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Associating Depressive Symptoms with Social Media Usage Through Sleep Deprivation in Adolescents

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ABSTRACT

Objective: Social media has become increasingly popular among adolescents in the last decade, which may impact their health and health behaviors, such as sleep and psychological well-being. However, our understanding of the relationships between social media use, sleep, and mental health among millennial adolescents is scarce. The objective of this study is to use nationally representative data to examine the associations between frequent social media usage, sleep deprivation, and depressive symptoms among young adolescents.
Methods: This study used data from the Monitoring the Future survey (2018 & 2019), an annual, cross-sectional, and nationally representative study of 8th and 10th graders (N=14,526). A scale of three CES-D type questions (hopelessness, unhappiness, and no enjoyment of life) were used to assess depressive symptoms. Path analysis was conducted to examine how the association between frequencies of social media usage and depressive symptoms was mediated through the levels of sleep deprivation. A 3D graph was generated from the Ordinary Least Squares Regression to display changes in the frequencies of social media use which resulted in varying levels of sleep deprivation and depressive symptoms.
Results: Results from the path analysis showed 39.73% of social media usage's total effect on depressive symptoms was mediated through sleep deprivation. The 3D graph showed that more frequent social media usage was correlated with higher levels of sleep deprivation and hence more depressive symptoms among young adolescents.
Conclusions: The findings implied that promoting less social media use could improve sleep adequacy which appears to be beneficial for adolescents' mental health.

Introduction

As the millennial generation arises, social media has become increasingly prevalent among young adolescents. Adolescents from Generation Z (born in 1997+) have been increasingly using social media more and more frequently. The technology age has rapidly improved access and quality of using social media on smartphones. In 2018, the Pew Research Center reported that 45% of adolescents used social media frequently as compared to 24% in 2014 and 2015. 34% of teens reported using social media more than once in 2012, compared to 70% in 2018.[1] [2] There is a rising concern that young adolescents are being shaped by social media. However, its effects have not yet been fully understood. As new data about social media use among young people has become available, emerging research examined the association between social media and sleep, [3–5] or sleep and mental health, [6,7] or social media and mental health.[8–10]

Association between Social Media Use and Sleep Deficiency

Social media can displace sleep directly or indirectly. This probably is one of the primary reasons behind poorer sleep quality, worse sleep efficiency, sleep deprivation, and later sleep onset and offset (The Impact of Social Media Use

on Sleep Efficiency). [11] Time spent on social media was found to be associated with sleep deprivation either directly or indirectly (H Scott Bmj) [3]. Longer time on social media can postpone activities such as sleep or homework, which in turn, delays sleep.

Social media might directly affect an adolescent's sleep.[3,12] Frequent social media use was found to be associated with decreased sleep time and increased tiredness.[11] In addition, social media can clog the brain which may result in individuals developing strong emotions in response to things they watch or see which can delay sleep onset and offset.[13] Furthermore, the blue light emitted by smartphones is particularly bad for one's circadian rhythm, which is the body's biological clock. It prevents melatonin, the sleep hormone, from being produced, increasing sleep deprivation.[14] Additionally, using one's phone before sleeping often delays the sleep onset and offset, which could harm sleep efficiency.[15] Most adolescents attend school on a daily basis. If sleep onset is delayed, but sleep offset is not due to alarms for being punctual at school, this results in increased sleep deprivation. Lastly, one overlooked fact about social media is the interruption of sleep due to notifications, which can decrease sleep quality and increase sleep deficiency.[16]

Association between Sleep and Mental Health

Unhealthy sleep behaviors were found to have negative mental health outcomes. Previous research showed sleep deprivation can increase risk of developing depressive symptoms. [17–19] For instance, people who are diagnosed with insomnia (difficulty falling or staying asleep) can have tenfold the risk of developing depressive symptoms compared to people who get the recommended amount of sleep.[18] Another study on adolescents found sleep problems often developed and unnoticed before depressive symptoms arose.[20]

The science behind the link between sleep and depressive symptoms is not fully understood. However, scientists have found that sleep disruption, such as insomnia, may affect neurotransmitters, stress hormones, and impair both thinking and emotional regulation.[20] If many functions of the brain are affected, this can increase the risk of developing depressive symptoms.

The Current Study

Given that data about social media use are limited, research about this topic, especially among adolescents, is still new. Previous research used regional samples or pilot studies to examine social media and its association with health outcomes or health behavior (eg., sleep, and/or depression) among adolescents or adults.[11,21] And most of them were conducted in countries (such as UK, Scotland) other than the United States.[3,21] National and adolescent studies of social media use and its impact on health outcomes are lacking.

This study aimed to advance the research in this area. Its goal was to use a US national representative sample of adolescents to provide a current profile of their social media usage, sleep, and mental health. It also aimed to provide new evidence about the association between social media use, sleep, and depressive symptoms among U.S. adolescents.

Third, although previous research examined the association between social media and sleep, or social media and mental health among young people,[3,9] few studies have examined the mechanism of all three relationships. This study aimed to advance this topic by examining the interconnection between social media, sleep deprivation, and depressive symptoms.

Besides the direct association between social media use and depressive symptoms, and between social media and sleep, the mediation effect of sleep for the linkage between social media use and depression is likely to play a role. With the insights shed by prior research theories and findings,[11,18] this study hypothesized that the association between high frequency of social media use and depression is partially mediated through sleep deprivation among adolescents. In other words, longer social media usage daily is likely to be associated with higher levels of sleep deprivation, which in turn is associated with increasing levels of depressive symptoms.

Methods

Study Sample

Data used for this study was released by the National Addiction & HIV Data Archive Program. It launched an annual survey called Monitoring the Future (MTF). MTF was a nationally representative, cross-sectional study of over 50,000 adolescents from 8th and 10th grade in 2018 and 2019 (see details Johnston 2015). It collected data via self-administered questionnaires and used a multistage random sampling design with geographic areas (stage 1), schools (stage 2), and students within schools (stage 3).[22] School participants would answer MTF surveys and would be selected according to their geographical region, type of school, and other factors for a nationally representative sample. Student response rates were above 80%. The data has been de-identified to protect the confidentiality of the adolescents. Public data files are available from the Inter-University Consortium for Political and Social Research. [23] The sample for this study included 14,526 adolescents who are not missing on any of the dependent or independent variables. Survey procedures were approved by the institutional review board at the University of Michigan at Ann Arbor. All data were deidentified.

Media Use Measure

Participants were asked to answer the following question, "About how many hours on an average day do you spend on social networking sites like Facebook, Twitter, Instagram, etc.?" They indicated how many hours of social media they used daily from 7 different categories (i: 0, ii: 1-2, iii: 3-4, iv: 5-6, v: 7-8, vi: 8-9, vii: 9+ hours). It was a continuous-likert scale. Increased social media use was represented by a greater number.

Sleep Deficiency Measure

Participants were asked, "How often do you get at least seven hours of sleep?". The frequency of sleep adequacy had 6 categories and ranged from (1) never, (2) seldom, (3) sometimes, (4) most days, (5) nearly everyday, to (6) everyday. Sleep inadequacy was inversely coded so that 1 represented always getting adequate sleep, and 6 indicated never getting adequate sleep. A greater number showed a higher level of sleep insufficiency.

Measure of Depressive Symptoms

MTF asked three questions that reflected depressive symptoms and similar to questions of the Center of Epidemiological Studies - Depression (CES-D) scale. Thus, depressive symptoms were measured with a combination of three questions including: (i) if the future often felt hopeless (1, disagree, 2, mostly disagree, 3, neither, 4, mostly agree, 5, agree); (ii) if they enjoyed life as much as anyone (reversely coded as 1, agree, 2, mostly agree, 3, neither, 4 mostly disagree, 5, disagree), and (iii) if they were happy these days (reversely coded as 1, agree, 2, neither, 3 disagree). The questions about happiness and enjoyment of life were inversely coded to show that a higher score on the scale contributed to increased depressive symptoms. Measures for hopelessness and enjoyment of life were collapsed from five into three categories (to match the 3-category scale of the happiness measure). Lastly, each measure of the depressive symptoms were changed to a scale of 0, 1, 2.

Together, these three items (little enjoyment of life, unhappiness, & hopelessness) were summed to create the composite measure for depressive symptoms. This measure ranged from 0 to 6 (mean 2.16; SD 0.014). A score of 0 represented very little to no depressive symptoms and a score of 6 indicated the highest level of depressive symptoms.

Control Variables

This study included the following demographic and socioeconomic variables as controls for multivariate analysis: grade, year, sex, race, school region, metropolitan statistical area, and parental education. Number of hours of homework per week was also accounted for.

Analysis Plan

Statistical analyses were performed in multiple steps. First, descriptive analysis was conducted to describe the characteristics for all variables of interest. Second, path analysis, a type of structural equation modeling, was used to examine mediation of sleep deprivation between social media use and depressive symptoms. Coefficients were presented as standardized betas.

Third, ordinary least squares regressions (OLS) were used to assess levels of depressive symptoms based on social media usage and sleep deprivation. Three models were generated. Model 1 included social media use while controlling for grade, year, gender, and race. Model 2 added sleep inadequacy. And Model 3 included additional control variables, including hours of homework, school region, metropolitan statistical area, and parental education. Model 3 was used to estimate the predicted levels of depressive symptoms based on the values of social media use and sleep. Then a 3D graph was generated to visualize trends of estimations. All analyses used individual-level sample weights provided in the public data files. Stata 16 (Stata LLC) was used to conduct all analyses and a significance level of $p < .05$ was used.

Table 1. Weighted Percentage as Descriptive Statistics (n = 14,526)

Characteristics		%
Grade		
	8th	47.09
	10th	52.91
Year		
	Year 2018	48.53
	Year 2019	51.47
Sex		
	Male	47.72
	Female	52.28
Race		
	Black	14.1
	White	62.27
	Hispanic	23.62
Metropolitan Standardized Area		

	NON SMSA	20.28
	STANDARD	79.72

Table 1. Weighted Percentage as Descriptive Statistics (n = 14,526) (Continued)

School Region		
	Northeast	16.13
	North Central	23.08
	South	38.18
	West	22.61
Hours spent on Homework Weekly		
	NONE:(1)	9.01
	1-4 HRS:	52.85
	5-9 HRS:	19.55
	10-14HRS	8.81
	15-19HRS	4.82
	20-24HRS	2.84
	25+ HRS:	2.11
Highest education out of the parents		
	Grade School	2.63
	Some High School	6.61
	High School Graduate	15.58
	Some College	15.01
	College Graduate	34.51
	Graduate School	25.66
Hours Daily Spent on Social Media		
	NONE:(1)	8.9
	<1 HOUR:	18.49
	1-2 HRS:	25.64
	3-4 HRS:	18.78

	5-6 HRS:	11.37
	7-8 HRS:	7.14
	9+ HRS:(	9.68
How often do you get 7 hours of sleep		
	Everyday	21.26
	Nearly Everyday	18.86

Table 1. Weighted Percentage as Descriptive Statistics (n = 14,526) (Continued)

	Most Days	19.69
	Sometimes	20.72
	Seldom	12.8
	Never	6.68
Little Happiness		
	0	16.3
	1	64.32
	2	19.38
Little Enjoyment of Life		
	0	63.72
	1	16.07
	2	20.21
Hopelessness		
	0	62.48
	1	17.29
	2	20.23
Depression Score		
	0	12.57
	1	35.43
	2	14.57
	3	15.8
	4	9.19
	5	6.04

6 6.4

Results

Table 1 displayed weighted descriptive results for all variables used in this study. The study population consisted of 47.72% females, 79.72% from a Metropolitan Statistical Area, and 38.18% from the South. 16.82% used popular social media websites such as Youtube, Twitter, Facebook, and Instagram for more than seven hours everyday.

Additionally, almost one third (28%) of adolescents used social media for 5 hours or more everyday. Almost 20% of 8th and 10th graders reported rarely or never sleeping for 7 hours.

Approximately 20% of adolescents agreed with the statement that their future often felt hopeless. One fifth agreed they were not enjoying life these days and were not happy. More than one fifth of adolescents scored between four and six on the composite measure for depressive symptoms.

Table 2 presented standardized coefficients for the path analysis (in SEM). It showed the estimation of indirect and direct effects of social media on depressive symptoms through the mediation of sleep insufficiency. About 32% of social media's total effect on depressive symptoms was mediated through sleep deprivation. Additionally, standardized coefficients were estimated for each pathway (Figure 1). The results showed that social media had greater direct effects on sleep deprivation (0.094) than depressive symptoms (0.079).

Table 3 showed coefficients for three models using OLS regressions for depressive symptoms. Higher frequencies of social media usage was associated with higher levels of depressive symptoms. Higher levels of sleep inadequacy was associated with higher levels of depressive symptoms. Coefficients for social media usage dropped by 26% from Model 1 to 2 when sleep deprivation was included. This indicates that part of social media's effect on depressive symptoms can be explained through sleep insufficiency.

Results for control variables showed that females had higher levels of depressive symptoms compared to males. Black and Hispanic adolescents had lower levels of depressive symptoms compared to their white counterparts.

The 3D Graph (Figure 2) produced from Model 3 (Table 3) displayed estimated levels of depressive symptoms with changes to social media usage and sleep insufficiency. It showed that higher frequencies of social media use appeared to increase the levels of sleep deprivation, which resulted in heightened levels of depressive symptoms. Spending little to no time on social media and sleeping 7 hours daily resulted in the lowest level of depressive symptoms (purple color). Young adolescents who never got adequate sleep and spent 9 hours or more on social media daily had the highest level of depressive symptoms, with an estimated value above 3 on the composite measure.

Table 2. Indirect and Total Effects from Path Analysis

Indirect effects			
	Coefficient (Standardized)	Standard Error	P-Value
Depressive Symptoms			
<- Social Media Usage	0.037	0.004	0.000
Total effects			
Sleep Deprivation			
<- Social Media Usage	0.094	0.010	0.000

Depressive Symptoms			
<- Sleep Deprivation	0.398	0.011	0.000
<- Social Media Usage	0.116	0.010	0.000

Table 3. Coefficient from the Ordinary Least Squares Regression for Depressive Symptoms

Social Media Usage	0.0962***	0.0714***	0.0413***
	(0.0124)	(0.0115)	(0.0120)
Sleep Deprivation		0.392***	0.365***
		(0.0126)	(0.0132)
Female	0.292***	0.208***	0.342***
	(0.0397)	(0.0372)	(0.0385)

Table 3. Coefficient from the Ordinary Least Squares Regression for Depressive Symptoms (Continued)

Grade	0.140***	-0.00207	-0.0293
	(0.0389)	(0.0367)	(0.0374)
Year	0.0675	0.0470	0.0386
	(0.0385)	(0.0361)	(0.0366)
Race/Ethnicity			
White (Reference)	---	---	---
Black	0.0611	0.0742	-0.0538
	(0.0592)	(0.0564)	(0.0593)
Hispanic	0.187***	0.156***	-0.0633
	(0.0463)	(0.0437)	(0.0524)
Parent Education			
High School or less (Reference)			---
Some College			-0.0383
			(0.0654)
College and Plus			-0.180***
			(0.0500)
Homework (Hours Weekly)			0.00397
			(0.0158)
Letter Grades			-0.154***

			(0.00993)
Metropolitan Statistical Area			0.0218
			(0.0442)
Region			
Northeast (Reference)			---
North Central			0.0946
			(0.0552)
West			0.207***
			(0.0610)
South			0.0752
			(0.0527)
Intercept	1.450***	0.495***	1.684***
	(0.053)	(0.0559)	(0.118)
Observations	55,787	55,787	54,731
R-squared	0.027	0.149	0.195

Note: Standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.05

Figure 1. Standardized Coefficient of Path Analysis (SEM)

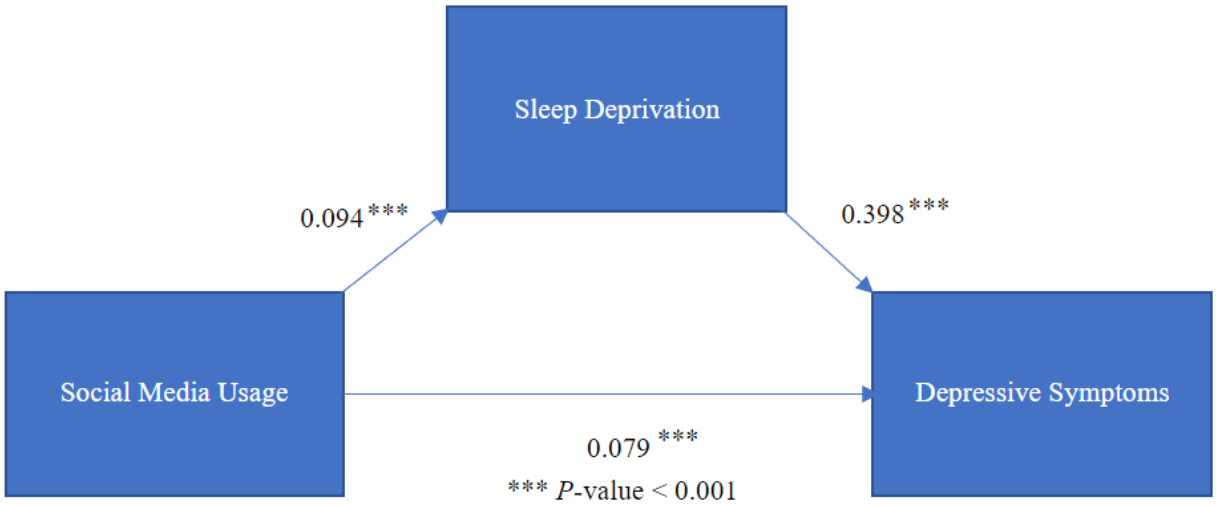
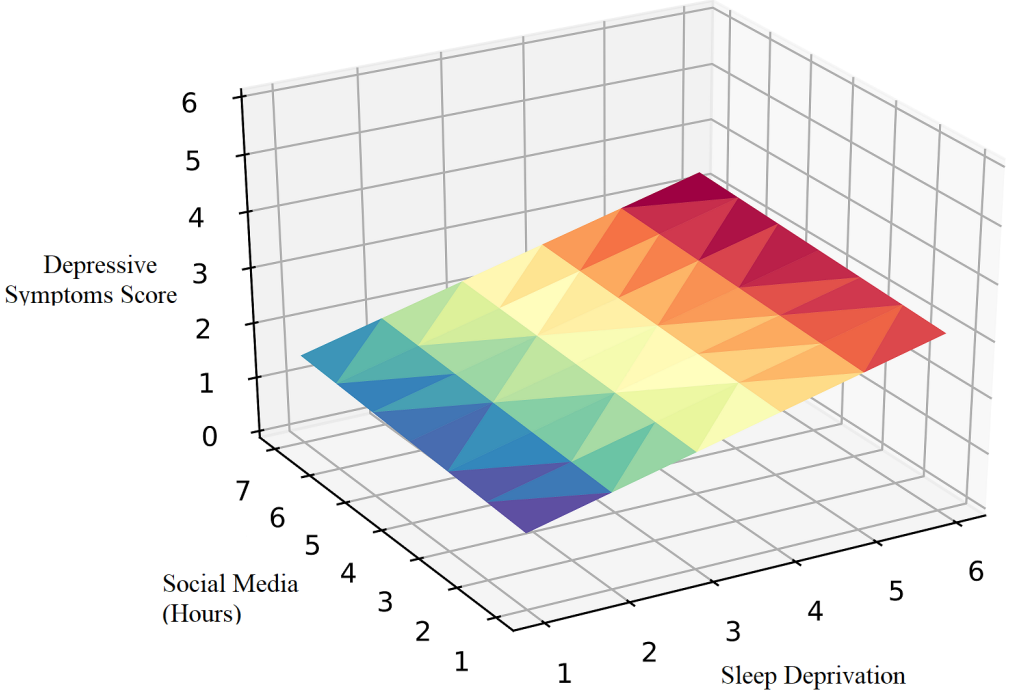


Figure 2. 3D Graph from OLS Regression
Depressive Symptoms Score by Social Media Use and Sleep Deprivation



Discussion

Our analyses produced three important findings. First, our results provide a current profile of adolescent health and health behaviors in terms of social media use, sleep, and mental health, nationwide. Second, the results from the path analysis indicated that social media use was associated with depressive symptoms through the mediation of sleep. Findings suggested that part of social media's effect on depressive symptoms could be explained by sleep inadequacy. Estimated higher frequencies of social media use appeared to be associated with worsened levels of sleep deprivation, which likely resulted in higher levels of depressive symptoms.

Our results are nationally representative of adolescents in the 8th and 10th grade. Recently, there has been a striking number of adolescents who use social media in excess. Findings show that more than 28% of adolescents use social media for 5 hours or more everyday. These statistics of the current representation of adolescents is striking. High frequencies of social media use could promote feelings of loneliness, dissatisfaction about body image, and self-harming thoughts (add citation helpguide.org). Moreover, high levels of social media use are prone to delay or prevent activities such as homework, exercise, chores, sleep and more. Delaying activities could increase sleep deprivation (BmJ Open). Procrastinating on social media can block out priorities in an adolescent's life which can lead to mental stress (procrastination and mental health paper add citation). Lastly, vulnerable users could be affected by being exposed to self-harm on social media, which could lead to risk of suicide.

Findings also demonstrated that almost 20% of 8th and 10th graders in generation Z seldom or never got seven hours of sleep. Astonishingly, many young adolescents already seem to be burdened with a lack of sleep. As a result, this sleep deprivation can increase problems with memory, trouble concentrating, increased risk for diseases such as heart disease and diabetes, and mood changes.[24] Constant mood changes could lead to depression.[24] Similarly,

sleep problems have often been found before depressive symptoms arise.[20] This is unsettling. The sweeping sleep epidemic could harm adolescents in many negative ways such as mental and physical illnesses, academic performance, and more.

Furthermore, this generation of adolescents is particularly depressed. Roughly one fifth of adolescents reported the highest level of depressive symptoms in terms of hopelessness, unhappiness, and little enjoyment of life. On the composite measure, more than 20% of 8th and 10th graders scored higher than the median level of depressive symptoms. 6% scored 5 and another 6% scored 6 on the composite measure. This is very concerning. In order to score a 5 (in a range of 0-6), one would have to report the highest level of depressive symptoms for two out of the three questions, and answer the third with a score of 1. Another 6% scored the highest possible score of 6, demonstrating that they answered the highest level of depressive symptoms on all three measures.

The statistics about these answers reported by 8th and 10th graders are shocking. The likelihood of developing depression often spikes during puberty.[25] Depression increases the susceptibility to negative thoughts about oneself and suicidal ideation.[26] Furthermore, the preoccupation with death is often accompanied with other negative emotional and physical symptoms. [26]

Another important finding of this study suggests that social media was associated with depressive symptoms through the mediation of sleep. 32% of social media's pathway on depressive symptoms can be explained through sleep. Little research has examined the mediation effect of sleep for the association between social media use and depressive symptoms. One exception was found to use a small regional sample in Scotland to study the topic.[21] There is a lack of national studies with available data about Generation Z. This study extended the literature by focusing on how sleep quality mediates the connection between social media use and mental health. The new findings suggested that more frequent social media use was associated with higher levels of sleep deprivation which in turn were associated with increased depressive symptoms.

If links between social media and depressive symptoms through sleep have been found, how detrimental could overuse of social media be on adolescents? Procrastination, mental stress, and worse sleep could result from an overuse of social media. In turn, sleep deprivation could worsen adolescent physical health and mental health. These problems are only worsened given the fact that the risk of depression increases during puberty.

Implications

This study has several implications. Findings suggest that using social media in moderation is important. This can have many benefits, including one of the most important, bettering and prolonging sleep. As the risk of being diagnosed with depression increases during adolescence, it is very important for adolescents to monitor social media use. With this in mind, it is crucial to manage sleep and possibly set rules. Among the many symptoms of sleep deprivation, depression has now been found to be associated with social media through the deprivation of sleep.

As younger generations begin to grow up more and more involved in the technological age and use social media more and more frequently,[1] it is extremely valuable to oversee both social media use and sleep quality and quantity. This study provides policy implications about monitoring and limiting social media usage and sleep for young adolescents. Developing preventive programs and intervention strategies to promote healthy ways of social media usage can improve sleep adequacy and, more importantly, mental health among adolescents.

There are some limitations of this study. Firstly, the study was cross-sectional, and focused on the association between social media, sleep, and depression that were measured at the same time. Future research could collect longitudinal data to assess social media use and long-term trajectories of sleep and their impact on changing patterns of mental health. In addition, social media use was not measured as a continuous variable, which could allow for more precise cutoffs to measure sleep inadequacy. Questions for depressive symptoms were relatively similar to CES-D items, but neither prompts nor scales were exactly the same. Lastly, the data from MTF included 8th and 10th graders. Future research could design surveys to include adolescents from other grades as well as adding original CES-D items to expand the research of this topic.

In summary, this study provides a current and nationally representative profile of social media use, sleep, and mental health among adolescents. Findings contribute a new understanding about the interconnection between social media use, sleep adequacy, and mental health. This research suggests that increased frequent use of social media is associated with worsened sleep which, in turn, likely leads to elevated levels of depressive symptoms among adolescents of Generation Z. New public health initiatives need to be developed to change adolescents' health behaviors, in terms of social media use and sleep, to improve their psychological well-being.

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