

The Wake-Up Call: The Repercussions of Short Sleep Duration on Adolescents

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ABSTRACT

Nearly eight in ten US teenagers do not sleep the recommended 8 to 10 hours per night. Short sleep duration is correlated with poor health and academic performance. We sought to determine if the average amount of sleep varied across high school grade levels and whether modifiable risk factors were linked with less sleep. Our study utilized nationally representative data from 20,103 high school-aged respondents surveyed in the 2023 Youth Risk Behavior Surveillance System. We fit a weighted linear regression model; the outcome was the quantity of sleep on an average school night. Covariates included socio-demographic, psychosocial, and school-related variables. Compared to 9th graders, 10th graders slept 0.21 hours less (95% confidence interval [CI]: 0.11 to 0.31 hours), 11th graders slept 0.24 hours less (95% CI: 0.14 to 0.34 hours), and 12th graders slept 0.36 hours less (95% CI: 0.26 to 0.46 hours). Compared to those who reported never experiencing poor mental health over the past month, those reporting sometimes slept 0.36 hours less (95% CI: 0.24 to 0.48 hours), and those who reported always slept 0.83 hours less (95% CI: 0.64 to 1.0 hours). Our results directly inform policies, like limiting the number of Advanced Placement courses a student can take, reducing homework, and delaying school start times to increase the number of students who receive adequate sleep. If adolescents can gain the recommended sleep with policies that mitigate deprivation, their overall well-being could improve.

INTRODUCTION

Adolescents aged 13 to 18 years old are recommended to sleep 8 to 10 hours each night by the Centers for Disease Control and Prevention (CDC)¹. Most teenagers do not adhere to this recommendation. Among US high school students, the prevalence of short sleep duration (i.e., <8 hours per night) increased from 69.1% in 2009 to 77.0% in 2021 (a 11.4% relative increase)^{2,3}.

Chronic short sleep duration can cause serious physical and mental health issues. For example, it can lead to obesity and weight gain, in part, through changes in the hypothalamus⁴⁻⁶. Owens (2014) found a dose-response relationship among the amount of sleep an adolescent receives and the risk of developing obesity⁷. Chronic short sleep duration also contributes to impaired cardiac autonomic balance and high blood pressure⁵. Chronic short sleep duration adversely impacts the inflammatory response released by the immune system when fighting an infection⁸. Inadequate sleep also leads to several other serious

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effects. These include faster biological aging in adolescents (detectable in their DNA), increased risk of developing asthma, and thinning of the brain cortex, which can disrupt brain function^{9–11}.

Serious mental health symptoms, including depression and schizophrenia, can be caused by short sleep duration¹². Insufficient sleep is correlated with a higher risk of depression^{12–15}. The risk of suicidal ideation and suicidal planning also increases as adolescents sleep less¹⁶. Weaver et al. (2018) found the risk of suicidal behavior increased threefold as sleep decreased from more than 8 hours to less than 6 hours¹⁷.

Insufficient sleep also affects academic performance in school by impairing neurocognition. Short sleep duration impairs adolescents' learning abilities, including focus, memory, and higher-order thinking^{18,19}. This impairment occurs as sleep is crucial for memory consolidation, concentration, and problem-solving¹⁹. Between the amount of sleep an adolescent receives and students' neurocognitive abilities, a dose-response relationship can be found²⁰. Those who reported sleep deprivation and daytime sleepiness failed more classes and had higher odds of receiving lower grades^{21,22}.

Insufficient sleep is also associated with an increase in high-risk behaviors. These behaviors include not wearing a helmet while biking, infrequently using a seatbelt, riding with drunk drivers, and drunk driving²³. Furthermore, adolescents with short sleep duration or inconsistent sleep schedules are more likely to consume full drinks of alcohol and participate in binge drinking^{24,25}. A lack of sufficient sleep in teenagers led to an increase in underage marijuana use and smoking^{24–26}. Short sleep duration also increases the risk of distracted driving. Short sleep duration impairs adolescents' neurocognitive abilities, affecting concentration and decision-making. This leads to an increase in teens who may get into motor vehicle accidents due to engaging in risky behaviors by running more yellow lights, texting while driving, drunk driving, or getting into a vehicle with a drunk driver^{23,25,27}. Violent behaviors are also furthered with insufficient sleep, as adolescents who have a chronic lack of sleep are more likely to bring weapons to school, participate in fights, and exhibit school-related violent behaviors^{25,28}.

While there are a myriad of consequences and risks that arise due to short sleep duration, there are numerous benefits of receiving sufficient sleep. Sufficient sleep improves an adolescent's overall health and emotional well-being^{29,30}. Physical health benefits are particularly notable. Adolescents have lower adiposity indicators, meaning they have lower levels of body fat and better metabolic health^{29,30}. They also experience lower cholesterol and blood pressure, along with improved weight regulation³⁰. Mental health, neurocognitive skills, and emotional regulation are also improved with sufficient sleep. Regarding mental health, obtaining sufficient sleep can help improve anxiety and depression³¹. Another benefit of receiving sufficient sleep is improved academic performance compared to those with inadequate sleep. Students with earlier bedtimes achieve better grade point averages (GPAs) than those who have insufficient or inconsistent sleep schedules³².

Many studies on the consequences of sleep deprivation among US teenagers consider high school students as a single population rather than assessing the prevalence of short sleep deprivation by school

grade and age. Some studies examine non-modifiable risk factors such as race and sex; however, few studies assess modifiable risk factors associated with the number of hours slept each night. Our study utilizes nationally-representative data from the US CDC Youth Risk Behavior Surveillance System 2023. We ascertain how the average level of sleep changes across school grades. We also consider an expansive scope of socio-demographic, behavioral, and health-related correlates of sleep duration. Of note, we consider the potential association between the usual location of sleep and average sleep duration. We also consider exposure to violence, mistreatment, and trauma that adolescents face at school, at home, or in their neighborhood. These adverse events may affect their feelings of security and directly lead to reductions in sleep. Past studies also do not necessarily focus on or acknowledge the potential causes of short sleep duration, but rather concentrate on its consequences. We hypothesize that a higher grade level in school will be associated with less average amount of sleep. We also hypothesize that a higher frequency of poor mental health will be associated with a lower average amount of sleep.

METHODS

Data: Our study utilized data from the 2023 Youth Risk Behavior Surveillance System (YRBSS), which is conducted biennially by the CDC³³. From US public and private schools, students in 9th to 12th grade were given the YRBSS, which contains 107 questions. The questionnaire for 2023 was also expanded from previous surveys to address new topics such as social media use, racism experienced at school, consent, transgender identity, and traumatic childhood events. There were two components of the 2023 YRBSS: the main sample for nationally representative data and a supplemental sample to increase the American Indian/Alaskan Native (AIAN) respondents³³. For the main survey, the CDC started with 1257 PSUs (Primary Sampling Units) and then selected 60 PSUs after categorizing them based on urban and rural locations and the percentage of Black and Hispanic students³³. They chose 180 schools from the PSUs and added 20 small schools to sample 200 schools, and chose 1 to 2 classes in every grade to survey³³. For the supplemental survey, the CDC began with the same 1257 PSUs but selected 55 based on the highest enrollment of AIAN students³³. The 55 PSUs resulted in 114 schools and ended up with 2 classrooms per grade surveyed³³. This design of the survey ensured that it was nationally representative of all students across the US.

Our outcome was the quantity of sleep on an average school night. Respondents could answer 4 or fewer hours, 5 hours, 6 hours, 7 hours, 8 hours, 9 hours, or 10 or more hours. Covariates spanned numerous socio-demographic, psychosocial, and school-related variables. Socio-demographic covariates included grade in school, sex, race/ethnicity, and usual location of sleep. Psychosocial covariates included a respondent witnessing someone being physically attacked, beaten, or stabbed in their neighborhood; being forced into sexual acts in the past 12 months; being bullied electronically in the past year; seriously considering suicide in the past 12 months; the frequency of social media use; and the frequency of poor mental health over the past month. School-related factors included feeling unsafe on the way to or from school in the past month, being threatened with a weapon on school property in the past year, being mistreated at school due to the respondent's race/ethnicity, and being bullied on school property. See

Appendix Table 1 for details of the specific survey questions and levels for the outcome and each covariate.

Although both followed the same process, the 2023 YRBSS sample weight was determined separately from the main sample and the supplemental data. Weight was placed on the respondent's sex, race and ethnicity, and grade in school³³. The final survey weights were a calculation of the combination of the two weighted data samples, which were concatenated³³. The final weights were then scaled to equalize the weighted number of students to the overall sample size, and the weighted students in each grade to the national population's weight³³.

Statistical Analysis: First, we calculated the distribution of the sample by socio-demographic, psychosocial, and school-related characteristics. Second, we calculated the weighted mean hours of sleep on an average school night by each characteristic. Third, we fit a weighted linear regression model; the outcome was the number of hours of sleep on an average school night, and the covariates included the socio-demographic, psychosocial, and school-related characteristics. We utilized R version 4.5.1 for all statistical analyses. We set the type I error rate at 5%.

RESULTS

Characteristics of the Sample: Our sample consisted of N = 20,103 respondents across four grade levels: 29.0% of respondents in 9th grade, 27.0% of respondents in 10th grade, 24.0% of respondents in 11th grade, and 20.0% of respondents in 12th grade (Table 1). The sample was evenly split by gender (50.0% female, 50.0% male). The racial/ethnic composition was as follows: 49.0% of respondents were non-Hispanic White, 20.0% of respondents were Hispanic, 9.2% of respondents were non-Hispanic Other, 9.1% of respondents were non-Hispanic Black, 6.8% of respondents were non-Hispanic American Indian/Alaskan Native (AIAN), 5.0% of respondents were non-Hispanic Asian, and 0.5% respondents were non-Hispanic Native Hawaiian/Other Pacific Islander (NHOPI). Additionally, 12.0% of the respondents did not attend school in the past month due to safety concerns during travel to or from school. Furthermore, 9.5% of respondents were threatened with a weapon on school property in the last year. In our sample, 24% of respondents reported having seen someone be physically attacked, beaten, stabbed, or shot in their neighborhood. Additionally, 12.0% of the respondents in the survey reported being forced to engage in sexual activities in the past 12 months. Our sample had 31.0% of respondents report feeling they were treated badly or unfairly in school because of their race/ethnicity. Regarding bullying experiences, 20.0% of respondents reported being bullied on school grounds, while 17.0% of respondents reported electronic bullying. In our sample, 21.0% of respondents reported having seriously considered attempting suicide in the past 12 months. Social media usage varied across the sample: 7.1% of respondents reported no social media use, 15.0% used it a few times a month to about once a day, and 78.0% used it several times a day to more than once an hour per day. Mental health experiences in the past 30 days were distributed as follows: 18.0% never experienced poor mental health, 21.0% rarely,

30.0% sometimes, 22.0% most of the time, and 9.1% always. Finally, regarding usual sleep location in the past 30 days: 97.0% slept in their parents' or guardians' homes, while 3.5% slept elsewhere.

Sleep Duration on Average School Night by Characteristics: The average hours of sleep on an average school day decreased as the respondents grade's increased: 6.7 hours for 9th graders (95% CI: 6.7 to 6.8), 6.5 hours for 10th graders (95% CI: 6.4 to 6.5), 6.4 hours for 11th graders (95% CI: 6.4 to 6.5), and to 6.4 hours for 12th graders (95% CI: 6.3 to 6.4; Table 2 & Figure 1). The average hours of sleep reportedly varied by the sex of the respondents: 6.6 hours for male respondents (95% CI: 6.5 to 6.6) to 6.5 hours for female respondents (95% CI: 6.4 to 6.5). The average hours of sleep varied by race/ethnicity: 6.8 hours for non-Hispanic AIAN (95% CI: 6.4 to 7.3), 6.6 hours for non-Hispanic White (95% CI: 6.5 to 6.6), 6.6 hours for non-Hispanic NHOPI (95% CI: 6.0 to 7.0), 6.5 hours for Hispanic (95% CI: 6.5 to 6.6), 6.3 hours for non-Hispanic Asian (95% CI: 6.2 to 6.5) to 6.3 hours for non-Hispanic Other (95% CI: 6.1 to 6.4), and 6.3 for non-Hispanic Black (95% CI: 6.2 to 6.3). Finally, the average hours of sleep were higher among those who reported their usual location of sleep as their parents' or guardians' home compared to those who did not: 6.5 hours (95% CI: 6.5 to 6.6) versus 5.9 (95% CI: 5.7 to 6.1), respectively.

The average hours of sleep decreased as a respondent witnessed someone in their neighborhood being physically attacked, beaten, or stabbed: 6.6 hours for those who reported they have not seen violence toward others in their neighborhood (95% CI: 6.6 to 6.7) to 6.2 hours for those who have seen violence towards others in their neighborhood (95% CI: 6.1 to 6.3). The average hours of sleep decreased as a result of being forced to engage in sexual activity in the past 12 months: 6.6 hours for those who have not been forced to engage in sexual activity in the past year (95% CI: 6.5 to 6.6) to 6.1 hours for those who have been forced (95% CI: 6.0 to 6.2). The average hours of sleep decreased as the respondent reported being electronically bullied in the past 12 months: 6.6 hours for those who have not been electronically bullied in the past year (95% CI: 6.5 to 6.6) to 6.2 hours for those who have been electronically bullied in the past year (95% CI: 6.1 to 6.3). The average hours of sleep decreased as the respondent seriously considered committing suicide in the past 12 months: 6.6 hours for those who reported they were not seriously considering suicide (95% CI: 6.6 to 6.7) to 6.0 hours for those who reported they were seriously considering suicide (95% CI: 5.9 to 6.1). The average hours of sleep decreased as the frequency of social media use increased: 6.6 hours for those who reported they do not use social media (95% CI: 6.5 to 6.8) to 6.6 hours for those who reported they use social media a few times a month to about once a day (95% CI: 6.5 to 6.7) to 6.5 hours for those who reported they use social media several times a day to more than once an hour (95% CI: 6.4 to 6.5). Finally, the average hours of sleep decreased as the frequency of poor mental health over the past month increased: 6.8 hours for those who reported never experiencing poor mental health over the past month (95% CI: 6.8 to 6.9), 6.5 hours for those who reported sometimes experiencing poor mental health over the past month (95% CI: 6.5 to 6.6), and 5.9 hours for those who reported always experiencing poor mental health over the past month (95% CI: 5.8 to 6.1; Figure 2).

The average hours of sleep decreased as a respondent reported not attending school due to feeling unsafe on the way to and from school in the past month: 6.6 hours for those who reported not feeling unsafe (95% CI: 6.5 to 6.6) to 6.2 hours for those who reported they did feel unsafe on the way or to from school

in the past month (95% CI: 6.1 to 6.3). The average number of hours of sleep decreased as the respondent was threatened with a weapon on school property in the past year: 6.5 hours for those who reported they were not attacked with a weapon on school property (95% CI: 6.5 to 6.6) to 6.1 hours for those who reported they were attacked with a weapon on school property (95% CI: 6.0 to 6.3). The average hours of sleep decreased as the respondent was mistreated at school due to their race/ethnicity: 6.6 hours for those who did not report being mistreated at school due to their race/ethnicity (95% CI: 6.5 to 6.6) to 6.3 for those who reported they have been treated unfairly at school due to their race/ethnicity (95% CI: 6.3 to 6.4). Finally, the average hours of sleep decreased as the respondent was being bullied on school property: 6.6 hours for those who reported not being bullied on school property (95% CI: 6.5 to 6.6) to 6.2 hours for those who reported being bullied on school property (95% CI: 6.2 to 6.3).

Regression Results: The hours slept on an average school night decreased with grade in high school (Table 3). Compared to 9th graders, 10th graders slept 0.21 hours less (95% CI: 0.11 to 0.31 hours; p -value = <0.001), 11th graders slept 0.24 hours less (95% CI: 0.14 to 0.34 hours; p -value = <0.001), and 12th graders slept 0.36 hours less (95% CI: 0.26 to 0.46 hours; p -value = <0.001). The hours slept on an average school night decreased between different sexes. Compared to females, males slept 0.11 hours less (95% CI: 0.04 to 0.19 hours; p -value = 0.004). The hours slept on an average school night decreased within race/ethnicities. Compared to non-Hispanic Whites, Hispanics slept 0.10 hours less (95% CI: 0.01 to 0.19 hours, p -value= 0.031), non-Hispanic Blacks slept 0.38 hours less (95% CI: 0.26 to 0.50 hours, p -value= <0.001), and non-Hispanic Asians slept 0.42 hours less (95% CI: 0.22 to 0.62 hours, p -value= <0.001). Finally, the average hours slept on a usual school night decreased as the integrity of the usual location of sleep in the past 30 days decreased. Compared to those who slept in their parents' or guardians' home, respondents who reported other slept 0.29 hours less (95% CI: 0.01 to 0.58 hours; p -value = 0.044).

Average sleep hours on school nights decreased among respondents who witnessed neighborhood violence (physical attacks, beatings, stabbings, or shootings). Compared to those who reported they had not witnessed someone be physically attacked, beaten, stabbed, or shot in the neighborhood, those who reported that they had slept 0.21 hours less (95% CI: 0.12 to 0.31 hours; p -value = <0.001). The average hours of sleep decreased on a usual school night as the respondent reported being forced to engage in sexual activity in the past 12 months. Compared to those who had not been forced to engage in sexual activities in the past year, those who had reported they had been forced to engage in sexual activities slept 0.17 hours less (95% CI: 0.04 to 0.29 hours; p -value = 0.009). The average hours of sleep decreased as the respondents reported seriously considering attempting suicide in the past 12 months. Compared to those who reported they had not seriously considered attempting suicide in the past year, those who reported that they had slept 0.31 hours less (95% CI: 0.21 to 0.42 hours; p -value = <0.001). The average hours of sleep decreased as the frequency of social media use increased. Compared to those who reported they did not use social media, those who reported they used social media several times a day to more than once an hour slept 0.19 hours less (95% CI: 0.02 to 0.37 hours; p -value = 0.030). Finally, the average hours of sleep decreased as the frequency of poor mental health in the past 30 days increased. Compared to those who reported 'never' experiencing poor mental health over the past month, those who reported

‘rarely’ slept 0.17 hours less (95% CI: 0.05 to 0.29 hours; p-value = 0.005), those reporting ‘sometimes’ slept 0.36 hours less (95% CI: 0.24 to 0.48 hours; p-value = <0.001), those reporting most of the time slept 0.63 hours less (95% CI: 0.5 to 0.77 hours; p-value = <0.001), and those who reported always slept 0.83 hours less (95% CI: 0.64 to 1.0 hours; p-value = <0.001)

DISCUSSION

Three central findings emerged from this nationally representative analysis of US adolescents. First, the total hours slept on an average school night decreased as the grade level in high school increased. Second, the number of hours slept varied by race/ethnicity. Third, the number of hours slept decreased as the frequency of poor mental health within the last month increased.

Our study supports the findings of previous literature, including the occurrence of short sleep duration (i.e., <8 hours) among US adolescents. According to the CDC, the relative occurrence of short sleep duration among US high school students in 2021 was 77.0%². Ming et al. (2011) also found that many US students slept fewer than 8 hours per night on average school nights: 12.6% of students slept 5 or fewer hours, 31.0% of students slept 5.5-6.5 hours, and 50.6% slept 7-8 hours³⁴. These findings align with ours, as they also found that a large proportion of students did not receive adequate sleep on school nights.

Our study also aligns with previous findings on racial/ethnic differences. In many studies, Blacks were found to be at greater odds of sleeping significantly less when compared to Whites³⁵. For example, Bohnert et al. (2025) found Black teens experience poorer sleep in terms of duration than their white non-Hispanic peers, with an average of 6 hours of sleep per night³⁶. Hispanic teens were also found to have experienced inadequate sleep. Neighborhoods with high crime and loud environmental noises due to socioeconomic conditions, and the practice of cultural traditions such as co-sleeping with family, are factors that may lead to inadequate sleep in Hispanic teens³⁷. Additionally, Guglielmo et al. (2017) found that Black teens sleep, on average, less than Hispanic teens and sleep worse overall based on measurements of sleep duration, sleep/wake problems, and bedtime/sleep onset³⁵. These studies connect to our study as they also investigated the decrease in the average hours slept across race and ethnicity. In our study, we found that non-Hispanic Blacks and Hispanics slept 6.3 hours and 6.5 hours on average, respectively, in comparison to non-Hispanic Whites who slept 6.6 hours per night.

Previous literature has found gender-based differences in the number of hours slept per night. According to the CDC, 80% of females in 2021 slept less than 8 hours compared to 75% of males². Numerous other studies have reached similar conclusions regarding teenage girls being more likely to experience sleep deprivation than teenage boys^{38,39}. Our study aligns with these previous findings: females slept 6.5 hours per school night on average, compared to 6.6 hours per school night on average for males.

Additionally, our study aligns with prior literature on the correlation between exposure to stressful situations and traumatic events and short sleep duration. Traumatic events likely lead to disrupted sleep,

insufficient sleep, and sleep deprivation⁴⁰⁻⁴³. For example, female adolescent survivors of domestic minor sex trafficking reported having insufficient sleep⁴³. Those with childhood trauma (e.g., parents' divorce, emotional abuse, or sexual abuse) also experience sleep deprivation^{41,42}. These findings are similar to those of our study, as we also concluded that trauma was associated with insufficient sleep.

We also note several important differences between the findings of our study and the literature. First, the average number of hours that US high school students slept decreased by grade level. Many studies on the occurrence of short sleep duration among US adolescents did not consider individual grade level^{10,44,45}. The prevalence by grade level is significant in understanding how teenagers may be differentially affected by sleep deprivation across high school. Our study advances this finding and concludes that the average number of hours slept per night decreased across grade levels in high school.

Teens who did not sleep in their parents' or guardians' home slept significantly less than their counterparts who did. The decrease in the average number of hours slept suggests the importance of housing security for adolescents. Secure housing provides a sense of safety and prevents students from worrying where they may have to sleep next, allowing students more time to sleep compared to their counterparts who do not have a strong housing situation⁴⁶. We found adolescents who sincerely considered attempting suicide in the last 12 months and reported poor mental health also slept significantly less than their counterparts who did not. Depression and anxiety are associated with short sleep duration¹²⁻¹⁴. Negative emotional states (e.g., depression) can also be associated with short sleep duration. For example, depressive moods⁴⁷. Adolescents with eating disorders, psychosis, and trauma have also been found to experience more fragmented sleep, which can lead to insufficient sleep⁴⁸.

A biological factor that leads to short sleep duration is a shift in the circadian rhythm, which causes melatonin to be released later in the night⁴⁹⁻⁵¹. The delay in the production of this hormone causes teenagers to lose more sleep as they fall asleep later. Due to falling asleep later because of the circadian rhythm, their biological wake times also shift to a later time, causing early school start times to lead to short sleep duration⁵⁰.

Academic pressure that students experience with school and work demands may affect sleep duration. With high homework loads, students reported being sleep-deprived, as many felt the need to sacrifice their sleep for studying and finishing assignments^{38,52,53}. Busy schedules, including extracurriculars such as a sport, club, or work to provide for their families or save money for college, can lead to homework starting late at night⁵³. It can also lead to late-night studying and further sleep deprivation due to early school starts. Jin and Shi (2008) found that sleep deprivation was associated with Advanced Placement (AP) courses, as those who took an AP class were found to sleep on average about 20 minutes less per night⁵⁴. For example, 9th to 10th graders slept 1 hour to 40 minutes less, respectively, with one AP class, and those who took 2 or more slept 1 hour and 30 minutes less, respectively.

Societal pressure and social media also impede a student's ability to sleep sufficiently. The ability to choose when an adolescent can sleep and societal pressure to gain independence can play a role in the

development of a habitually late bedtime⁵⁵. Numerous studies found that social networking late at night was associated with sleep deprivation as adolescents sacrificed sleep to communicate with their friends online or by spending time with them^{53,55}. Teenagers also found themselves experiencing peer pressure to pull all-nighters with their friends due to fear of missing out, ‘FOMO’, which caused insufficient sleep⁵⁵. Social media is also a huge factor in why many adolescents lose sleep. The American Academy of Sleep Medicine conducted a survey that found 93% of Generation Z lost sleep due to interacting with social media⁵⁶. The average number of hours using an electronic device and social media was 7 hours and more than 2 hours, respectively, leading to the finding that a third of adolescents slept 6 hours or less⁵⁷. Electronic devices emit blue light that is useful in the day to help with alertness, but at night, disrupts the brain’s production of melatonin and the circadian rhythm⁵⁸. It decreases melatonin production and increases alertness, making it challenging for adolescents to go to sleep on time. TikTok, a popular social media platform among adolescents, was found to have addictive properties as its 15 to 60-second videos stimulate the reward system in the brain by releasing a short dose of dopamine⁵⁹. The short releases of dopamine create an addiction to the TikTok algorithm and make it difficult for adolescents to choose to go to sleep, which causes insufficient sleep⁶⁰.

Our results directly inform school-, district-, state-, and national policies. Limiting the number of AP courses a student can take in a year has been an improvement that some school districts have implemented. For example, Harvard-Westlake School (private) in California announced AP class caps beginning in 2022⁶¹. In California, Gunn High School (public) and Palo Alto High School (public) both suggest a maximum of 2 AP classes per semester^{62,63}. New Trier High School (public) in Illinois doesn’t allow 9th and 10th grade students to take AP courses and restricts enrollment for juniors and seniors⁶⁴. The Meadows School (private) in Nevada restricts students to 4 AP classes a year⁶⁵. Stuyvesant High School (public) in New York City uses GPA-based AP enrollment limits⁶⁶. These schools established restrictions to protect students’ overall well-being since excessive AP courses can be disruptive to an adolescent’s mental health and sleep. These limitations support national efforts to reduce sleep deprivation among US high school students by preventing academic overload and encouraging sufficient sleep.

Many school districts have adopted a rule that recommends the number of minutes a student should spend doing homework per night⁶⁷. The National Parent Teacher Association and National Education Association support the popular “10-minute rule”⁶⁸. The rule is used by multiplying the child’s grade by 10 to determine how many minutes of homework they should be assigned a night. For example, 2nd graders should receive about 20 minutes of homework nightly, while 12th graders should receive about 120 minutes of homework. The majority of school districts have incorporated it into their policies, pushing for students not to spend their whole night doing homework. Lafayette Parish Public Schools in Louisiana went further by implementing a policy that eliminates homework grading from 2nd grade to 12th grade⁶⁹. While the motivation for the rule differed across schools, it still helps reduce student stress over nightly homework loads and decreases sleep sacrificed over academic work.

Another policy that has been recently developed is delayed school start times among US high schools. Two states, California and Florida, have created mandates requiring high schools to delay early start times

to improve student well-being. California became the first state to mandate later start times in 2022⁷⁰. Middle schools cannot begin before 8:00 a.m., and high schools cannot begin before 8:30 a.m. under this law. Florida enacted a similar law that must be implemented by July 2026⁷¹. Estimates say that 1,000 to 2,000 school districts across the country have moved their school start times to 8:30 a.m., the recommended start time from the American Medical Association⁷¹. These changes across the country demonstrate the progressive efforts to improve student health. Such actions help reduce the number of students experiencing insufficient sleep in US high schools.

We note several strengths. First, our study utilized data from the YRBSS, a nationally representative survey of teenagers around the country. The survey was compiled of respondents with various backgrounds, such as different racial/ethnic groups, geographic locations, and socioeconomic status. This allowed our study to be more representative when compared to a larger population. Second, a focal point of our study is the finding of the average number of hours grade levels slept per night on an average school night. In most studies, adolescents aged 13-18 are considered as one population. We focused on individual grade levels separately. Third, we also assessed a wide range of socio-demographic, psychosocial, and school-related correlates. For example, we were able to identify an association between worsening mental health and a decrease in sleep duration.

We also note several important limitations. First, the YRBSS relies on respondents' self-reporting of sleep duration, which may be subject to recall bias. Second, the YRBSS did not assess the quality of sleep received.

CONCLUSION

In conclusion, our study found that a substantial number of US high school students did not obtain the recommended 8 to 10 hours of sleep per night. Despite the many harmful consequences associated with short sleep duration, national acknowledgment is not extensive. However, if adolescents can receive the advised hours of sleep per night with the creation of more school, school district, state, and federal policies that mitigate the risk of sleep deprivation, they could improve their overall mental and physical well-being.

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APPENDIX

Table 1. Sample Characteristics

Characteristic	N = 20,103 ¹
Grade	
9	5,680 (29%)
10	5,410 (27%)
11	4,811 (24%)
12	3,961 (20%)
Sex	
Female	9,884 (50%)
Male	10,061 (50%)
Race/Ethnicity	
Non-Hispanic White	9,700 (49%)
Hispanic	3,994 (20%)
Non-Hispanic AIAN	1,334 (6.8%)
Non-Hispanic Asian	995 (5.0%)
Non-Hispanic Black	1,791 (9.1%)

Non-Hispanic NHOPI	105 (0.5%)
Non-Hispanic Other	1,814 (9.2%)
Did not go to school because felt unsafe on way to or from school, past month	2,301 (12%)
Threatened with a weapon on school property, past year	1,714 (9.5%)
Physically attacked, beaten, stabbed in neighborhood	3,495 (24%)
Forced sexual activity, past 12 months	1,840 (12%)
Felt treated badly or unfairly in school because of race/ethnicity	5,756 (31%)
Bullied on school property, past 12 months	4,046 (20%)
Electronically bullied, past 12 months	3,423 (17%)
Ever seriously consider attempting suicide, past 12 months	4,214 (21%)
Frequency of social media use	
I do not use social media	1,082 (7.1%)
A few times a month to about once a day	2,249 (15%)
Several times a day to more than once an hour	11,872 (78%)
Mental health not good, past 30 days	
Never	2,838 (18%)
Rarely	3,308 (21%)
Sometimes	4,751 (30%)
Most of the time	3,377 (22%)
Always	1,431 (9.1%)
Usual location of sleep, past 30 days	
In my parent's or guardian's home	13,851 (97%)
Other	498 (3.5%)

^an (%)

Note: AIAN=American Indian/Alaskan Native; NHOPI=Native Hawaiian/Other Pacific Islander.

Table 2. Average Duration of Sleep by Characteristic

Characteristic	Mean	Lower 95% CI	Upper 95% CI
Grade			
9	6.7	6.7	6.8
10	6.5	6.4	6.5
11	6.4	6.4	6.5
12	6.4	6.3	6.4
Sex			
Female	6.4	6.4	6.5
Male	6.6	6.5	6.6
Race/Ethnicity			
Non-Hispanic White	6.6	6.6	6.6
Hispanic	6.5	6.5	6.6
Non-Hispanic AIAN	6.8	6.4	7.3
Non-Hispanic Asian	6.3	6.2	6.4
Non-Hispanic Black	6.3	6.2	6.4
Non-Hispanic NHOPI	6.5	6.0	7.1
Non-Hispanic Other	6.3	6.1	6.4
Unsafe At School			
No	6.5	6.5	6.6
Yes	6.2	6.1	6.3
Threatened Injured With Weapon			
No	6.5	6.5	6.6
Yes	6.1	6.0	6.3
Attacked In Neighborhood			
No	6.6	6.6	6.6
Yes	6.2	6.1	6.3
Forced Sexual Acts			
No	6.6	6.5	6.6
Yes	6.1	6.0	6.2
Treated Unfairly			

No	6.6	6.5	6.6
Yes	6.3	6.3	6.4
Bullied School Property			
No	6.6	6.5	6.6
Yes	6.2	6.2	6.3
Bullied Electronically			
No	6.6	6.5	6.6
Yes	6.2	6.1	6.3
Suicidal Ideation			
No	6.6	6.6	6.7
Yes	6.0	5.9	6.1
Frequency Social Media Use			
I do not use social media	6.6	6.5	6.8
A few times a month to about once a day	6.5	6.5	6.6
Several times a day to more than once an hour	6.5	6.4	6.5
Frequency of Poor Mental Health			
Never	6.8	6.7	6.9
Rarely	6.8	6.7	6.8
Sometimes	6.5	6.5	6.6
Most of the time	6.1	6.1	6.2
Always	5.9	5.8	6.1
Usual Location Of Sleep			
In my parent's or guardian's home	6.5	6.5	6.6
Other	5.9	5.7	6.1

Note: AIAN=American Indian/Alaskan Native; NHOPI=Native Hawaiian/Other Pacific Islander.

Table 3. Linear Regression Results

Characteristic	Beta	95% CI ^l	p-value
Grade			
9	—	—	
10	-0.21	-0.31, -0.11	<0.001
11	-0.24	-0.34, -0.14	<0.001
12	-0.36	-0.46, -0.26	<0.001
Sex			
Female	—	—	
Male	-0.11	-0.19, -0.04	0.004
Race/Ethnicity			
Non-Hispanic White	—	—	
Hispanic	-0.10	-0.19, -0.01	0.031
Non-Hispanic AIAN	-0.20	-0.51, 0.11	0.20
Non-Hispanic Asian	-0.42	-0.62, -0.22	<0.001
Non-Hispanic Black	-0.38	-0.50, -0.26	<0.001
Non-Hispanic NHOPI	-0.04	-0.61, 0.53	0.90
Non-Hispanic Other	-0.28	-0.43, -0.13	<0.001
Did not go to school because felt unsafe on way to or from school, past month			
No	—	—	
Yes	-0.09	-0.22, 0.04	0.19
Threatened with a weapon on school property, past year			
No	—	—	
Yes	-0.07	-0.21, 0.08	0.35
Physically attacked, beaten, stabbed in neighborhood			
No	—	—	
Yes	-0.21	-0.31, -0.12	<0.001
Forced sexual activity, past 12 months			
No	—	—	
Yes	-0.17	-0.29, -0.04	0.009

Felt treated badly or unfairly in school because of race/ethnicity			
No	—	—	
Yes	0.00	-0.09, 0.09	>0.99
Bullied on school property, past 12 months			
No	—	—	
Yes	-0.11	-0.22, 0.01	0.062
Electronically bullied, past 12 months			
No	—	—	
Yes	0.06	-0.05, 0.18	0.29
Ever seriously consider attempting suicide, past 12 months			
No	—	—	
Yes	-0.31	-0.42, -0.21	<0.001
Frequency of social media use			
I do not use social media	—	—	
A few times a month to about once a day	-0.14	-0.34, 0.06	0.16
Several times a day to more than once an hour	-0.19	-0.37, -0.02	0.030
Mental health not good, past 30 days			
Never	—	—	
Rarely	-0.17	-0.29, -0.05	0.005
Sometimes	-0.36	-0.48, -0.24	<0.001
Most of the time	-0.63	-0.77, -0.50	<0.001
Always	-0.83	-1.0, -0.64	<0.001
Usual location of sleep, past 30 days			
In my parent's or guardian's home	—	—	
Other	-0.29	-0.58, -0.01	0.044

¹CI = Confidence Interval

Note: AIAN=American Indian/Alaskan Native; NHOPI=Native Hawaiian/Other Pacific Islander.

Figure 1. Average Duration of Sleep by Grade Level

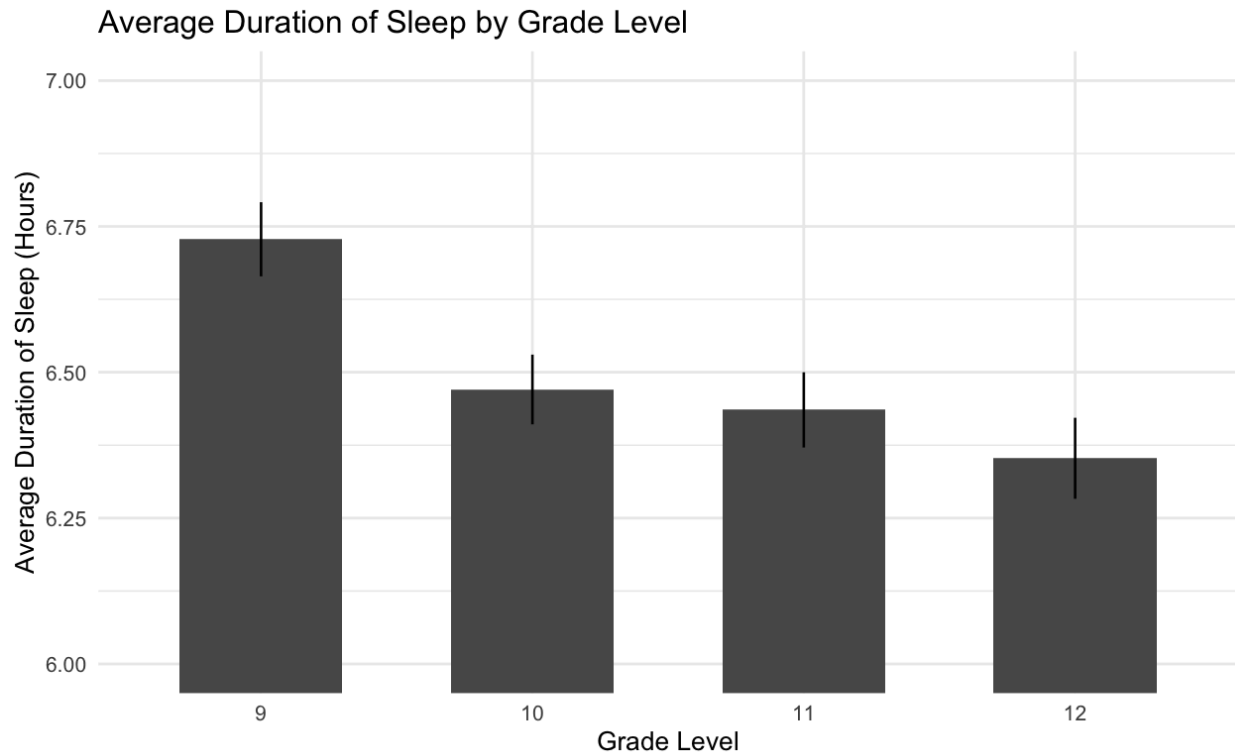
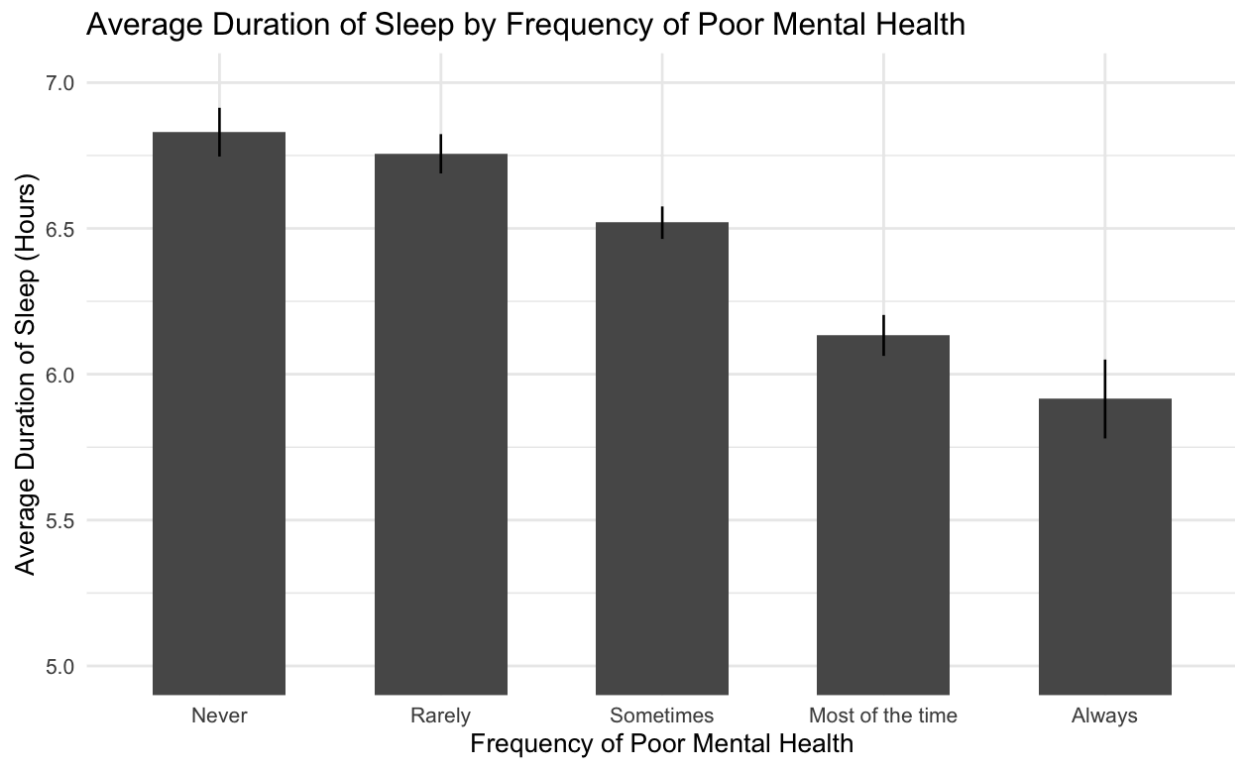


Figure 2. Average Duration of Sleep by Frequency of Poor Mental Health



Appendix Table 1. Details of Covariates

Covariate	Survey Question	Original Levels	Levels in Analysis
Grade	“In what grade are you?”	9th, 10th, 11th, and 12th	9th, 10th, 11th, and 12th
Sex	“What is your sex?”	Female and Male	Female and Male
Race/Ethnicity	1. “Are you Hispanic or Latino?” 2. “What is your race? (Select one or more responses.)”	1. Yes and No 2. American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, and White.	Hispanic, Non-Hispanic AIAN, Non-Hispanic Asian, Non-Hispanic Black, Non-Hispanic NHOPI, Non-Hispanic Other, and Non-Hispanic Whites
Unsafe At School	“During the past 30 days, on how many days did you not go to school because you felt you would be unsafe at school or on your way to or from school?”	0 days, 1 day, 2 or 3 days, 4 or 5 days, 6 or more days	No and Yes
Threatened Injured with Weapon	“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?”	0 times, 1 time, 2 or 3 times, 4 or 5 times, 6 or 7 times, 8 or 9 times, 10 or 11 times, and 12 or more times	No and Yes
Attacked in Neighborhood	“Have you ever seen someone get physically attacked, beaten, stabbed, or shot in your	Yes and No	No and Yes

	neighborhood?"		
Forced Sexual Acts	"During the past 12 months, how many times did anyone force you to do sexual things that you did not want to do? (Count such things as kissing, touching, or being physically forced to have sexual intercourse.)"	0 times, 1 time, 2 or 3 times, 4 or 5 times, and 6 or more times	No and Yes
Treated Unfairly	"During your life, how often have you felt that you were treated badly or unfairly in school because of your race or ethnicity?"	Never, Rarely, Sometimes, Most of the time, and Always	No and Yes
Bullied School Property	"During the past 12 months, have you ever been bullied on school property?"	Yes and No	No and Yes
Bullied Electronically	"During the past 12 months, have you ever been electronically bullied? (Count being bullied through texting, Instagram, Facebook, or other social media.)"	Yes and No	No and Yes
Suicidal Ideation	"During the past 12 months, did you ever seriously consider attempting suicide?"	Yes and No	No and Yes
Frequency of Social Media Use	"How often do you use social media?"	I do not use social media, A few times a month, About once a week, A few times a	I do not use social media, A few times a month to about once a day, and Several times a

		week, About once a day, Several times a day, About once an hour, and More than once an hour	day to more than once an hour
Mental Health not Good	“During the past 30 days, how often was your mental health not good? (Poor mental health includes stress, anxiety, and depression.)”	Never, Rarely, Sometimes, Most of the time, and Always	Never, Rarely, Sometimes, Most of the time, and Always
Usual Location Of Sleep	“During the past 30 days, where did you usually sleep?”	In my parent's or guardian's home, In the home of a friend, family member, or other person because I had to leave my home or my parent or guardian cannot afford housing, In a shelter or emergency housing, In a motel or hotel, In a car, park, campground, or other public place, I do not have a usual place to sleep, and Somewhere else	In my parent's or guardian's home and Other