

Associations of Social Media Use Frequency with Sadness or Hopelessness among U.S. Adolescents:
A Cross-Sectional Analysis of the 2023 Youth Risk Behavior Surveillance System

Sian Nun Siam

A thesis

submitted in partial fulfillment of the
requirements for the degree of

Master of Public Health

University of Washington

2025

Committee:

Daniel A. Enquobahrie

Isaac Rhew

Program Authorized to Offer Degree:

Epidemiology

©Copyright 2025

Sian Nun Siam

University of Washington

Abstract

Associations of Social Media Use Frequency with Sadness or Hopelessness among U.S. Adolescents:
A Cross-Sectional Analysis of the 2023 Youth Risk Behavior Surveillance System

Sian Nun Siam

Chair of the Supervisory Committee

Daniel A. Enquobahrie

Department of Epidemiology

Background: Adolescent mental health problems, including persistent sadness or hopelessness, are major public health concerns in the United States. Recent increases in adolescent mental health problems coincide with the near-ubiquitous adoption of social media. The relationship between social media use frequency and adolescent mental well-being is complex, with varying existing theories, such as the "Goldilocks hypothesis" (suggesting that moderate use is optimal). However, comprehensive evidence is lacking requiring further research that offers empirical validation. Sleep duration, often compromised in adolescents and potentially influenced by social media, is another critical factor for mental health. However, its precise role in the social media-mental health relationship remains underexplored.

Objectives: This study aimed to quantify associations of social media use frequency (low, moderate, high) with feelings of sadness or hopelessness among U.S. high school students. It also examined whether sleep duration mediates or modifies the relationship between social media use frequency and sadness or hopelessness.

Methods: A cross-sectional analysis was conducted using data from 12,675 U.S. high school students (grades 9-12) participating in the 2023 Youth Risk Behavior Surveillance System (YRBSS), a study representative of the national population of high school students. The primary exposure was social media use frequency (Low: no use to few times per week; Moderate: about once per day; High: several times per day to >once per hour). The primary outcome was self-reported sadness or hopelessness. Sleep duration was dichotomized (Sufficient: 8-9 hours; Insufficient/Excessive: <8 or \geq 10 hours). In complete case analyses, survey-weighted logistic regression models (adjusted for age, sex, race/ethnicity, household adult support and academic performance, with or without sleep duration) were used to estimate adjusted odds ratios (AORs) and 95% confidence intervals (CIs). Effect modification by sleep duration was assessed using stratified adjusted models and testing sleep duration by social media use frequency interaction terms.

Results: Social media use was reported as low by 6.0 % of students, moderate by 13.8%, and high by 80.2%. Overall, 40% of students reported sadness or hopelessness, and 78.9% reported insufficient or excessive sleep. Compared to moderate social media use, low social media use was not associated with lower or higher odds of sadness or hopelessness (AOR = 0.96; 95% CI: 0.75, 1.23; $p = 0.734$), while high social media use was significantly associated with higher odds of sadness or hopelessness (AOR 1.62; 95% CI 1.29-2.05; $p < 0.001$). In stratified analyses, among students with sufficient sleep (8-9 hours), neither low social media use (AOR = 0.69; 95% CI: 0.34, 1.39; $p = 0.290$) nor high social media use (AOR = 1.67; 95% CI: 0.93, 3.00; $p = 0.082$) were significantly associated with sadness or

hopelessness compared to moderate social media use. Among students with insufficient or excessive sleep (<8 or \geq 10 hours), high social media use was significantly associated with increased odds of sadness or hopelessness (AOR = 1.60; 95% CI: 1.24, 2.08; $p < 0.001$) while low social media use was not associated with sadness or hopelessness (AOR = 1.02; 95% CI: 0.74, 1.40; $p = 0.911$). The interaction term between social media use and sleep duration was not statistically significant ($p = 0.193$).

Conclusion: High social media use frequency is significantly associated with increased odds of persistent sadness or hopelessness among U.S. adolescents. The results suggest that public health interventions should focus on reducing high social media use and promoting sufficient sleep hygiene. Longitudinal studies with more nuanced measures of digital engagement and mental health measures are needed to establish causal relationships and inform evidence-based interventions.

Keywords: adolescent mental health, social media, sleep duration, YRBS, sadness, hopelessness

I. Introduction

The increasing burden of mental health disorders among adolescents in the United States represents a significant public health challenge. Data indicate a substantial rise in the prevalence of persistent sadness or hopelessness among high school students, from 28.5% in 2011 to 42% in 2021¹.

Similarly, prevalence of major depressive episode among individuals aged 12 and older also increased markedly from 8.1% to 15.8% between 2009 and 2019². The temporal convergence of this trend with the near-ubiquitous integration of social media use among adolescents, averaging 4.8 hours of daily use in 2023, necessitates a rigorous epidemiological investigation into the potential associations of social media use with mental health problems³.

Considerable debate surrounds the relationships between social media exposure and mental health outcomes. The "Goldilocks hypothesis" posits a curvilinear, non-monotonic relationship, where moderate exposure proves protective, while both low and high levels of exposure are detrimental.⁵ In contrast, other studies document stronger, linear dose-response relationships between time-based exposure to social media and adverse mental health outcomes⁴. The proposed mechanisms suggest that excessive use may heighten risk through factors like social comparison and sleep disruption, whereas no exposure may elevate risk through social isolation.⁶⁻⁸ However, some research reports suggest that the proportion of variance in adolescent well-being explained by digital technology use is minimal (at most 0.4%), questioning the significance of the association.⁹ Existing studies used a variety of methods to measure social media use, raising issues of misclassification in some instances, and were largely conducted in study populations that differ in characteristics, limiting comparability and generalizability of findings. Therefore, consensus is lacking on the precise nature of the association.

Moreover, sleep duration is a potentially critical variable in this relationship, as sleep deprivation plays an important risk factor for mental health disorders and is related to social media use⁵⁻⁷. The majority of U.S. adolescents do not meet the recommended 8-10 hours of sleep per night^{8,9}. Multiple studies have documented that both insufficient and excessive sleep durations are associated with increased depression risk among adolescents^{10,11}. The neurobiological vulnerability and cognitive resource models posit that insufficient sleep modifies an individual's susceptibility to the effects of social media use by impairing emotional regulation and the adaptive processing of social stimuli.¹² This suggests sleep duration status may mediate or modify the strength or direction of the association between social media use and mental health.

This cross-sectional study utilized data from the 2023 U.S. Youth Risk Behavior Surveillance System (YRBSS) to examine associations of social media use frequency with self-reported sadness or hopelessness among U.S. high school students. We hypothesized that both low and high social media use increase the likelihood of reporting sadness or hopelessness compared to moderate social media use. We also examined whether sleep duration influenced the relationship between social media use and reporting sadness or hopelessness. We hypothesized that the association between social media use and sadness or hopelessness will be attenuated after adjusting for sleep duration, assuming that sleep may partially account for this relationship. We also hypothesized that the association of social media use with sadness or hopelessness will be stronger among adolescents who have insufficient or excessive sleep compared to those with sufficient sleep. Study findings can inform research, practice, or policy aimed at promoting healthy social media use and sufficient sleep, thereby improved mental health outcomes among adolescents.

II. Methods

2.1 Study Design and Data Source

This study employed a cross-sectional design, analyzing data from the 2023 Youth Risk Behavior Surveillance System (YRBSS). YRBS is a biennial school-based survey coordinated by the U.S. Centers for Disease Control and Prevention (CDC) to monitor health-risk behaviors among students in grades 9-12. The YRBSS uses a three-stage cluster sampling design to generate a nationally representative sample. In the first stage, primary sampling units (PSUs) consisting of counties, subareas of large counties, or groups of smaller adjacent counties are selected. In the second stage, schools with grades 9-12 are selected from within each chosen PSU with probability proportional to school enrollment size. In the third stage, intact classes of students are randomly selected from each participating school, and all students in selected classes are eligible to participate.^{13(p6)}

2.2 Study Population and Sample

Participation is voluntary at both the school and student levels. Schools may decline participation, and individual students may refuse to complete the survey or skip specific questions. Parental consent procedures vary by local jurisdictions, requiring active consent and passive consent procedures. The initial 2023 YRBS dataset encompassed 20,103 participants, which were intended to represent approximately 15.6 million U.S. high school students nationally.¹⁴ The final analytic sample for this study comprised 12,675 students (63.1% of the original sample), with complete data for the primary outcome (sadness or hopelessness), exposure (social media use frequency), modifier (sleep duration), and all specified covariates (see below). Since this study involves a secondary analysis of publicly available, de-identified data, it is exempt from IRB review and does not constitute human subjects research.

2.3 Data Collection and Variable Definitions and Measures

All variables were derived from student self-reports on the YRBS questionnaire. The survey is administered anonymously at schools during a regular class period, typically lasting 45 minutes. Students complete the questionnaire using either paper-and-pencil or computer-based formats, depending on school preference and technological capacity. Generally, the YRBS was administered using a pencil-and-paper format, where students would record their answers in a computer-scannable booklet or on a separate answer sheet. As part of a data modernization effort, the CDC began developing and testing a web-based version in 2021.

2.3.1 Primary Outcome: Sadness or Hopelessness

The primary outcome was assessed using the YRBS question: "During the past 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing some usual activities?" This question captures a key screening criterion for major depressive episodes¹⁵. Responses were recoded into a binary variable: '1' for "Yes" (felt sad/hopeless) and '0' for "No".

2.3.2 Primary Exposure: Social Media Use Frequency

Social media use frequency was derived from the YRBS question assessing how often students used social media. Social media use variable was categorized, in alignment with the Goldilocks hypothesis, into three levels: low use (no use to a few times a week), moderate use (about once a day), and high use (several times a day to more than once an hour). The moderate use category served as the reference group in regression models.

2.3.3 Modifier/Explanatory Variable: Sleep Duration

Sleep duration was assessed with the YRBS question about average hours of sleep on a school night. Responses were dichotomized based on current recommendations from the American Academy of Sleep

Medicine and the Sleep Research Society, which recommends 8-10 hours of sleep for adolescents aged 13-18 years, with some allowance for individual variation⁸. Sufficient Sleep was defined as 8-9 hours on an average school night (original YRBS codes 5 for 8 hours, 6 for 9 hours). This category served as the reference group. Insufficient or excessive Sleep included less than 8 hours or 10 or more hours, respectively, on an average school night (original YRBS codes 1-4 for <8 hours, 7 for 10+ hours). In the current analyses, we combined insufficient and excessive sleep based on evidence that both extremes are associated with adverse health outcomes. In sensitivity analyses, we used a three-category classification (insufficient, sufficient, /excessive) to examine whether this distinction (i.e., insufficient and excessive) results in meaningful differences in our conclusions.

2.3.4 Covariates

The adjusted models incorporated several demographic and academic performance variables as covariates to account for potential confounding. Age was categorized into five groups: 14 years or younger, 15 years (reference), 16 years, 17 years, and 18 years or older. Sex was classified as male (reference) and female. Race and ethnicity were classified using the standard YRBSS categories: Non-Hispanic White (reference), Non-Hispanic Black or African American, Hispanic or Latino, Non-Hispanic Asian, and Non-Hispanic Other or Multiple Race. Academic performance was self-reported and categorized into five groups: Mostly As (reference), Mostly Bs, Mostly Cs, Mostly Ds/Fs, and None/Not Sure. Household adult support was measured using the question, “During your life, how often has there been an adult in your household who tried hard to make sure your basic needs were met, such as looking after your safety and making sure you had clean clothes and enough to eat?” This was categorized as 'Consistent Support' (most of the time or always) versus 'Inconsistent Support' (never, rarely, or sometimes). This variable was included in descriptive analyses as a proxy for both socioeconomic status and psychosocial support, reflecting the presence of a dependable adult providing

for basic needs. Additional covariates directly related to socioeconomic status, chronic conditions, and disability status were considered in the YRBSS dataset but were excluded from final models due to data unavailability or excessive missingness.

2.4 Statistical Analysis

2.4.1 Descriptive Analysis

Weighted percentages and 95% confidence intervals (CIs) were calculated for all variables, overall and stratified by social media use categories. Chi-square tests, adjusted for the survey design, were used to assess differences in characteristics across social media use groups. The substantial reduction in sample size with 7,428 participants (36.9% of the original sample) excluded, raises important concerns about potential selection bias. To address this concern, we conducted formal comparisons between the analytic sample and excluded participants across key demographic characteristics.

2.4.2 Association of Social Media Use with Sadness/Hopelessness, and Role of Sleep Duration

We used survey-weighted logistic regression models to examine associations of social media use with sadness or hopelessness among adolescents. We calculated adjusted odds ratios (AORs) and 95% confidence intervals (CIs). Moderate social media use served as the reference category and was compared with both low social media use and high social media use. We fit three different statistical models to understand how the association might change when we account for different factors. The first model examined the relationship between social media use and sadness or hopelessness without adjusting for any other variable. The second model adjusted for important demographic and academic factors including age, sex, race and ethnicity, academic performance and household adult support. The third model included all the same covariates as the second model and sleep duration to examine the extent to which sleep duration explains part of the relationship between social media use and sadness or

hopelessness.

2.4.3: Effect Modification by Sleep Duration

To examine if sleep duration modifies the association between social media use and sadness or hopelessness, analyses were stratified by the dichotomous sleep duration variable (Sufficient: 8-9 hours; Insufficient/Excessive: <8 or ≥ 10 hours per school night). Unadjusted and adjusted logistic regression models were run within each sleep duration stratum. Additionally, an interaction term between social media use categories and sleep duration was included in a fully adjusted logistic regression model using the entire sample to formally test for effect modification.

2.4.4 Handling Missing Data

Complete Case Analysis (CCA), also known as listwise deletion, was the selected method for managing missing data in this study. First, an initial assessment was conducted to quantify the extent and distribution of missing values across all variables intended for the analysis, including the primary exposure, outcome, and all covariates. Following this assessment, the analytic dataset was constructed by applying the CCA criteria, which involved the exclusion of any participant record that contained one or more missing values for any variable required for the final regression models. This included survey design variables (weights, strata, and PSUs). A total of 7,428 participants (36.9% of the original sample) were excluded due to missing data on one or more variables. The substantial missing data resulted from certain geographic regions and Primary Sampling Units (PSUs) either not administering specific questions or using locally modified version of the YRBS questionnaires that omitted some items¹⁶. All subsequent descriptive and inferential statistical analyses were then conducted exclusively on this complete-case dataset.

2.4.5 Sensitivity Analyses

Sensitivity Analyses were conducted to rigorously assess the robustness of the primary findings as follows. First, we examined associations using recategorized exposure (social media use frequency) groups as follows: low use (no social media use), moderate use (few times per month to about once per hour (serving as the reference category) and high use (more than once per hour). Sensitivity analyses models were adjusted for age, sex, race/ethnicity, academic performance, and household adult support.

2.4.6 Software and Statistical Significance

All statistical analyses were performed using R version 4.4.3 (2025-02-28), incorporating the survey package version 4.4.2 to account for the complex sampling design of the YRBS, including weights, strata, and PSUs. This approach was used to produce nationally representative estimates. Statistical significance for all analyses was based on the $p < 0.05$ cutoff.

III. Results

3.1 Characteristics of the Study Sample

In this sample of U.S. high school students, 80.2% (**10156**) of students used social media with high frequency, 13.8% (**1754**) with moderate frequency, and 6.0% (**765**) with low frequency (**Table 1**). Males represented 63.8% of the low-use group, while females made up 52.6% of the high-use group. Distributions of academic performance as well as other demographic characteristics (e.g., age and race) were similar across the social media use groups. Lower percentage of students in the high social media use group (19.8%) reported sufficient sleep compared with students in the moderate (26.3%) or low (26.1%) social media use groups.

3.2 Associations of Social Media Use with Sadness or Hopelessness

Overall, 40% of students reported persistent sadness or hopelessness. Among students with low social media use, 31.7% reported persistent sadness or hopelessness, compared to 40.7% among moderate social media users and 47.4% of high social media users (**Table 2**). This difference in prevalence was statistically significant ($p < 0.001$). In unadjusted logistic regression models, compared with moderate social media users, the odds of sadness or hopelessness for students with low social media use was not statistically different (OR = 1.03; 95% CI: 0.81, 1.33; $p = 0.794$) while it was significantly higher among high social media users (OR = 2.02; 95% CI: 1.59, 2.56; $p < 0.001$). After adjustment for demographic and academic factors, the difference in odds for low social media users remained non-significant (AOR = 0.95; 95% CI: 0.74, 1.23; $p = 0.710$), while the higher odds observed for high social media users persisted (AOR = 1.67; 95% CI: 1.32, 2.12; $p < 0.001$). Adding sleep duration as an additional covariate did not substantially change the odds for the low social media use group (AOR = 0.96; 95% CI: 0.75, 1.23; $p = 0.734$) or the high social media use group (AOR = 1.62; 95% CI: 1.29, 2.05; $p < 0.001$).

3.3 Effect Modification by Sleep duration

In sleep duration stratified models, among students with sufficient sleep, the odds of sadness or hopelessness for neither the low social media use (OR = 0.69; 95% CI: 0.34, 1.39; $p = 0.290$) nor high social media use (OR = 1.67; 95% CI: 0.93, 3.00; $p = 0.082$) groups were statistically significantly different from the moderate social media use group (**Table 3**). Among students with insufficient or excessive sleep, compared with moderate social media users, the odds of sadness or hopelessness for high social media users were statistically significantly higher (OR = 1.60; 95% CI: 1.24, 2.08; $p < 0.001$). Similar to the other strata, the odds of sadness or hopelessness for low social media users was not significantly different from that of the moderate social media users (OR = 1.02; 95% CI: 0.74, 1.40;

$p = 0.911$). The overall social media use and sleep duration interaction was not statistically significant (interaction- $p = 0.193$).

3.4. Sensitivity Analyses

In the sensitivity analyses using alternate categorizations of social media use, compared to students in the moderate social media use category, those in the low social media use category had lower odds of sadness or hopelessness (OR = 0.68; 95% CI: 0.52, 0.89; $p = 0.007$) (**Table 4**). On the other hand, compared to students in the moderate social media use category, those in the high social media use category had higher odds of sadness or hopelessness (OR = 1.26; 95% CI: 1.13, 1.40; $p < 0.001$).

IV. Discussion

4. 1 Summary of Key Findings

In this cross-sectional analysis of 12,675 U.S. high school students from the 2023 YRBSS, a large majority of students (80.2%) engaged in high social media use, defined as several times per day to more than once per hour, while only 13.8% engaged in moderate social media use (about once per day) and 6% engaged in low social media use (no use to few times per week). The prevalence of sadness or hopelessness among low, moderate, and high social media users was 31.9%, 31.2%, and 44.1%, respectively. The high prevalence of sadness or hopelessness, 40% overall, is consistent with recent national trends showing worsening adolescent mental health outcomes. Compared to moderate social media use, low social media use was not associated with sadness or hopelessness (AOR = 0.96; 95% CI: 0.75, 1.23), while high social media use was associated with significantly higher odds (AOR = 1.62; 95% CI: 1.29, 2.05). Adjustment for sleep duration did not substantially attenuate the associations between social media use frequency and sadness or hopelessness. Effect modification analyses revealed no significant interaction between social media use and sufficient sleep ($p = 0.193$), indicating that the

associations were similar across different sleep patterns. Findings from sensitivity analyses were largely similar to findings from the primary analyses.

4.2 Comparison with Existing Literature and Theoretical Context

4.2.1 Implications for the Goldilocks Hypothesis

The findings from this study provide important empirical evidence relevant to the ongoing debate surrounding the "digital Goldilocks hypothesis." This hypothesis, originally proposed by Przybylski and Weinstein, posits a curvilinear relationship between digital technology use and well-being, suggesting that moderate engagement represents an optimal "just right" level, while both very low and very high levels of use are associated with detrimental outcomes.¹⁷ According to this framework, both extremes of too little and too much use should show greater risk than moderate use. Our primary findings challenge this hypothesis. Adolescents with low social media use showed similar mental health outcomes compared to those with moderate use. In contrast, adolescents with high social media use reported significantly greater odds of hopelessness or sadness. These results may suggest a threshold effect where risk for adverse mental health outcomes is only elevated at high levels of social media engagement. Sensitivity analyses using alternative categorizations revealed a linear pattern. Adolescents who reported no social media use had 32% lower odds of sadness compared to moderate users (AOR = 0.68; 95% CI: 0.52, 0.89). Those who reported using social media more than once per hour had 26% higher odds of sadness (AOR = 1.26; 95% CI: 1.13, 1.40). This pattern suggests that complete abstinence may be protective while excessive use is still harmful. The discrepancy between primary and sensitivity analyses may stem from several factors. First, the operationalization of exposure is critical. This study defined "moderate use" as checking social media "about once a day." This threshold may already be beyond a truly minimal or optimal level of engagement. Second, the Goldilocks hypothesis often pertains to general screen time or broad well-being constructs. This study focused specifically on social media

frequency. The nature of digital engagement may be more relevant than frequency alone. The hypothesis assumes that "no use" of social media equates to social isolation. However, adolescents in the "low use" category may not be socially isolated, especially individual identified as "male" in this sample. They may be displacing screen time with other, potentially more beneficial, forms of social activity. These include face-to-face interaction and other forms of online interaction such as gaming, texting, and using Discord. This reframes the discussion from seeking the optimal dose of social media to understanding the optimal range of social activities for adolescent well-being.

4.2.2 Debating causal claims of impacts of social media

Our findings contribute to ongoing academic debates regarding impact of social media on adolescent mental health. For example, research from Jean Twenge and colleagues has claimed a causal relationship between the rise of smartphones and social media since 2012 and the concurrent increase in adolescent depression, anxiety, and suicide-related outcomes, particularly among females.¹⁸ The significant associations we observed between high social media use and persistent sadness support Twenge's argument. There are measurable negative effects associated with high social media use. The threshold pattern we identified is consistent with her advocacy for reducing adolescent social media engagement. In contrast, Katherine Keyes and others have adopted a more cautious epidemiological approach, emphasizing the methodological limitations inherent in establishing causal relationships from largely correlational data.¹⁹ Our findings also align with Keyes' emphasis on methodological rigor and the importance of considering multiple factors. The modest effect sizes observed suggest that social media use frequency explains only a portion of the variance in adolescent mental health outcomes. This is consistent with Keyes' argument that social media is not the primary driver of the adolescent mental health crisis. Other factors such as peer relationships²⁰, family environment, early life factors²¹, parent's

own mental health, school climate²² likely play substantial roles.

4.3 Potential Explanatory Mechanisms

Several theoretical frameworks may help explain the observed association between high social media use and increased sadness or hopelessness.

4.3.1 Social Comparison Theory

Social Comparison Theory, originally developed by Leon Festinger, provides one of the most compelling explanations for the negative mental health effects of social media use²³. This theory posits that individuals have an innate drive to evaluate themselves, often in comparison to others. These comparisons significantly influence self-perception and emotional well-being. In the context of social media, adolescents are constantly exposed to curated, idealized representations of their peers' lives, leading to upward social comparisons that can result in feelings of inadequacy, envy, and depressive symptoms. High social media use maximizes exposure to others' "highlight reels," increasing opportunities for negative social comparisons. Research has demonstrated that exposure to upward comparison targets on social media is associated with decreased self-evaluations and increased negative emotions²⁴. Adolescents who limit their social media engagement have fewer opportunities for upward social comparisons and may be more likely to base their self-evaluations on real-world interactions and achievements. This mechanism is consistent with our findings showing that high social media users had significantly higher odds of persistent sadness compared to moderate users.

4.3.2 Displacement Hypothesis

The Displacement Hypothesis suggests that time spent on social media displaces other activities that are more beneficial for mental health and well-being²⁵. These displaced activities may include protective

factors such as face-to-face social interactions, physical activity, sleep, academic pursuits, or creative endeavors. Sleep displacement represents one of the most well-documented applications of this hypothesis. The blue light emitted by screens can disrupt circadian rhythms, and the stimulating content of social media can make it difficult to wind down before bedtime²⁶. Our finding that 78.9% of students reported insufficient or excessive sleep suggests that sleep displacement may be occurring in this population. However, the fact that adjusting for sleep duration did not substantially attenuate the associations between social media use and mental health outcomes suggests that sleep displacement alone does not fully explain the relationship.

4.3.3 Cyberbullying and Online Harassment

Exposure to cyberbullying and online harassment represents a direct mechanism through which social media use can negatively impact adolescent mental health. Unlike traditional bullying, cyberbullying can occur at all times and reach victims in spaces that were previously considered safe, such as their homes²⁷. The persistent and pervasive nature of online harassment can have particularly severe effects on mental health, including increased rates of depression, anxiety, and suicidal ideation. High social media users, as identified in our study, may be at increased risk for cyberbullying exposure simply due to their greater online presence and visibility. The protective effect of low social media use observed in our study may partially reflect reduced exposure to cyberbullying and online harassment

4.4 The Role of Sleep Duration as a Potential Modifier

We hypothesized that insufficient sleep would strengthen the link between social media use and adolescent sadness/hopelessness, as sleep deprivation impairs emotional regulation. The initial hypothesis suggested that insufficient sleep would amplify the negative link between social media use and adolescent sadness or hopelessness, given that sleep deprivation is known to hinder emotional

regulation. However, the primary analysis within this study did not reveal a statistically significant modifying effect of sleep adequacy on this relationship. This suggests that, within the statistical power and design limitations of this analysis, sleep duration did not significantly modify the association between social media use and mental health. The absence of a significant interaction, despite a robust main effect of sleep duration, highlights the methodological challenges in detecting effect modification in observational studies, particularly when not explicitly powered for interaction testing. Despite current findings, the idea that sufficient sleep could offer protection against the adverse impacts of high social media use remains a plausible avenue for future research because studies designed with sufficient power to investigate such interactions and explore the qualitative aspects of social media engagement are needed.

4.5 Study Strengths and Limitations

This study has several notable strengths. Its primary strength is the use of the 2023 YRBSS, a large, nationally representative dataset that enhances the generalizability of the findings to U.S. high school students.¹ The analysis appropriately accounted for the complex survey design, yielding robust, weighted population-level estimates. Furthermore, the study systematically examined the role of sleep duration as both a potential mediator and an effect modifier, addressing a key related factor in adolescent mental health. However, the findings must be interpreted considering several limitations. The foremost limitation is the cross-sectional design of the YRBS data, which precludes any inference of causality. It is impossible to determine whether high social media use leads to sadness, whether adolescents experiencing sadness turn to social media more frequently, or whether an unmeasured third factor influences both. All variables were derived from self-report measure which may introduce important psychometric challenges that warrant careful consideration such as recall bias, social

desirability bias, and misinterpretation of questions. One particular concern is the potential for measurement error in the self-reported depressed mood outcome, which could be either differential or non-differential with respect to social media use exposure. In addition, the measure of social media exposure is crude. The YRBSS question captures only the frequency of use and provides no information on the duration of use per session, specific platforms used, content consumed, or the nature of engagement (e.g., active creation vs. passive consumption). These unmeasured dimensions are likely critical determinants of social media impact on mental health. Similarly, the outcome measure, while a valid screening item for depressive mood, is not equivalent to a clinical diagnosis of a major depressive disorder or other mental health conditions.

A significant methodological limitation of this study was the reliance on Complete Case Analysis (CCA) for handling missing data, resulting in the exclusion of 36% of the original sample and introducing the potential for selection bias. The highest proportions of missingness were observed for social media use (24.4%), academic performance (17.8%), and sleep duration (13.2%). The systematic patterns of missingness 11% (9 out of 81 PSU) observed in social media use data across different PSUs suggest that some geographic or administrative factors may have influenced data collection, though the direction and magnitude of potential bias cannot be definitively determined. The conducted sensitivity analyses were valuable for examining the robustness of findings under alternative variable definitions, and yet they do not directly mitigate the potential bias arising from the CCA approach to missing data. Therefore, although these analyses added valuable context to the main findings, the issue of potential selection bias due to missing data remains a limitation inherent to the CCA method. Future research should consider employing more advanced techniques like multiple imputation to better account for missing data and further assess the robustness of these findings. The control for potential confounding was limited by available variables in the YRBSS dataset. Important unmeasured confounders may include family

mental health history, socioeconomic status indicators, chronic medical conditions, and other behavioral risk factors that could influence both social media use patterns and mental health outcomes. Despite these limitations, the large sample size, nationally representative design, and consistent findings across multiple analytical approaches provide confidence in the robustness of the observed associations.

4.6 Public Health Implications and Future Directions

This study has important implications for public health, clinical practice, and future research. The high prevalence of both persistent sadness or hopelessness (40.1%) and suboptimal sleep (78.9%) among U.S. adolescents represents a significant and ongoing public health challenge that demands urgent attention.¹ The consistent finding that low social media use is associated with the most favorable mental health outcomes suggests that public health messaging should evolve. Rather than promoting a vague concept of "balance" or a "moderate" level of use, which the Goldilocks hypothesis might suggest, a more direct and evidence-based message would be to encourage lower frequencies of social media engagement. For clinicians, these findings support the routine inclusion of questions about social media use frequency and sleep patterns as part of comprehensive adolescent mental health assessments. Future research should address the limitations of this work and build upon its findings by focusing on several key areas. First, longitudinal studies should be conducted to understand the evolving relationship between social media use and mental health. Second, nuanced measurement is necessary to move beyond simple metrics and capture the context of social media use, including platforms, content, and active versus passive engagement, using methods like ecological momentary assessment. Third, mechanistic investigation should explore the causal links between social media use and mental health, including factors such as social comparison, cyberbullying, and the displacement of healthy activities. Fourth, intervention research should develop, and test interventions focused on digital literacy, mindful

technology use, and emotional regulation. Advanced analytical methods, such as multiple imputation in secondary analyses of large datasets, should be employed to address missing data.

4.7. Conclusion

Our analysis of 2023 YRBS data provides evidence that high social media use is associated with persistent sadness or hopelessness among U.S. high school students. This is particularly important given that 80% of adolescents engage in high social media use. The high prevalence of persistent sadness (40% of students) observed in this study underscores the magnitude of the adolescent mental health crisis facing the United States. The co-occurrence of this mental health burden with high social media use (80% of students) and inadequate sleep (78% of students) suggests that these factors may represent interconnected components of a broader pattern of adolescent health risk behaviors that require comprehensive intervention approaches.

The evidence suggests that social media use may represent one important factor among many influencing adolescent well-being, requiring comprehensive approaches that address the complex interplay of digital, social, and environmental factors shaping mental health outcomes. Future longitudinal studies with more detailed digital engagement measures are needed to fully understand the complex relationship between social media, sleep, and adolescent well-being, and to inform effective interventions.

VI. References

1. CDC. 2021 Youth Risk Behavior Survey Results. Youth Risk Behavior Surveillance System (YRBSS). February 7, 2025. Accessed May 19, 2025. <https://www.cdc.gov/yrbs/results/2021-yrbs-results.html>
2. Daly M. Prevalence of Depression Among Adolescents in the U.S. From 2009 to 2019: Analysis of Trends by Sex, Race/Ethnicity, and Income. *J Adolesc Health Off Publ Soc Adolesc Med.* 2022;70(3):496-499. doi:10.1016/j.jadohealth.2021.08.026
3. page 80 TD 1 min read V 55 N 3 P version: Teens are spending nearly 5 hours daily on social media. Here are the mental health outcomes. <https://www.apa.org>. Accessed June 4, 2025. <https://www.apa.org/monitor/2024/04/teen-social-use-mental-health>
4. Boers E, Afzali MH, Newton N, Conrod P. Association of Screen Time and Depression in Adolescence. *JAMA Pediatr.* 2019;173(9):853-859. doi:10.1001/jamapediatrics.2019.1759
5. Babson KA, Trainor CD, Feldner MT, Blumenthal H. A test of the effects of acute sleep deprivation on general and specific self-reported anxiety and depressive symptoms: an experimental extension. *J Behav Ther Exp Psychiatry.* 2010;41(3):297-303. doi:10.1016/j.jbtep.2010.02.008
6. Roberts RE, Duong HT. The Prospective Association between Sleep Deprivation and Depression among Adolescents. *Sleep.* 2014;37(2):239-244. doi:10.5665/sleep.3388
7. Palmer CA, Bower JL, Cho KW, et al. Sleep loss and emotion: A systematic review and meta-analysis of over 50 years of experimental research. *Psychol Bull.* 2024;150(4):440-463. doi:10.1037/bul0000410
8. Recommended Amount of Sleep for Pediatric Populations: A Consensus Statement of the American Academy of Sleep Medicine | Journal of Clinical Sleep Medicine. Accessed June 27, 2025. <https://jcsm.aasm.org/doi/10.5664/jcsm.5866>
9. Are you getting enough sleep? USAFacts. Accessed June 27, 2025. <https://usafacts.org/articles/are-you-getting-enough-sleep/>
10. Zheng Q qiang, Yang WW, He SS, Li YR. Association between sleep duration and depression in adolescents and young adults: a system review of observational studies and a genetic research of Mendelian randomization analysis. *Postgrad Med J.* Published online February 5, 2025:qgaf013. doi:10.1093/postmj/qgaf013
11. Liu BP, Wang XT, Liu ZZ, et al. Depressive symptoms are associated with short and long sleep duration: A longitudinal study of Chinese adolescents. *J Affect Disord.* 2020;263:267-273. doi:10.1016/j.jad.2019.11.113
12. Khan MA, Al-Jahdali H. The consequences of sleep deprivation on cognitive performance. *Neurosci Riyadh Saudi Arab.* 2023;28(2):91-99. doi:10.17712/nsj.2023.2.20220108
13. 2023 YRBS Data Users Guide. Published online 2023.
14. Press Release - NCES Data Show Public School Enrollment Held Steady Overall From Fall

2022 to Fall 2023 - December 5, 2024. Accessed June 26, 2025.
https://nces.ed.gov/whatsnew/press_releases/12_5_2024.asp

15. Verlenden J, Pampati S, Viox MH, et al. Measuring Population-Level Adolescent Mental Health Using a Single-Item Indicator of Experiences of Sadness and Hopelessness: Cross-Sectional Study. *JMIR Form Res.* 2024;8(1):e54288. doi:10.2196/54288
16. Overview and Methods for the Youth Risk Behavior Surveillance System — United States, 2023. PubMed Central (PMC). Accessed June 27, 2025.
<https://pmc.ncbi.nlm.nih.gov/articles/PMC11559678/>
17. Przybylski AK, Weinstein N. A Large-Scale Test of the Goldilocks Hypothesis. *Psychol Sci.* 2017;28(2):204-215. doi:10.1177/0956797616678438
18. Twenge JM. Increases in Depression, Self-Harm, and Suicide Among U.S. Adolescents After 2012 and Links to Technology Use: Possible Mechanisms. *Psychiatr Res Clin Pract.* 2020;2(1):19-25. doi:10.1176/appi.prcp.20190015
19. Keyes KM, Platt JM. Annual Research Review: Sex, gender, and internalizing conditions among adolescents in the 21st century - trends, causes, consequences. *J Child Psychol Psychiatry.* 2024;65(4):384-407. doi:10.1111/jcpp.13864
20. Stuke H, Schlack R, Erhart M, Kaman A, Ravens-Sieberer U, Irrgang C. Peer Relationships Are a Direct Cause of the Adolescent Mental Health Crisis: Interpretable Machine Learning Analysis of 2 Large Cohort Studies. *JMIR Public Health Surveill.* 2025;11(1):e60125. doi:10.2196/60125
21. Straatmann VS, Lai E, Lange T, et al. How do early-life factors explain social inequalities in adolescent mental health? Findings from the UK Millennium Cohort Study. *J Epidemiol Community Health.* 2019;73(11):1049-1060. doi:10.1136/jech-2019-212367
22. Lin J, Guo W. The Research on Risk Factors for Adolescents' Mental Health. *Behav Sci.* 2024;14(4):263. doi:10.3390/bs14040263
23. A Theory of Social Comparison Processes - Leon Festinger, 1954. Accessed June 25, 2025.
<https://journals.sagepub.com/doi/10.1177/001872675400700202>
24. McComb CA, Vanman ,Eric J., and Tobin SJ. A Meta-Analysis of the Effects of Social Media Exposure to Upward Comparison Targets on Self-Evaluations and Emotions. *Media Psychol.* 2023;26(5):612-635. doi:10.1080/15213269.2023.2180647
25. Online Communication and Adolescent Well-Being: Testing the Stimulation versus the Displacement Hypothesis | Journal of Computer-Mediated Communication | Oxford Academic. Accessed June 27, 2025. <https://academic.oup.com/jcmc/article/12/4/1169/4582968?login=false>
26. Electronic Screen Use and Sleep Duration and Timing in Adults | Public Health | JAMA Network Open | JAMA Network. Accessed June 27, 2025.
<https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2831993>
27. Nixon CL. Current perspectives: the impact of cyberbullying on adolescent health. *Adolesc Health Med Ther.* 2014;5:143-158. doi:10.2147/AHMT.S36456

VII. Tables

Table 1. Selected Characteristics of U.S. High School Students by Social Media Use Frequency, YRBSS 2023 (N=12675)

Characteristic	Overall (N=12675)	Low Use (n=765) 6.0%	Moderate Use (n=1754) 13.8%	High Use (n=10156) 80.2%
Age (years)				
≤14	1,448 (11.4%)	95 (12.4%)	232 (13.2%)	1,121 (11.0%)
15	3,467 (27.4%)	229 (29.9%)	500 (28.5%)	2,738 (27.0%)
16	3,198 (25.2%)	190 (24.8%)	419 (23.9%)	2,589 (25.5%)
17	3,007 (23.7%)	148 (19.3%)	382 (21.8%)	2,477 (24.4%)
≥18	1,555 (12.3%)	103 (13.5%)	221 (12.6%)	1,231 (12.1%)
Sex				
Male	6,395 (50.5%)	488 (63.8%)	1,093 (62.3%)	4,814 (47.4%)
Female	6,280 (49.5%)	277 (36.2%)	661 (37.7%)	5,342 (52.6%)
Race/Ethnicity				
White	5,857 (46.2%)	392 (51.2%)	785 (44.8%)	4,680 (46.1%)
Hispanic/Latino	935 (7.4%)	51 (6.7%)	125 (7.1%)	759 (7.5%)
Black/African American	1,278 (10.1%)	63 (8.2%)	176 (10.0%)	1,039 (10.2%)
AIAN	842 (6.6%)	61 (8.0%)	147 (8.4%)	634 (6.2%)
Other	3,763 (29.7%)	198 (25.9%)	521 (29.7%)	3,044 (30.0%)
Sexual Identity				
Heterosexual	9,272 (74.6%)	580 (76.9%)	1,232 (71.9%)	7,460 (74.9%)
Gay or lesbian	427 (3.4%)	22 (2.9%)	61 (3.6%)	344 (3.5%)
Bisexual	1,409 (11.3%)	69 (9.2%)	175 (10.2%)	1,165 (11.7%)
Other identity	462 (3.7%)	26 (3.4%)	66 (3.9%)	370 (3.7%)
Questioning	581 (4.7%)	32 (4.2%)	81 (4.7%)	468 (4.7%)
Not understand question	280 (2.3%)	25 (3.3%)	98 (5.7%)	157 (1.6%)
Academic Performance				
Mostly A's	4,831 (38.1%)	315 (41.2%)	675 (38.5%)	3,841 (37.8%)
Mostly B's	3,910 (30.8%)	222 (29.0%)	506 (28.8%)	3,182 (31.3%)
Mostly C's or <	3,934 (31.0%)	228 (29.8%)	573 (32.7%)	3,133 (30.8%)
Household Adult Support				
Consistent	11,014 (86.9%)	671 (87.7%)	1,429 (81.5%)	8,914 (87.8%)
Inconsistent	1,661 (13.1%)	94 (12.3%)	325 (18.5%)	1,242 (12.2%)
Sleep Duration				
Sufficient Sleep	2,675 (21.1%)	200 (26.1%)	461 (26.3%)	2,014 (19.8%)
Insufficient/ Excessive Sleep	10,000 (78.9%)	565 (73.9%)	1,293 (73.7%)	8,142 (80.2%)

N (%) Data are presented as unweighted frequencies (N) and weighted percentages (%)

Social Media Use Frequency Categories: Low Use: No social media use, few times per month, about once per week, or few times per week. Moderate Use: About once daily, High Use: Several times daily, about once hourly, or more than once hourly

AIAN: American Indian/Alaska Native

Sleep Duration Categories: Sufficient: 8-9 hours per school night, Insufficient/Excessive: <8 hours or ≥10 hours per school night

Race/Ethnicity: Am Indian/Alaska Native = American Indian or Alaska Native; Other includes Asian, Native Hawaiian/Other Pacific Islander, and Multiple races

Household Adult Support: Adult in household who tried hard to ensure basic needs were met (safety, clean clothes, food),

Consistent Support: Adult support 'Always' or 'Most of the time', Inconsistent Support: Adult support 'Sometimes,' 'Rarely,' or 'Never'

Sexual Identity: Self-reported sexual identity categories as per YRBSS Q64

Table 2. Association Between Social Media Use Frequency and Sadness or Hopelessness Among US High School Students YRBS 2023^a

Social Media Use	Sadness or Hopelessness, n/N (%)	Unadjusted	p-value	Adjusted ^e	p-value	Adjusted + Sleep ^f	p-value
		OR (95% CI)		OR (95% CI)		OR (95% CI)	
Low use ^b	245/765 (31.7%)	1.03 (0.81, 1.33)	0.794	0.95 (0.74, 1.23)	0.710	0.96 (0.75, 1.23)	0.734
Moderate use ^c	715/1754 (40.7%)	1.00 [Reference]		1.00 [Reference]		1.00 [Reference]	
High use ^d	4102/10156 (47.4%)	2.02 (1.59, 2.56)	<0.001	1.67 (1.32, 2.12)	<0.001	1.62 (1.29, 2.05)	<0.001

Abbreviations: CI, confidence interval; OR, odds ratio; YRBSS, Youth Risk Behavior Surveillance System.

^aData are from the 2023 YRBSS. Sample includes US high school students in grades 9-12 (N = 12,675 complete cases).

Percentages are survey-weighted to be nationally representative. Statistical significance was set at $P < .05$

^bLow use indicates no social media use, few times per month, about once per week, or few times per week.

^cModerate use indicates about once daily. This category serves as the reference group for all comparisons.

^dHigh use indicates several times daily, about once hourly, or more than once hourly.

^eAdjusted for age (continuous), sex (male/female), race and ethnicity (White, Hispanic or Latino,

Black or African American, other), academic performance (mostly A's, mostly B's, mostly C's or lower), and household adult support (consistent/inconsistent).

^f Additionally adjusted for sleep duration (Sufficient [8-9 hours] vs Insufficient or excessive [<8 or ≥ 10 hours] per school night).

Table 3. Effect Modification: Association Between Social Media Use and Sadness/Hopelessness, Stratified by Sleep Duration^a

Social Media Use	Sadness or Hopelessness, No./Total No. (%)	Sufficient Sleep ^e (n = 2,675)		Insufficient/Excessive Sleep ^f (n = 10,000)	
		AOR (95% CI)	p-value	AOR (95% CI)	p-value
Low use ^b	245/765 (31.7%)	0.69 (0.34, 1.39)	0.290	1.02 (0.74, 1.40)	0.911
Moderate use ^c	715/1754 (40.7%)	1.00 [Reference]	[Reference]	1.00 [Reference]	[Reference]
High use ^d	4102/10156 (47.4%)	1.67 (0.93, 3.00)	0.082	1.60 (1.24, 2.08)	<0.001

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; YRBSS, Youth Risk Behavior Surveillance System.

^aData are from the 2023 YRBSS. Models adjusted for age, sex, race/ethnicity, academic performance, and household adult support, stratified by sleep duration. Interaction P value = 0.193.

^bLow use indicates no social media use, few times per month, about once per week, or few times per week.

^cModerate use indicates about once daily. This category serves as the reference group for all comparisons.

^dHigh use indicates several times daily, about once hourly, or more than once hourly.

^eSufficient sleep: 8-9 hours per school night.

^fInsufficient/Excessive sleep: <8 or ≥10 hours per school night.

Table 4. Sensitivity Analysis: Comparison of Adjusted Odds Ratios Using Primary and Alternative Social Media Use Categorizations ^a

Social Media Use	Sadness or Hopelessness, No./Total No. (%)	Primary Categorization ^e	Alternative Categorization ^f
		AOR (95% CI)	AOR (95% CI)
Low use ^b	245/765 (31.7%)	0.96 (0.75, 1.23)	0.68 (0.52–0.89)
Moderate use ^c	715/1754 (40.7%)	1.00 [Reference]	1.00 [Reference]
High use ^d	4102/10156 (47.4%)	1.62 (1.29, 2.05)	1.26 (1.13–1.40)

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; YRBSS, Youth Risk Behavior Surveillance System.

^a Data are from the 2023 YRBSS. All models adjusted for age, sex, race/ethnicity, academic performance, household adult support, and sleep duration.

^b Low use indicates no social media use, few times per month, about once per week, or few times per week.

^c Moderate use indicates about once daily. This category serves as the reference group for all comparisons.

^d High use indicates several times daily, about once hourly, or more than once hourly.

^e Primary categorization: Low use (no use to few times per week), Moderate use (about once daily), High use (several times daily to more than once hourly).

^f Alternative categorization: Low use (no use to few times per month), Moderate use (about once weekly to about once daily), High use (several times daily to more than once hourly).