

SCIENTIFIC INVESTIGATIONS

Associations between insufficient sleep and prescription opioid misuse among high school students in the United States

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Study Objectives: The aim of this study was to estimate the association between insufficient sleep and prescription opioid misuse among US high school students.

Methods: Participants were 6,884 high school students who self-reported on sleep duration and prescription opioid misuse in the 2019 Youth Risk Behavior Survey. Sleep duration was categorized by the Youth Risk Behavior Survey according to the American Academy of Sleep Medicine guidelines as follows: recommended sleep duration (8–9 hours) vs insufficient sleep (< 8 hours). Participants also reported whether they had any prescription opioid misuse during their lifetime and whether they had prescription opioid misuse within the past 30 days.

Results: Most (79.4%) participants reported sleeping less than 8 hours per night. Among all youth, 12.9% reported lifetime prescription opioid misuse and 6.2% reported current prescription opioid misuse. Prevalence of both lifetime and current opioid medication misuse was higher among those also reporting insufficient sleep compared to those reporting recommended sleep duration (14.3% vs 7.7%, $P < .0001$ for lifetime misuse and 6.6% vs 4.3%, $P = .0091$ for current misuse). In multivariate models, insufficient sleep was associated with an increased odds of lifetime prescription opioid misuse (adjusted odds ratios = 1.4; 95% confidence interval, 1.1–1.2; $P = .006$); however, we did not find an association between sleep duration and current prescription opioid misuse in multivariate analysis.

Conclusions: Sleep duration is associated with lifetime opioid misuse among US youth. Longitudinal studies are needed to test whether causal relationships exist, and to understand biobehavioral mechanisms that underlie associations between sleep deficiency and opioid misuse in adolescents.

Keywords: insufficient sleep, adolescent, opioid misuse, high school students

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BRIEF SUMMARY

Current Knowledge/Study Rationale: Insufficient sleep and the opioid epidemic are 2 public health concerns affecting adolescents in the United States, yet associations between these 2 health concerns remain poorly described. This study was performed to determine whether insufficient sleep is associated with lifetime and current prescription opioid misuse using data from a large, nationally representative study designed to measure health behaviors affecting high school students in the US.

Study Impact: Compared to students who obtained the recommended sleep duration (8–9 hours per weeknight), those with insufficient sleep (< 8 hours per weeknight) had increased rates of both lifetime (14.3% vs 7.7%, $P < .0001$) and past 30 days' prescription opioid misuse (6.6% vs 4.3%, $P = .0091$ for current misuse).

INTRODUCTION

Obtaining adequate sleep is important for the overall health and well-being of adolescents,¹ including their physical, social, and psychological health. However, up to 75% of adolescents do not obtain recommended sleep duration,² defined as 8–10 hours of sleep per night by the American Academy of Sleep Medicine and National Sleep Foundation.^{3,4} Furthermore, there has been a progressive reduction in nighttime sleep duration for adolescents over the past 3 decades.⁵ According to the Youth Risk Behavior Survey (YRBS), the proportion of high school students who reported adequate sleep decreased from 31.1% to 25.4% from 2007 to 2017.⁶

Prescription opioid misuse is defined as using prescribed opioids such as oxycodone, hydrocodone, or codeine in a manner other than directed by a health care provider. This includes using opioids in greater amounts, for longer than prescribed, or from

someone else's prescription.⁷ The National Survey on Drug Use and Health documented 2.3% of adolescents (12–17 years) with prescription opioid misuse in 2019, a decrease from 2017 when 3.8% of adolescents reported prescription opioid misuse.^{8,9} Regardless of this decrease, prescription opioid misuse remains a primary driver of opioid overdose and development of opioid use disorder, contributing to an unprecedented opioid crisis currently facing adolescents in the United States.^{10,11} Indeed, of those adolescents who initiate heroin use, > 90% started with prescription opioid misuse.^{12,13}

There is increasing evidence that sleep disturbance is linked to prescription opioid misuse across the lifespan, likely due to multiple biobehavioral mechanisms. Tang et al¹⁴ found higher rates of current (past month) prescription opioid misuse among a community sample of Chinese adolescents with poor sleep quality, while we recently found increased lifetime rates of prescription

opioid misuse among adults who reported sleep disturbance during adolescence.¹⁵ However, no study has examined the associations between sleep duration and current and lifetime prescription opioid misuse in a nationally representative sample of adolescents from the United States. This represents an important gap in knowledge: A clearer understanding of the link between sleep and opioid misuse may lead to population-based public health interventions in the adolescent population.

Therefore, the primary aim of this study was to determine whether insufficient sleep is associated with prescription opioid misuse among high school students in a large nationally representative dataset in the United States. We hypothesized that insufficient sleep would be associated with increased prevalence rates of both lifetime prescription opioid misuse and current prescription opioid misuse (past 30 days). Further, we expected that these associations would remain significant after controlling for other known risk factors, including sociodemographic factors (age, sex, race, and ethnicity), depressive symptoms, experiencing violence, and other substance use behaviors, which have all been shown previously to affect both sleep and opioid misuse behaviors. A secondary aim of this study was to determine whether a dose-dependent relationship exists between sleep duration (hours of sleep per night) and the prevalence of opioid misuse in adolescents. Previous studies have found that the odds of other substance use behaviors (tobacco, alcohol, and marijuana) increase for each hour decrease in sleep duration; however, this relationship has not been described in the context of opioid misuse.¹⁶ With respect to youth in our sample, we hypothesized that each hour decrease in sleep duration on school nights would be associated with an incremental increase in rates of current and lifetime prescription opioid misuse in both univariate and multivariate analyses.

METHODS

Participants and procedure

For this analysis we used cross-sectional data from the 2019 YRBS. The YRBS is conducted every 2 years by the Centers for Disease Control and Prevention and is the largest public health surveillance system of adolescent health behavior risk factors in the United States. The YRBS uses a 3-stage cluster sampling design to produce nationally representative estimates of health behaviors (including self-reported sleep duration and prescription opioid misuse) of US public and private school students in grades 9–12 (high school in the US). Surveys are school-based: Parents give permission, and surveys are self-administered by participating youth at their schools during a single class period (time to complete is approximately 45 minutes). The overall response rate for 2019 YRBS was 60.3%. Additional information about YRBS is available at <https://www.cdc.gov/healthyouth/data/yrbs/index.htm>.¹⁷ As data were de-identified and are publicly available, our IRB deemed this study as exempt from review.

Measures

Insufficient sleep

Our primary predictor variable of interest was insufficient sleep defined as adolescent self-report of hours of sleep on an

average school night. Participants were asked, “On an average school night, how many hours of sleep do you get?” The response options were “4 or less hours,” “5 hours,” “6 hours,” “7 hours,” “8 hours,” “9 hours,” and “10 or more hours.” The YRBS then dichotomized responses, with those obtaining < 8 hours of sleep per night categorized as having insufficient sleep vs those obtaining 8 or more hours of sleep per night as having sufficient sleep. For this analysis we excluded participants who reported 10 or more hours of sleep from analyses ($n = 186$).¹⁷ Consequently, we defined those reporting 8–9 hours of sleep as obtaining “recommended sleep duration” vs those reporting < 8 hours of sleep as obtaining “insufficient sleep.” This categorization is based on guidelines from the American Academy of Sleep Medicine.

Prescription opioid misuse

Current prescription opioid misuse was defined as any prescription opioid medication misuse during the past 30 days.¹⁸ Adolescents were asked, “During the past 30 days, how many times have you taken prescription pain medicine without a doctor’s prescription or differently than how a doctor told you to use it?” with response options: “0 times,” “1 or 2 times,” “3 to 9 times,” “10 to 19 times,” “20 to 39 times,” and “40 or more times.” Participants were asked to include drugs such as codeine, Vicodin, OxyContin, hydrocodone, and Percocet. The YRBS then categorized those participants reporting “1 or 2 times” or more as current prescription opioid misusers.

Lifetime prescription opioid misuse was defined as any prescription opioid misuse during the teen’s lifetime. Participants were asked, “During your lifetime have you taken prescription pain medication without a doctor’s prescription or differently than how a doctor told you to use it?” with response options: “0 times,” “1 or 2 times,” “3 to 9 times,” “10 to 19 times,” “20 to 39 times,” and “40 or more times.” Participants were again asked to count drugs such as codeine, Vicodin, OxyContin, hydrocodone, and Percocet. The YRBS categorized those participants reporting “1 or 2 times” or more as lifetime prescription opioid misusers.

Covariates

We included covariates previously shown to be associated with both insufficient sleep and prescription opioid misuse, including sociodemographic factors (age, sex, race, and ethnicity),¹⁹ other substance use behaviors (tobacco, marijuana, alcohol),⁹ depressive symptoms,²⁰ and a history of exposure to violence (sexual violence and/or violence at school).²¹

Sociodemographics

Students were asked to self-report their age, sex, race, and ethnicity (White, non-Hispanic; Black, non-Hispanic; Hispanic; Asian, non-Hispanic; American Indian/Alaska Native; Native Hawaiian/Other Pacific Islander; and multiple race).

Alcohol, tobacco, and marijuana use

Participants who reported 1 or more episodes of alcohol use over the past 30 days were coded as having current alcohol use; those who reported 1 day or more of tobacco use were coded as having current tobacco use; those reporting marijuana use more than once over the past 30 days were coded as having current marijuana use. All 3 variables were coded as binary (0 = no; 1 = yes).

Depressive symptoms

Depressive symptoms were captured as a binary (0 = no; 1 = yes) variable in response to the question “During the past 12 months, did you ever feel so sad or hopeless almost every day for 2 weeks or more in a row that you stopped doing some usual activities?”

History of violence

Participants who responded “yes” to the question “Have you ever been forced to have sexual intercourse when you did not want to?” were categorized as having a history of sexual violence. Responses of “1 time” or more to the question “During the past 12 months, how many times has someone threatened or injured you with a weapon such as a gun, knife, or club on school property?” were categorized as having a history of experiencing violence at school. Both variables were coded as binary (0 = no; 1 = yes).

Statistical analysis plan

Analyses were conducted using Stata version 14.2 (StataCorp, College Station, TX); α was set at .05, and hypothesis testing was 2-tailed. Missing data were not imputed. We adjusted for the complex sample design of YRBS by using sampling weights, regional stratification, and primary sampling unit information to provide nationally representative estimates of high school students in the United States.

We first conducted descriptive analysis to analyze the distribution of variables in the sample.

To address our primary aim, we used Pearson chi-square analysis to compare prevalence rates of both current and lifetime prescription opioid misuse between participants with recommended sleep duration (8–9 hours) relative to those with insufficient sleep (< 8 hours). For multivariate analyses, we performed multivariate logistic regression to determine the association between insufficient sleep and current and lifetime prescription opioid misuse. Our multivariate models controlled for sociodemographics (age, sex, race, and ethnicity), depressive symptoms, other substance use behaviors (tobacco, alcohol, and marijuana use), and experience of violence (history of sexual violence and violence at school).

To address our secondary aim, we first conducted univariate analyses to compare rates of both current and lifetime prescription opioid misuse by sleep duration using Pearson chi-square analysis. Then we performed multivariate logistic regression analysis to determine whether incremental sleep loss (each hour under the recommended sleep duration of 8–9 hours) was associated with increased odds of lifetime or current prescription opioid misuse after controlling for the same covariates as listed for our primary analyses.

RESULTS

Sample characteristics

Our sample included 6,884 participants. Of these, 1,414 (weighted percentage: 20.6%) reported sleeping 8 or more hours per school night, while 5,470 (79.4%) reported insufficient sleep (< 8 hours of sleep on school nights) (Table 1). Overall, 901

(weighted 12.9%) reported 1 or more episodes of prescription opioid misuse during their lifetime, while 450 (6.2%) reported 1 or more episodes of prescription opioid misuse during the past 30 days. Most adolescents self-identified as being White, non-Hispanic (54.7%), followed by 22.1% who self-identified as being multiracial; fewer identified as being Black, non-Hispanic (8.4%); Hispanic (8.9%); and Asian (5.2%). In our sample, 33.9% reported current tobacco use, 21.3% reported current marijuana use, and 29.8% reported current alcohol use. More than one-third (37.1%) reported past-year depressive symptoms. Less than 10% reported a history of sexual violence (6.8%) or physical violence (6.3%).

Associations between insufficient sleep with lifetime and current prescription opioid misuse

Rates of lifetime and current prescription opioid misuse by average sleep duration on school nights are presented in Table 2. In univariate analyses, the rate of lifetime prescription opioid misuse was almost double (14.3%) among students reporting insufficient sleep on school nights as compared to those receiving the recommended sleep duration on school nights (7.7%, $P < .0001$). The rate of current prescription opioid misuse was 6.6% among students reporting insufficient sleep, while the rate of current opioid misuse was significantly lower (4.3%, $P = .0091$) among those reporting recommended sleep duration on school nights.

Results of multivariate analyses examining associations between current and lifetime prescription opioid misuse and average sleep duration on school nights are presented in Table 3. Similar to univariate findings, insufficient sleep was significantly associated with lifetime prescription opioid misuse (adjusted odds ratio [aOR] = 1.4; 95% confidence interval [CI], 1.1–1.2; $P = .006$), after controlling for covariates. In contrast to univariate findings, however, insufficient sleep was not associated with an increased risk of current prescription opioid misuse (aOR = 1.0; 95% CI, 0.7–1.4; $P = .85$), after controlling for covariates. Age and sex were not associated with prescription opioid misuse in either model. High school students who self-reported their race and ethnicity as Black/non-Hispanic, Hispanic, or multiracial were at increased risk for current prescription opioid misuse relative to those who self-reported as White/non-Hispanic and these associations held in multivariate analysis. In both models, current alcohol use was associated with significantly increased odds of both current and lifetime prescription opioid misuse, while current tobacco use was associated with increased odds of current use only and marijuana use was associated with lifetime use only. Those with a past-year history of depressive symptoms and of experiencing sexual assault or violence at school had increased odds for both current and lifetime prescription opioid misuse.

Rates of lifetime and current prescription opioid misuse by hours slept

In univariate analyses, the prevalence of lifetime prescription opioid misuse varied according to sleep duration in a dose-dependent fashion (Figure 1A). Among adolescents who reported sleeping 9 hours/night on school nights, the prevalence

Table 1—Baseline characteristics of participants in the 2019 Youth Risk Behavior Surveillance Survey with completed data on all variables.

	Total Sample (n = 6,884)	Weighted %	95% CI
Sleep			
Sleep 8–9 h per night	1,414	20.6	(18.9–22.5)
Sleep < 8 h per night	5,470	79.4	(77.5–81.1)
Lifetime prescription opioid misuse			
No	5,983	87.1	(85.2–88.7)
Yes	901	12.9	(11.3–14.8)
Current (past 30 d) prescription opioid misuse			
No	6,434	93.9	(92.8–94.7)
Yes	450	6.2	(5.3–7.2)
Age (mean/standard deviation)	6,884	16.0	1.25
Sex			
Male	3,326	49.7	(47.6–51.8)
Female	3,558	50.3	(48.2–52.4)
Race and ethnicity			
White, non-Hispanic	3,560	54.7	(48.8–60.4)
Black, non-Hispanic	769	8.4	(6.3–11.1)
Hispanic	572	8.9	(7.0–11.4)
Asian	375	5.2	(2.6–10.1)
American Indian/Alaska Native	47	0.4	(0.3–0.7)
Native Hawaiian/other Pacific Islander	25	0.3	(0.2–0.5)
Multiple	1,536	22.1	(18.6–26.1)
Current tobacco use			
No	4,651	66.1	(63.4–68.7)
Yes	2,233	33.9	(31.3–36.6)
Current marijuana use			
No	5,471	78.7	(76.2–81.0)
Yes	1,413	21.3	(19.0–23.8)
Current alcohol use			
No	4,891	70.2	(67.8–72.4)
Yes	1,993	29.8	(27.6–32.2)
Felt sad or hopeless			
No	4,295	62.9	(60.9–64.8)
Yes	2,589	37.1	(35.2–39.1)
Sexual assault history			
No	6,420	93.2	(92.3–94.1)
Yes	464	6.8	(5.9–7.7)
Threatened or injured with a weapon on school property			
No	6,447	93.7	(92.6–94.6)
Yes	437	6.3	(5.4–7.4)

CI = confidence interval.

of lifetime prescription opioid misuse was 6.7%, and this increased to 14.2% among adolescents who reported sleeping 6 hours/night on school nights, and to 22.1% among those reporting 4 or fewer hours of sleep ($P < .0001$). This pattern held in

multivariate analysis. Specifically, the odds of lifetime prescription opioid misuse was 1.5 times greater among those sleeping 6 hours compared to those sleeping the recommended 8–9 hours (aOR = 1.5; 95% CI, 1.1–1.9; $P = .008$), while the odds for lifetime

Table 2—Univariate analyses comparing rates of lifetime and current prescription opioid misuse between high school students reporting insufficient sleep to those who reported 8–9 hours of sleep per night.

Opioid Measure	Insufficient Sleep (< 8 h per night)		Recommended Sleep Duration (8–9 h per night)		P
	Weighted %	95% CI	Weighted %	95% CI	
Current opioid misuse	6.6	(5.7–7.7)	4.3	(3.1–6.0)	.0091
Lifetime opioid misuse	14.3	(12.5–16.3)	7.7	(5.9–9.9)	< .0001

CI = confidence interval.

prescription opioid misuse was 1.8 times greater among those sleeping 4 or less hours per night relative to those reporting 8–9 hours of sleep (aOR = 1.8; 95% CI, 1.2–2.6; $P = .002$) (Table 4).

The prevalence of current prescription opioid misuse in univariate analyses also increased as sleep hours decreased (Figure 1B). The prevalence of current prescription opioid misuse was 3% among students reporting 9 hours of sleep and increased to 11% among those reporting 4 or less hours of sleep ($P = .002$). However, in multivariate analysis this association was not observed; incremental sleep loss was not associated with an increased odds of current opioid misuse after controlling for covariates.

DISCUSSION

Using a nationally representative sample of high school students in the United States, we found that high school students with insufficient sleep on school nights (less than 8 hours of sleep per night) reported higher rates of both lifetime prescription opioid misuse and current prescription opioid misuse, relative to those who obtained the recommended 8–9 hours of sleep duration per school night. In partial support of our hypothesis, the association between insufficient sleep and lifetime prescription opioid misuse remained significant after controlling for demographic, behavioral, and psychological covariates in multivariate analyses. However, in contrast to our expectation, we did not detect a significant association between insufficient sleep and current prescription opioid misuse in our multivariate model. We also examined whether there was a dose-response relationship between sleep duration and rates of opioid misuse. As expected, we found that a sequential reduction in average hours slept on school nights was associated with an incremental increase in the rates of both current and lifetime prescription opioid misuse in univariate analyses, and this association remained significant when we examined lifetime opioid misuse in multivariate analyses. However, contrary to our hypothesis, we did not detect significant associations between sleep duration and current prescription opioid misuse after controlling for relevant covariates in multivariate analysis. These findings add to our limited understanding of associations between sleep deficiency and prescription opioid misuse in young people.

Indeed, in a previous study we found that adolescent sleep disturbances (including chronic insufficient sleep, chronic unrestful sleep, and insomnia symptoms), but not self-reported

sleep duration, were prospectively associated with the development of prescription opioid misuse in young adulthood using a sample from the National Longitudinal Study of Adolescent to Adult Health.¹⁵ Tang et al¹⁴ found increased rates of prescription opioid misuse use among a community sample of Chinese adolescents with poor sleep quality (as measured using the Chinese Pittsburgh Sleep Quality Index) in a cross-sectional analysis. Our study extends these findings to show associations between sleep duration and prescription opioid misuse in a large, nationally representative sample of high school students. Given our findings and the existing literature, it appears that multiple aspects of sleep disturbance, including quantity and quality of sleep, may be associated with prescription opioid misuse in adolescence.

Adolescence has been identified as “the perfect storm” for the development and maintenance of sleep disturbances due to developmental changes in biological circadian rhythms (ie, sleep timing shifting to later in the evening) as well as behavioral and environmental factors unique to this age group that decrease opportunity for nighttime sleep (eg, homework load, evening activities for sports/clubs, early school start times, use of electronics and social media after bedtime, and decreased monitoring and supervision from adults at night).²² Adolescence is also a high-risk period for initiating prescription opioid misuse²³ and contributors to this risk are multifactorial. For example, adolescent brain development is characterized by unequal maturation, with brain reward and pleasure-seeking centers maturing rapidly, while the prefrontal cortex, involved in executive function, only matures in adulthood.^{24,25} This unequal maturation can increase propensity for risk-taking behaviors as well as vulnerability to the positive reinforcing effects of opioids and other substances.²⁶ There are also behavioral risk factors that are shared between sleep disturbances and opioid misuse that arise or are already established during adolescence, including mental health conditions,^{20,27} history of adverse childhood experiences,^{21,28} and other substance use.^{9,29} Given the known negative outcomes associated with sleep disturbances and opioid misuse for adolescents, understanding these associations may help inform policy and clinical practice targeting improved individual health and public health.

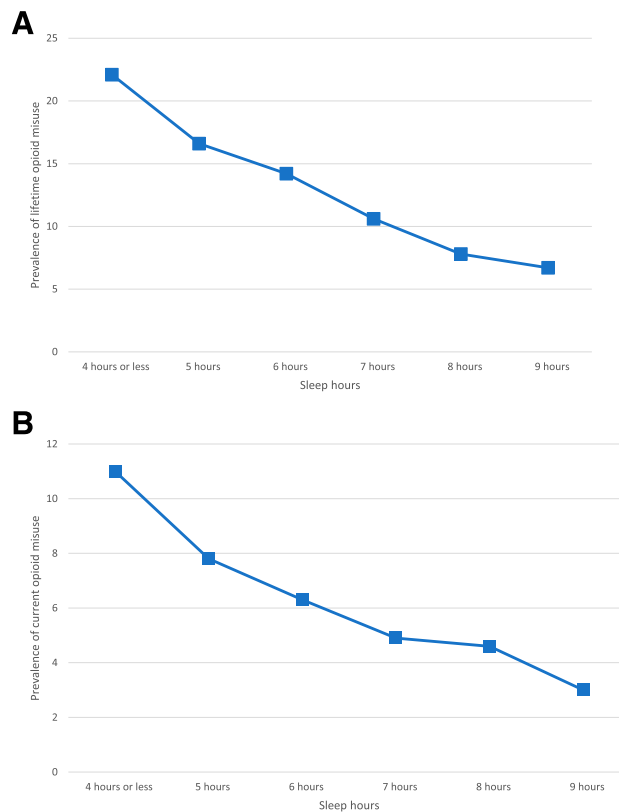
To date, potential mechanisms underlying the sleep-opioid relationship in youth have been largely unexplored. Research on the sleep-opioid relationship in adults has focused on long-term opioid therapy among individuals with chronic pain conditions. Sleep disturbances are known to reduce pain thresholds,³⁰ and

Table 3—Multivariate logistic regression analysis determining associations between insufficient sleep and both lifetime and current prescription opioid misuse.

Variables	Lifetime Prescription Opioid Misuse			Current Prescription Opioid Misuse		
	aOR	95% CI	P	aOR	95% CI	P
Sleep						
Sleeps 8–9 h per night	Ref			Ref		
Sleeps < 8 h per night	1.4	(1.1–1.2)	.006	1.0	(0.7–1.4)	.850
Age	1.0	(0.9–1)	.36	0.9	(0.8–1.1)	.238
Sex						
Male	Ref			Ref		
Female	1.0	(0.8–1.3)	.971	1.0	(0.8–1.2)	.878
Race and ethnicity						
White, non-Hispanic	Ref			Ref		
Black, non-Hispanic	1.4	(0.9–2.0)	.116	1.8	(1–3.2)	.035
Hispanic	1.0	(0.7–1.6)	.856	1.9	(1.2–3.1)	.013
Asian	1.0	(0.6–1.5)	.928	1.3	(0.8–2.3)	.322
American Indian/Alaska Native	1.5	(0.4–5.8)	.58	0.6	(0.2–2.4)	.495
Native Hawaiian/other Pacific Islander	0.6	(0.1–3.4)	.597	1.7	(0.3–9.9)	.539
Multiple race	1.3	(0.9–1.9)	.103	1.8	(1.2–2.8)	.006
Current tobacco use						
No	Ref			Ref		
Yes	1.2	(1–1.6)	.066	1.6	(1.2–2.1)	.002
Current marijuana use						
No	Ref			Ref		
Yes	1.9	(1.5–2.4)	<.0001	1.3	(1–1.7)	.059
Current alcohol use						
No	Ref			Ref		
Yes	1.7	(1.4–2.1)	<.0001	2.3	(1.7–3.1)	<.0001
Felt sad or hopeless						
No	Ref			Ref		
Yes	2.3	(2–2.7)	<.0001	2.4	(1.8–3.2)	<.0001
Sexual assault history						
No	Ref			Ref		
Yes	2.0	(1.4–2.9)	<.0001	2.0	(1.5–2.8)	<.0001
Threatened or injured with a weapon on school property						
No	Ref			Ref		
Yes	2.0	(1.5–2.7)	<.0001	1.9	(1.3–2.9)	.002

aOR = adjusted odds ratio, CI = confidence interval, Ref = reference.

Figure 1—Prescription opioid misuse by reported hours slept.



(A) Prevalence of lifetime prescription opioid misuse by reported hours slept. **(B)** Prevalence of current prescription opioid misuse by reported hours slept.

self-treatment of pain is the most commonly reported motivating factor for adolescent prescription opioid misuse.¹⁹ Adolescents may also misuse prescription opioids in order to facilitate sleep.^{31,32} A bidirectional, cyclical association is also possible, where opioid use causes sleep disturbance that subsequently triggers ongoing or increased opioid use in order to facilitate sleep and prevent withdrawal.³³ While research in adolescents is scarce, long-term opioid therapy is known to disrupt sleep architecture, reduce sleep efficiency, decrease sleep quality, and

increase daytime sleepiness among adults with chronic pain.^{34,35} Opioid use can also cause respiratory depression and contribute to the onset or exacerbation of sleep-related breathing disorders.³⁶ Recently, the American Academy of Sleep Medicine released a position statement highlighting the potential adverse effects of opioid therapy on sleep in adults.³⁷ However, similar guidance does not exist for adolescents.

Among covariates examined, we found that Black, non-Hispanic high school students reported increased rates of current

Table 4—Multivariate logistic regression analysis determining associations between insufficient sleep (number of hours sleep reported) and both lifetime and current prescription opioid misuse.

Sleep Reported	Lifetime Prescription Opioid Misuse			Current Prescription Opioid Misuse		
	aOR*	95% CI	P	aOR*	95% CI	P
8–9 h (reference)	Ref			Ref		
7 h	1.2	(0.9–1.7)	.208	0.9	(0.7–1.3)	.656
6 h	1.5	(1.1–1.9)	.008	1.0	(0.7–1.5)	.966
5 h	1.5	(1.1–2.1)	.016	1.1	(0.7–1.5)	.787
4 h or less	1.8	(1.2–2.6)	.002	1.3	(0.8–2.3)	.301

*Adjusted for age, sex, race, and ethnicity; current tobacco use; current marijuana use; current alcohol use; depressive symptoms; sexual assault; and being threatened with a weapon. aOR = adjusted odds ratio, CI = confidence interval.

prescription opioid misuse relative to White, non-Hispanic students. Historically, White, non-Hispanic adolescents have reported increased rates of opioid misuse relative to minority populations; however, other studies have found that this trend has reversed over the past few years.⁸ Our findings are consistent with recent data from the National Survey on Drug Use and Health and the Monitoring the Future survey, both of which now show that Black, non-Hispanic youth are at increased risk of prescription opioid misuse relative to other population groups.^{19,38} We also found a strong association between depressive symptoms (feeling sad or hopeless) and both lifetime and current prescription opioid misuse. Depressive symptoms are strongly correlated with both sleep disturbance and opioid misuse³⁹ among youth, reflecting overlapping neurobiology between these conditions.⁴⁰ We therefore included depressive symptoms as a covariate in multivariate analysis. However, we found that insufficient sleep is associated with lifetime prescription opioid misuse independently of depressive symptoms.

Our study also found a dose-response relationship between lifetime opioid misuse and hours of sleep on school nights, where the prevalence of lifetime opioid misuse increased as sleep duration decreased. This pattern was not replicated when we examined current opioid misuse. A prior study also found increased odds of substance use (tobacco, alcohol, and marijuana) for each hour of sleep lost in a community sample of adolescents from Fairfax County, VA.¹⁶ To our knowledge, this study is the first to demonstrate a similar dose-response relationship for lifetime opioid misuse.

It is important to point out that we did not find an association between insufficient sleep and current prescription opioid misuse in multivariate analysis. This negative finding should not necessarily be interpreted as a lack of association: It is possible that no association exists; however, it is also possible that the sample size was not large enough to detect an association (lack of power). One possible reason for finding no association between sleep and current opioid misuse is related to changes in prescription opioid misuse rates among youth in the United States over time. Rates of prescription opioid misuse declined between 2010–2019^{8,9} in response to greater awareness of the opioid crisis and reduced opioid prescribing to youth.⁴¹ This decline in opioid misuse may have resulted in weaker associations between sleep and current opioid use in our sample due to lack of power. We should also keep in mind that 2019 was the first year during which YRBS surveyed youth about current prescription opioid misuse behaviors. It is possible that associations between sleep duration and current opioid misuse will emerge once larger samples sizes from future years of YRBS are combined (eg, combining 2019 and 2021 data). Although reductions in prescription opioid misuse among adolescents are promising, it is still very important to clarify the association between sleep and opioid misuse, as rates of opioid-related overdose deaths among adolescents have continued to escalate significantly over time.¹⁰

This study has several limitations that should be considered. First, the cross-sectional design limited our ability to draw a cause-effect relationship between sleep and opioid misuse. Longitudinal data are needed to understand the potential causal relationships to better understand how sleep deprivation leads to subsequent opioid misuse. Second, both sleep and opioid misuse

were measured using single items. Sleep is a complex phenomenon that includes other dimensions, such as sleep quality, efficiency, architecture, and disturbance. Future studies should include assessment of multiple aspects of sleep, in addition to duration, and consider objective measurements using actigraphy or polysomnography. Third, when interpreting results from our study, it is important to recognize that the rates of prescription opioid misuse reported in our sample are not directly comparable to other, large nationally representative surveys (eg, the National Survey on Drug Use and Health and the Monitoring the Future study^{9,42}) due to differences in sampling procedures and survey methodology. The YRBS asked about prescription pain medication misuse, which could consist of both opioids and nonopioids (acetaminophen, nonsteroidal anti-inflammatory medications, and the gabapentinoids). However, the question provides examples of opioid or opioid-combination prescription medications only.¹⁸ Although unlikely in this community sample, it is possible that some participants reported on misuse of nonopioid pain medication, which could have inflated rates of prescription opioid misuse and led to differences between the rates of opioid misuse identified in our study compared to published data from other nationally representative surveys. Finally, the YRBS does not assess chronic pain or chronic health conditions, and therefore it is unknown if the survey participants were using opioid medication for chronic pain.

Despite these limitations, our study has several strengths that should also be considered when interpreting the data. Specific to the US adolescent population, the YRBS is the largest risk surveillance system in the United States to survey both sleep and current prescription opioid misuse. Other large databases, such as the National Survey on Drug Use and Health and Monitoring the Future, do not ask participants about sleep duration. Furthermore, using the YRBS allowed us to control for other risk factors in our analysis, allowing us to isolate the specific risk associated with insufficient sleep.

From a population health perspective, our findings, although speculative, suggest that targeting sleep has a role in reducing the impact of the opioid epidemic on adolescents. Furthermore, our findings confirm that during health care visits all adolescents, especially those with sleep disturbance, should be screened for prescription opioid misuse using validated screening tools such as the Brief Screener for Tobacco, Alcohol, and other Drugs.⁴³ Adolescent sleep disturbances may be targeted via community and/or school-based strategies, or at the individual level. Efforts to delay school start times of adolescents have been ongoing for the last decade, and education on the importance of sleep also has been promoted to a broader audience.²²

From a research perspective, there is a clear need to consider insufficient sleep in future studies aimed at understanding the development of prescription opioid misuse behaviors. Longitudinal research is needed to test whether causal relationships exist, and to understand potential mechanisms linking sleep deficiency and opioid misuse in adolescents. Ideally, studies should follow youth after a first opioid prescription, for example after surgery, and assess multiple aspects of sleep, including objective measurements of sleep using actigraphy and polysomnography.

In conclusion, we found that insufficient sleep was independently associated with prescription opioid misuse in a nationally

representative sample participating in the Youth Risk Behavior Survey. Insufficient sleep and the opioid epidemic are major public health concerns that have affected the adolescent population over the past 20 years. Given the significant impact of the opioid epidemic on public health in the United States, it is urgent that the role of sleep be elucidated.

ABBREVIATIONS

aOR, adjusted odds ratio

CI, confidence interval

YRBS, Youth Risk Behavior Survey

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