement, and work experience while in college. First, we included dichotomous indicators of whether the student received financial aid in the survey semester. Because the WNS distinguished between grants and student loans, we created two dichotomous indicators. Students were also asked how many hours they worked per week on-campus and off-campus during the semester, as well as the number of hours they spent on studying per week. Finally, the WNS provided information from schools on how many credits each student earned that survey year and how many cumulative credits they had earned thus far.

2.5. Empirical strategy

The statistical analysis began with descriptive statistics of key variables in wave 2, which is considered the baseline because we only used data from the last two waves. Next, we used regressions to link sleep deprivation to students' outcomes. To assess the association between sleep deprivation and GPA, we started with random-effects models. Next, fixed-effects models were applied to eliminate time-invariant, unobserved heterogeneity, thus obtaining a more conservative estimate of the association. To assess the association between sleep deprivation and college graduation, we used logistic regression. For all regressions, we started with demographic control variables and gradually added indicators of health behaviors and measures of college experience. We used multiple imputations to deal with missing values in variables. Under the assumption of missing at random (MAR), multiple imputations can lead to consistent estimates (Rubin, 2004). A total of 20 imputations were created. All analysis was done using Stata 15.

3. Results

3.1. Descriptive statistics

Table 1 shows descriptive statistics for students in the spring of their freshman year (i.e., wave 2). The majority of respondents were female (63%) and approximately three-fourths of the respondents were white (74%). The mean age of students in the survey was 18 years old. On average, students' parents had 16 years of education and the mean annual family income was \$136,000. These indicators suggest that, although the WNS was not designed as a nationally representative sample of U.S. college students, the students' socioeconomic and demographic characteristics are close to those from national data (U.S. Department of Education, n.d.).

The prevalence of sleep deprivation was high. Forty-two percent of respondents reported chronic sleep deprivation in the spring of their freshman year. The average level of self-rated health was 4.28. Approximately 4% of students smoked in the past year and over 40% of students reported binge drinking in the past year. Interestingly, while the socioeconomic indicators suggested that a large number of students in the WNS were from middle- or upper-class families, many students received financial aid. For example, approximately 80% of respondents reported having a grant or scholarship and approximately 60% of students reported having student loans. On average, these students spent very few hours (i.e., less than 5 hours) working off-campus and on-campus each week. In contrast, on average students spent more than 11 hours on coursework each week.

3.2. Regression results

Table 2 presents the regression results that link sleep deprivation and GPA using the random-effects model. The first model controlled for

Table 1
Descriptive statistics of the 2006–2008 cohorts of US Wabash National Study (N = 3549).

	Mean/percentage	Standard deviation
<i>Chronic sleep deprivation</i>		
No chronic sleep deprivation	43%	
Freshman year only	15%	
Senior year only	16%	
Both freshman and senior year	26%	
<i>Demographic background (freshman year)</i>		
Age	18.05	0.60
Female	63%	
Race		
White	74%	
African American	6%	
Asian	5%	
Hispanic	5%	
Unknown	11%	
International student	2%	
Having a dependent	1%	
Highest parental education (years)	16.36	2.38
Family income (thousands)	136.14	117.36
<i>Health and lifestyle behaviors (freshman year)</i>		
Self-rated health (from 1 to 5)	4.28	0.60
Smoking	4%	
Binge drinking	44%	
Self-autonomy	4.32	0.60
Purpose in life	4.66	0.60
Frequency of physical activity per week	3.69	2.38
<i>College experience (freshman year)</i>		
Grant/scholarship recipient	80%	
Having student loan	60%	
Off-campus work per week (hours)	1.32	1.19
On-campus work per week (hours)	1.81	1.19
Time spent on studying per week (hours)	4.74	1.79
Credits earned	15.3	2.98
GPA	3.32	0.60

demographic characteristics, the second model added health behaviors and lifestyle factors, and the third model added variables related to college experience. The results show that chronic sleep deprivation was negatively associated with GPA. Furthermore, the inclusion of additional control variables such as health behaviors and college experiences did not explain the association. However, many of the associations between these control variables and GPA were in the expected directions.

Table 3 shows that chronic sleep deprivation was associated with lower GPA after the application of the fixed-effects model. A fixed-effects model eliminates the influence of time-invariant covariates (including unobserved ones) and thus better accounts for unobserved heterogeneity. However, because the fixed-effects model relies on within-individual variations, its estimates are less efficient. As Table 3 shows, the coefficients of sleep deprivation from the fixed-effects model were similar to the random-effects models. Taken together, Tables 2 and 3 suggest that chronic sleep deprivation is an important factor predicting college students' academic performance, as measured by GPA.

Next, we examined the relationship between chronic sleep deprivation and another key indicator of academic outcomes: graduation within four years. Table 4 presents the results from the logistic regressions. Model 1 shows that students who reported chronic sleep deprivation during their senior year only and during both their freshman and senior years had lower odds of graduation within four years than students who reported no chronic sleep deprivation. Specifically, those who reported having chronic sleep deprivation only during their senior year were 40% less likely to graduate, and those who reported having chronic sleep deprivation during their freshman and senior years were 25% less likely to graduate. The associations

Table 2

Longitudinal results of association between sleep deprivation and GPA, random effects using 2006–2008 cohorts of US Wabash National Study (N = 3549).

	Model 1			Model 2			Model 3		
	Coefficient	S.E.	95% CI	Coefficient	S.E.	95% CI	Coefficient	S.E.	95% CI
<i>Chronic sleep deprivation</i>	−0.08	0.02	[−0.12, −0.04]	−0.06	0.02	[−0.10, −0.01]	−0.07	0.03	[−0.12, −0.01]
<i>Demographic background</i>									
Age	−0.02	0.01	[−0.05, 0.01]	−0.02	0.01	[−0.05, 0.00]	−0.02	0.01	[−0.05, 0.00]
Female	0.16	0.03	[0.09, 0.22]	0.11	0.03	[0.05, 0.17]	0.12	0.04	[0.05, 0.19]
Race (Ref: White)									
African American	−0.36	0.07	[−0.49, −0.22]	−0.37	0.07	[−0.52, −0.22]	−0.35	0.06	[−0.47, −0.23]
Asian	−0.14	0.09	[−0.32, 0.04]	−0.13	0.09	[−0.31, 0.05]	−0.13	0.09	[−0.30, 0.05]
Hispanic	−0.16	0.06	[−0.27, −0.05]	−0.15	0.06	[−0.26, −0.04]	−0.15	0.05	[−0.24, −0.05]
Unknown	−0.02	0.06	[−0.13, 0.10]	0.00	0.06	[−0.12, 0.11]	0.00	0.06	[−0.11, 0.11]
International student	−0.10	0.19	[−0.46, 0.27]	−0.10	0.19	[−0.47, 0.26]	−0.16	0.17	[−0.48, 0.17]
Having a dependent	−0.10	0.08	[−0.26, 0.06]	−0.06	0.08	[−0.22, 0.11]	−0.03	0.09	[−0.20, 0.14]
Highest parental education (years)	0.02	0.01	[0.00, 0.04]	0.02	0.01	[0.00, 0.04]	0.02	0.01	[0.00, 0.03]
Family income (thousands)	0.00	0.00	[0.00, 0.00]	0.00	0.00	[0.00, 0.00]	0.00	0.00	[0.00, 0.00]
<i>Health behaviors and personal characteristics</i>									
Self-rated health				0.05	0.02	[0.02, 0.09]	0.05	0.02	[0.02, 0.08]
Smoking				−0.15	0.05	[−0.24, −0.06]	−0.15	0.04	[−0.24, −0.06]
Binge drinking				−0.06	0.02	[−0.11, −0.02]	−0.04	0.02	[−0.09, 0.00]
Self-autonomy				−0.03	0.02	[−0.06, 0.01]	−0.03	0.02	[−0.06, 0.01]
Purpose in life				0.11	0.02	[0.07, 0.16]	0.10	0.02	[0.06, 0.15]
Aerobic exercise				−0.02	0.00	[−0.02, −0.01]	−0.02	0.00	[−0.02, −0.01]
<i>College experience</i>									
Grant/scholarship recipient							0.18	0.08	[0.02, 0.34]
Having student loan							−0.08	0.02	[−0.13, −0.03]
Off-campus work per week (hours)							−0.01	0.01	[−0.03, 0.01]
On-campus work per week (hours)							0.01	0.02	[−0.03, 0.05]
Time spent on studying per week (hours)							0.01	0.01	[−0.01, 0.04]
Credits earned							0.01	0.01	[−0.01, 0.03]
Constant	3.38	0.33	[2.73, 4.03]	2.89	0.40	[2.11, 3.66]	2.59	0.45	[1.71, 3.47]

Table 3

Longitudinal results of association between sleep deprivation and GPA, fixed effects using 2006–2008 cohorts from US Wabash National Study (N = 3549).

	Coefficient	S.E.	95% CI
<i>Chronic sleep deprivation</i>	−0.05	0.03	[−0.11, 0.01]
<i>Health and lifestyle behaviors</i>			
Self-rated health	0.04	0.03	[−0.01, 0.10]
Smoking	−0.09	0.06	[−0.21, 0.02]
Binge drinking	0.03	0.03	[−0.02, 0.09]
Autonomy	0.00	0.02	[−0.05, 0.04]
Purpose in life	0.09	0.04	[0.00, 0.18]
Aerobic exercise	0.00	0.01	[−0.02, 0.01]
<i>College experience</i>			
Grant/scholarship recipient	0.00	0.04	[−0.08, 0.08]
Having student loan	−0.02	0.07	[−0.16, 0.11]
Off-campus work per week (hours)	0.00	0.01	[−0.02, 0.02]
On-campus work per week (hours)	0.01	0.03	[−0.05, 0.06]
Time spent on studying per week (hours)	0.00	0.01	[−0.02, 0.01]
Credits earned	0.03	0.01	[0.01, 0.04]
Constant	2.37	0.39	[1.59, 3.16]

changed very little after adding variables for health behaviors and college experience. Note that chronic sleep deprivation during freshman year only was not associated with the likelihood of graduation.

The authors conducted a number of sensitivity analyses to check the robustness of the results, including: (1) whether the association varies by gender or race/ethnicity, (2) treating sleep deprivation as an ordinal variable, and (3) using listwise deletion instead of multiple imputation. Results from the first sensitivity analysis suggest that the association between chronic sleep deprivation and academic performance did not vary by gender or race/ethnicity. The pattern of results from the second and third sensitivity analyses were similar to results in the main analysis. The results of all sensitivity analyses are available upon request.

4. Discussion

A growing number of studies have shown that biological changes during adolescence and transitions into adulthood hinder young people's sleep health. Although prior studies have documented that poor sleep negatively affects child development (i.e., Beebe, 2011), research on the consequences of sleep deprivation for college students has remained sparse. Motivated by this concern, this study takes advantage of a longitudinal design and administrative data to examine the impact of chronic sleep deprivation during the college years on GPA and college graduation. Three important findings emerge. First, consistent with findings from prior studies using convenience samples and cross-sectional data (Gilbert and Weaver, 2010; Kelly et al., 2001; Gomes et al., 2011), chronic sleep deprivation was associated with lower GPA. These results were similar in both the random-effects and fixed-effects models. Second, chronic sleep deprivation was associated with lower odds of college graduation, especially when it occurs during the senior year. Third, the associations changed very little with the inclusion of health behaviors and variables related to college experiences. This finding suggests that chronic sleep deprivation may have an independent effect on academic outcomes that does not operate through the influence on health behaviors and time use. In sum, these findings reveal that chronic sleep deprivation is an influential predictor of academic achievement among college students.

Scholars in adolescent health have long recognized the role of health in college students' performance. However, this literature has traditionally focused more on health behaviors and mental health (Buchanan, 2012). Some studies suggest that poor sleep is a pathway through which risky health behaviors and mental health affects school performance (Singleton and Wolfson, 2009). However, since the WNS provided no measures of mental health, it is up to future studies to examine the role of poor sleep in how mental illness affects academic outcomes.

The finding that sleep deprivation during senior year appears to be more important than sleep deprivation during freshman year deserves

Table 4

Results of association between sleep deprivation and graduation within four years, logistic regression using 2006–2008 cohorts from US Wabash National Study (N = 3870).

	Model 1		Model 2		Model 3	
	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
<i>Chronic sleep deprivation (Ref: None)</i>						
Freshman year only	1.06	[0.78, 1.43]	1.06	[0.77, 1.45]	1.01	[0.72, 1.40]
Senior year only	0.59	[0.43, 0.79]	0.59	[0.43, 0.80]	0.59	[0.42, 0.84]
Both freshman and senior years	0.75	[0.60, 0.93]	0.78	[0.61, 1.01]	0.71	[0.55, 0.92]
<i>Demographic background</i>						
Age	0.97	[0.92, 1.03]	0.98	[0.92, 1.04]	1.06	[0.98, 1.14]
Female	0.96	[0.69, 1.33]	0.98	[0.73, 1.33]	1.13	[0.83, 1.52]
<i>Race (Ref: White)</i>						
African American	0.29	[0.11, 0.81]	0.34	[0.12, 0.98]	0.41	[0.17, 1.03]
Asian	0.46	[0.18, 1.15]	0.51	[0.21, 1.24]	0.56	[0.25, 1.22]
Hispanic	0.61	[0.36, 1.03]	0.64	[0.38, 1.08]	0.65	[0.39, 1.06]
Unknown	1.27	[0.72, 2.26]	1.32	[0.76, 2.30]	1.24	[0.74, 2.09]
International student	2.44	[0.67, 8.89]	2.45	[0.67, 8.94]	1.68	[0.44, 6.38]
Having a dependent	0.45	[0.20, 0.99]	0.46	[0.21, 1.02]	0.50	[0.19, 1.34]
Highest parental education (years)	1.07	[1.00, 1.15]	1.07	[1.00, 1.15]	1.05	[0.99, 1.12]
Family income (thousand dollars)	1.00	[1.00, 1.00]	1.00	[1.00, 1.00]	1.00	[1.00, 1.00]
<i>Health behaviors and personal characteristics</i>						
Self-rated health (average of freshman and senior)			1.16	[0.89, 1.51]	1.13	[0.88, 1.44]
<i>Smoking (Ref: None)</i>						
Freshman			1.41	[0.58, 3.41]	1.53	[0.60, 3.93]
Senior			1.35	[0.66, 2.76]	1.24	[0.59, 2.63]
Both freshman and senior			0.79	[0.39, 1.62]	0.84	[0.42, 1.68]
<i>Binge drinking (Ref: None)</i>						
Freshman			0.91	[0.59, 1.39]	1.05	[0.62, 1.75]
Senior			1.28	[0.94, 1.75]	1.31	[0.97, 1.77]
Both freshman and senior			1.39	[1.01, 1.92]	1.54	[1.09, 2.19]
Autonomy (average of freshman and senior)			0.83	[0.71, 0.98]	0.86	[0.72, 1.03]
Purpose in life (average of freshman and senior)			1.34	[1.09, 1.65]	1.24	[0.98, 1.55]
Aerobic exercise (average of freshman and senior)			1.07	[1.01, 1.12]	1.05	[1.00, 1.12]
<i>College experience</i>						
<i>Grant/scholarship recipient (Ref: None)</i>						
Freshman					0.72	[0.35, 1.45]
Senior					0.59	[0.39, 0.90]
Both freshman and senior					1.08	[0.57, 2.05]
<i>Having student loan (Ref: None)</i>						
Freshman					0.96	[0.50, 1.86]
Senior					0.82	[0.57, 1.18]
Both freshman and senior					1.04	[0.67, 1.60]
Off-campus work per week (average of freshman and senior)					0.77	[0.69, 0.85]
On-campus work per week (average of freshman and senior)					1.50	[1.31, 1.70]
Time spent on studying per week (average of freshman and senior)					1.10	[0.98, 1.23]
Cumulative credits earned					1.01	[0.99, 1.02]
GPA in senior year					1.59	[1.02, 2.50]
Constant	4.10	[0.74, 22.81]	0.75	[0.11, 5.25]	0.01	[0.00, 0.24]

some discussion. One possible explanation for the relative importance of chronic sleep deprivation during students' senior year may be the higher concentration of required coursework in the major during their junior and senior years. Required coursework in the major often requires a higher grade to pass (i.e., a "C" or higher) than general education courses do (i.e., a "D" or higher). Thus, the negative impact of sleep during freshmen year might not greatly affect students while they are mostly taking courses in general education but does during senior year when students are trying to meet the requirements set by their majors, which in turn affects graduation.

A few limitations of the present study need to be mentioned. First, the WNS is not a nationally representative dataset so the results cannot be generalized to all U.S. college students. That said, the large sample size in the WNS and its inclusion of different types of colleges (i.e., liberal arts colleges, regional universities, flagship universities) make the results very informative in understanding how chronic sleep deprivation affects a general population of college students. As such, with regard to sample and research design, this study makes significant improvements over previous studies (i.e., Gilbert and Weaver, 2010). Second, chronic sleep deprivation was measured only twice in four

years. No information about college students' sleep between the two waves was available. As such, this study was not able to map how sleep deprivation was patterned throughout college how those patterns impacted academic outcomes. Third, while this study has the advantage of using administrative records for GPA and graduation, using graduation in the 4th year may overestimate the impact of sleep deprivation because students may finish their coursework and receive their degree in their 5th or 6th year. Fourth, some readers may be concerned about the relevance of the data given the heavy use of smartphones and social media today and their impact on college students' sleep. However, technology and social media use were prevalent when the WNS began (Rideout et al., 2010) and youth were already spending a substantial amount of time using them. Given this, results from this study remain highly relevant. Nevertheless, it must be made clear that the WNS provided no direct information on time spent with technology and social media. Future studies are needed to understand the extent to which the high prevalence of chronic sleep deprivation in college students is from their increased use of technology. Finally, even with longitudinal data and the application of a fixed-effects model, the results cannot be interpreted as causal. It remains possible that unobserved variables

could make the observed association spurious, even though we controlled for a wide range of variables. Additionally, reverse causality may be a concern. For example, it is possible that having a low GPA or feeling that one's graduation is at risk can lead to chronic sleep deprivation. Future efforts need to focus on finding exogenous variation in chronic sleep deprivation to further test the causal direction between sleep deprivation and academic outcomes.

Limitations notwithstanding, this study provides valuable insight, adding to the literature on adolescent health and its consequences in considerable ways. By examining the consequences of chronic sleep deprivation for academic outcomes, this study points out that sleep health is an influential factor that should be included in studies of educational achievement. In other words, poor sleep is not merely a symptom of depression or a marker of a disorderly lifestyles; it can also potentially affect the life course trajectory for adolescents. The study's findings also send a strong message to adolescent health practitioners and college administrators. A recent report from the American College Health Association ([American College Health Association, n.d.](#)) ranks sleep problems as second among the factors that negatively impact academic outcomes, behind stress. The findings from this study are in line with that report and suggest the need for greater investment in college students' sleep health. In doing so, schools and agencies can not only promote better health among college students but also improve their educational outcomes.

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