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Research Article

The Impact of Smartphone and Social Media Use on Adolescent Sleep Quality and Mental Health during the COVID-19 Pandemic

Young Lee [1] Judy Blebea [1] Furhut Janssen [1] and Sarah E. Domoff [2]

[1]*College of Medicine, Central Michigan University, Mount Pleasant, MI 48858, USA*
[2]*Department of Psychology, Central Michigan University, Mount Pleasant, MI 48858, USA*

Correspondence should be addressed to Young Lee; lee8y@cmich.edu

Objective. Social media (SM) has gained almost ubiquitous use in society and especially among adolescents; however, there has been rising concern over its negative consequences, including the effects on child behavioral health, such as sleep and internalizing symptoms. Research elucidating the impacts of SM use on young people should be conducted to inform healthier SM usage. This study seeks to understand how SM use and use of phones around bedtime associates with worse sleep quality, depression, and anxiety among youth during the peak of the COVID-19 pandemic and social distancing. *Methods*. This project uses archival data collected in fall 2020 through school-based surveys to adolescents in a rural school district in Michigan. There were a total of 200 participants (91.7% response rate) of which 180 adolescents (12-15 years old, 40.0% male, 55.6% female, 3.9% nonbinary) were included in the analysis based on their SM use, the majority of whom identified as white (91.7%). *Results*. Linear regression analyses indicated that higher self-reported SM use was associated with poorer sleep quality and greater depression ($p < 0.05$). Sleep quality mediated the association between SM use and depression ($p < 0.05$). Furthermore, youth who brought their smartphones to bed with them had poorer sleep quality than those without phones ($p < 0.05$). SM use was not associated with anxiety after controlling for age and gender. *Conclusions*. SM use is associated with higher rates of adolescent depression; however, sleep appears to mediate the relationship. The impacts of bringing a smartphone to bed and self-reported SM use on adolescent mental health may be better predicted via sleep disruption even during a widescale event such as COVID-19.

1. Introduction

COVID-19 has had far-reaching impacts on all levels of society including in the lives of youth when many turned to a digital world to remain connected during lockdowns [1]. There has been debate as to whether this increased screen time, including on social media (SM), has improved mental health through providing a medium of social connection during an isolating time or whether excessive use still worsens mental health [1].

Simultaneously, there has been rising concern over the negative impacts of SM on adolescent mental health and physical well-being. SM has gained almost ubiquitous use in society and especially among adolescents [2]. Concurrently, there has been a rise in depression and anxiety among youth [3]. Adolescent mental health is a pressing public

health issue with 10-20% of children and adolescents being impacted by mental health problems worldwide [4], which was further highlighted and exacerbated by the COVID-19 pandemic [1]. Current research has identified a link between SM use and higher rates of anxiety [5], depression [5], and worse sleep quality [6], yet more research must be conducted to elucidate the relationships between these variables especially in the context of COVID-19.

There has been a well-documented link between increased screen time and worse sleep quality among adolescents [7]. Poor sleep hygiene among adolescents has also been connected to higher rates of mental health problems [8]. It is especially important to investigate SM use in adolescents as it is a period of critical childhood behavioral development and identity formation. One of the first studies to examine SM use, sleep quality, and adolescent mental health

found that sleep mediated the association between SM use and depression and anxiety in Scottish adolescents [7]. Indeed, a recent systematic review of the literature on SM use and depression and anxiety found that sleep quality is a key mechanism linking SM use to adolescent mental health [8].

Although many studies have considered SM use and adolescent behavioral health, few investigations have considered these associations during the COVID-19 pandemic, which is critical given its ongoing impact. For example, social distancing measures and virtual schooling during the pandemic increased adolescents' screen time [9] and created shifts to their daily schedules. As the impact of the pandemic has elevated concerns about adolescent mental health, it is critical to examine if and how SM use and smartphone use at bedtime may be an additional risk factor for poorer mental health among adolescents.

This study is aimed at assessing the associations of SM use with anxiety, depression, and sleep quality in a sample of rural adolescents in the Midwest during the early part of the COVID-19 pandemic. Our first hypothesis (H1) was that increased SM use would be associated with poorer sleep quality, greater depression, and higher anxiety [8]. Our second hypothesis (H2) was that youth who bring their smartphones to bed will have poorer sleep quality, greater depression, and higher anxiety compared to youth who do not bring their smartphones to bed and those without phones [8]. We also predicted that there would be an indirect effect of poor sleep quality on the associations between SM use and depression and anxiety (H3) [8].

2. Methods

Measures were administered to 200 7th and 8th grade students (91.7% response rate) in two schools to evaluate the efficacy of a school-based prevention program on developing healthy SM use during the 2020-2021 academic school year and the height of social distancing and the pandemic. These schools were in a rural school district in Michigan. Students received a link to the survey (which was on Qualtrics) from their classroom teacher. For youth, who were in a virtual classroom, their teachers provided the survey link electronically. To avoid the confound of receiving the intervention, only the baseline survey data was used in the present study. Youth provided assent to participate, and parents completed a form requesting their child not to participate (i.e., a waiver of informed consent was approved). The author's IRB approved this research project (code number: 2020-1179).

3. Measures

The survey gathered information about the amount of self-reported SM use, drawn from prior research [10]. The specific question about SM use asked, "On a typical day, how much TIME do you spend using ANY social media? If you are not sure, just take your best guess. Social media refers to any apps or websites that involve social interaction, such as Facebook, Twitter, TikTok, Instagram, or Snapchat." Participants were asked to respond to the SM use question with the following options: "I don't use social media," "less than 1

hour," "1 hour," "2 hours," "3 hours," and "10 or more hours." Additional data was collected on the amount of time and whether youth brought their phones to bed with them. The question in the survey asked, "Do you bring your smartphone or cellphone with you when you go to sleep," and the potential responses included, "I do not have a smartphone or cellphone," "yes," or "no."

Sleep quality was measured using the sleep-related impairment (SRI) and sleep disturbance (SD) questionnaires from the pediatric Patient-Reported Outcomes Measurement Information System (PROMIS) [11]. PROMIS is a repository of surveys that can be used to assess health behavior among children and adults and was started by the US National Institutes of Health. The PROMIS pediatric short form SRI and SD questionnaires each contain four items, and responses can range from "never" (1) to "always" (5). One example of an item was "I had a hard time concentrating because I was sleepy." A mean score of the 8 items (combined scales) was calculated. The PROMIS pediatric short form is a well-validated measure among adolescents [12]. Cronbach's alpha for this sample was 0.82.

Depression was measured using the Center for Epidemiological Studies Depression Scale for Children (CESD) [13]. This scale is a well-validated measure [14] which contains 20 items, and each response is scored from 0 to 3, with 0 representing "not at all" to 3 representing "a lot." CESD scores can range from 0 to 60. One example of an item is "I was bothered by things that usually don't bother me." Higher scores represent greater depression, with scores of 15 or higher indicative of significant levels of depressive symptoms in children and adolescents. Cronbach's alpha for this sample was 0.85.

Anxiety was assessed via the Penn State Worry Questionnaire (PSWQ) [15]. The PSWQ contains 16 items and asks questions in a Likert scale with 1 representing "not at all typical of me" to 5 "very typical of me." One example of an items is "My worries overwhelm me." Prior research supports the validity of the PSWQ [16]. Total scores can range from 16 to 80, and higher scores represent greater anxiety. Cronbach's alpha for this sample was 0.81.

4. Data Analysis

Prior to testing the hypotheses, the data were examined for normality and presence of outliers. All major study variables were normally distributed, and no outliers were detected. Descriptive statistics and bivariate correlations between major study variables (self-reported SM use, depression, anxiety, and sleep quality) were conducted. Furthermore, group differences in study variables were examined based on demographics, using analyses of variance with Bonferroni's corrected post hoc comparisons. To test H1, linear regression was used (covariates of age and gender were entered into the first step). To test H2, ANOVA was conducted to assess group differences in sleep quality, depression, and anxiety by bringing a smartphone to bed at bedtime. Finally, for H3, mediation analysis was conducted using Hayes' 2017 PROCESS macro and bootstrapping. All statistical tests were conducted using IBM Statistical Package for Social Sciences (SPSS) version 28.0.1.

5. Results

Of the 200 participants, $n = 20$ were removed because these youth reported no SM use. The following information is based on the final sample of $n = 180$. Racial distribution of study participants was predominantly white (91.7%) with a mean age of 13.97 years (SD = 0.67). There were 72 males (40.0%), 100 females (55.6%), seven individuals who identify in neither category (referred to as "nonbinary") (3.9%), and one missing response. Additional demographic information of the sample can be found in Table 1.

One-way analysis of variance (ANOVA) with post hoc Bonferroni comparisons revealed no statistically significant differences in self-reported SM use between gender categories (see Table 2). However, there were meaningful associations between gender and internalizing symptoms of depression $(F(2,178) = 9.27,\ p < 0.001)$ and anxiety $(F(2,176) = 10.40,\ p < 0.001)$. Gender nonconforming youth reported the greatest levels of anxiety $(n = 7,\ M = 65.43,\ \text{SD} = 16.91)$ followed by females $(n = 99,\ M = 51.66,\ \text{SD} = 15.11)$ and then males with the lowest levels of anxiety $(n = 71,\ M = 43.97,\ \text{SD} = 13.37)$. Age was not associated with any major study variables.

H1 was that increased SM use being associated with greater depression, anxiety, and poorer sleep quality. Greater self-reported SM use was correlated with depression $(r = 0.36,\ p < 0.01)$ and worse sleep quality $(r = 0.32,\ p < 0.01)$. Poorer sleep quality was also associated with anxiety and depression $(r = 0.51,\ p < 0.01$ and $r = 0.73,\ p < 0.01$, respectively). Table 3 includes additional bivariate correlation analyses.

Adjusting for age and gender, self-reported SM use is associated with higher rates of depression $(B = 0.29,\ p < 0.01)$. However, this association disappeared when adding sleep quality in the second step of the regression $(B = 0.69,\ p < 0.01;$ see Table 4). Linear regression assessing that the association between SM use and anxiety was not statistically significant indicated that SM use did not associate with anxiety (see Table 5). As demonstrated by the liner regression and bivariate correlation analyses, H1 was supported.

H2 was that bringing smartphones to bed would be associated with higher report of anxiety and depression and poorer sleep quality. ANOVA with pairwise comparisons demonstrated group differences among youth who bring their smartphones versus those who did not (or did not have a phone) on sleep quality $(F(2,178) = 4.61,\ p < 0.05)$. Youth who brought their phones to bed with them $(n = 122,\ M = 2.72,\ \text{SD} = 0.98)$ had the worst sleep quality followed by those who did not bring their phone to bed with them $(n = 49,\ M = 2.42,\ \text{SD} = 0.93)$ and then to those without phones $(n = 8,\ M = 1.80,\ \text{SD} = 0.32)$. One-way ANOVA with post hoc Bonferroni comparison was significant when examining differences in levels of depression by whether youth brought their phones to bed with them (or did not) $(F(2,178) = 7.55,\ p < 0.001)$. Adolescents who brought their phones to bed had higher reported depression $(n = 122,\ M = 23.07,\ \text{SD} = 15.45)$ compared to those who did not bring their phone to bed with them $(n = 49,\ M = 15.51,\ \text{SD} = 13.59)$ and those without phones $(n = 8,\ M = 7.88,$

Table 1: Participant characteristics.

	n (%)/M (SD)
Age (years)	13.97 (0.67)
Gender	
Male	72 (40.0%)
Female	100 (55.6%)
Nonbinary	7 (3.9%)
Race	
White	165 (91.7%)
Black	2 (1.1%)
American Indian or Alaska Native	1 (0.6%)
Asian	3 (1.7%)
Native Hawaiian or Pacific Islander	0 (0.0%)
Biracial	4 (2.2%)
Other	5 (2.8%)
Ethnicity	
Hispanic	5 (3.1%)
Non-Hispanic	158 (96.9%)

Note: one person did not report gender. Percentages may not add to 100 due to rounding.

SD = 9.49). In contrast, anxiety levels did not significantly differ across the groups $(p > 0.05)$. That is, anxiety levels were consistent for those who brought their phones to bed, did not bring phones to bed, or did not have a phone. H2 was supported in that youth who brought their smartphones to bed had higher rates of depression and poorer sleep quality than those who did not bring their phones to bed or who did not have phones.

H3 stated that sleep quality would have an indirect effect on the association between SM use and depression and anxiety. Using 10,000 bootstrap samples, the 95th percentile confidence interval (CI) of the indirect effect was (0.53, 1.73), indicating that there was a significant indirect effect $(ab = 1.11,\ \text{SE} = 0.31)$. Thus, our hypothesis was supported. We examined if there was an indirect effect of sleep quality on the association between SM use and anxiety. Using 10,000 bootstrap samples, the 95th percentile CI of the indirect effect was (0.38, 1.29), indicating that there was an indirect effect $(ab = 0.81,\ \text{SE} = 0.24)$. These results support H3, with sleep quality having an indirect effect on the relationship between self-reported SM use and anxiety.

6. Discussion/Conclusion

This study is aimed at examining the relationship between adolescent SM and smartphone use and sleep quality, depression, and anxiety early during the COVID-19 pandemic. We found that higher levels of self-reported SM use and bringing smartphones to bed were associated with self-reported worse sleep quality and depression. Further, there was an indirect effect of poorer sleep quality on the association between self-reported SM use and depression as well as anxiety, suggesting that SM use around or after bedtime may be the driving factor linking SM use with adolescent mental health concerns. Lending further support to this was our

TABLE 2: One-way analysis of variance with post hoc comparison examining major study variables with gender.

	Male ($n = 72$) M (SD)	Female ($n = 108$) M (SD)	Nonbinary ($n = 7$) M (SD)
PSWQ ($n = 177$)	43.80 (13.05)[a]	51.20 (15.08)[b]	65.43 (16.91)[c]
CESD ($n = 179$)	14.52 (11.22)[a]	22.40 (15.80)[b]	34.71 (20.25)[b]
Social media use (hours) ($n = 179$)	4.95 (3.66)[a]	5.66 (3.29)[a]	7.29 (3.40)[a]
PROMIS pediatric short form ($n = 179$)	2.43 (0.88)[a]	2.64 (0.98)[a]	3.64 (1.38)[b]

Note: superscripts reflect significant mean differences ($p < 0.01$). PSWQ = Penn State Worry Questionnaire; CESD = Center for Epidemiological Studies Depression Scale for Children.

TABLE 3: Pearson's correlations of major study variables (with descriptive statistics).

	PSWQ	CESD	Social media use (hours)	PROMIS pediatric short form
PSWQ ($n = 178$)	—	0.63*	0.13	0.51*
CESD ($n = 180$)	0.63*	—	0.36*	0.73*
Social media use (hours) ($n = 180$)	0.13	0.36*	—	0.32*
PROMIS pediatric short form ($n = 180$)	0.51*	0.73*	0.32*	—
Mean (SD)	49.16 (15.23)	20.32 (15.26)	4.72 (2.86)	2.60 (0.98)
Range	21-80	0-60	1-11	1-5

*$p < 0.01$. Note: PSWQ = Penn State Worry Questionnaire; CESD = Center for Epidemiological Studies Depression Scale for Children.

TABLE 4: Linear regression examining gender, age, social media use, and sleep quality with depression.

	ΔR^2	B
Step 1	0.01	
Gender: male		-0.62**
Gender: female		-0.37*
Age		0.03
$F(3,178) = 6.23**$		
Step 2	0.17	
Gender: male		-0.45*
Gender: female		-0.27
Age		0.02
SM use		0.29**
$F(4,178) = 8.99**$		
Step 3	0.57	
Gender: male		-0.15
Gender: female		0.01
Age		0.06
SM use		0.08
Sleep problems		0.69**
$F(5,178) = 42.27**$		

**$p < 0.01$; *$p < 0.05$. Note: male coded as 1 in gender: male (female and other identified gender as 0) and female coded as 1 in gender: female (male and other identified gender as 0).

TABLE 5: Linear regression examining gender, age, social media use, and sleep quality with anxiety.

	ΔR^2	B
Step 1	0.11	
Gender: male		-0.69**
Gender: female		-0.45*
Age		0.02
$F(3,176) = 6.91**$		
Step 2	0.11	
Gender: male		-0.67**
Gender: female		-0.43*
Age		0.01
SM use		0.03
$F(4,176) = 5.21**$		
Step 3	0.32	
Gender: male		-0.45**
Gender: female		-0.23
Age		0.04
SM use		-0.12
Sleep problems		0.50**
$F(5,176) = 16.14**$		

**$p < 0.01$; *$p < 0.05$. Note: male coded as 1 in gender: male (female and other identified gender as 0) and female coded as 1 in gender: female (male and other identified gender as 0).

finding that youth who had smartphones, and brought them to bed, reported poorer sleep quality compared to youth without phones (and youth who did not bring phones to bed). Although self-reported SM use was not associated with anxiety, an indirect effect emerged suggesting that poorer

sleep quality mediated the association between SM use and anxiety.

Our primary results are consistent with prior literature on association between bringing a phone to bed and SM use and sleep quality [7, 8]. Indeed, sleep as the explanatory

mechanism linking phone or SM use and internalizing symptoms has also been supported in research among adolescents internationally [8].

A surprising finding was the lack of association between self-reported SM use and anxiety. Contrary to our hypothesis, increased SM use was not associated with higher anxiety as has been found in other studies [5]. It is possible that the measure of anxiety used in this study was more reflective of "worries" versus clinical anxiety. Alternatively, given that prior research on this association occurred prior to the pandemic, it is possible that the timing of this administration (during the first year of the pandemic) occurred when adolescents were already experiencing heightened anxiety [17]. Another possibility is we did not capture content or experiences on SM that may exacerbate anxiety, such as fear of missing out [18] or viewing harmful content on social media [19]. Clearly, there is a complex relationship between SM use and adolescent mental health that must be further and more fully studied.

For clinicians or other professionals working with adolescents, greater emphasis should be placed on the importance of good sleep hygiene and educating youth on how increased SM and smartphone use around or after bedtime may disrupt it. Routine health examination screening should also include questions regarding SM and smartphone use in addition to sleep habits.

There were some limitations to this study. The dataset only examined a rural community in Michigan and may not be representative of the greater United States adolescent population. The sample was predominantly white, as typical of this particular rural school setting. Future studies should include more diverse populations regarding age, race, and geographic location. Additionally, there is concern about the accuracy of self-reported SM and smartphone usage. Thus, further research should prioritize using more objective measures of smartphone and social media use, which may more closely approximate actual use [20].

Furthermore, future studies should analyze the directionality of the association between smartphone and SM use with internalizing symptoms. Adolescents who report greater SM and smartphone use may already have anxiety and depression. Utilizing a longitudinal study design would help to assess this directionality, as opposed to the cross-sectional design used in this present study. Additionally, more studies should seek to identify theoretical mechanisms explaining how SM use causes sleep disruption. SM already plays a large role in shaping society and especially more in the lives of youth [3]. To this end, it is critical for further research to be conducted into the impacts of SM use on adolescents and improve their overall well-being.

Abbreviations

SM: Social media.

Data Availability

The survey data used to support the findings of this study have not been made available because the participants did not give consent for their data to be shared publicly.

Conflicts of Interest

Dr. Domoff receives honoraria to present research on problematic media use at nonprofit organizations, schools, and hospital/health systems. She has consulted with health systems about problematic media use and mental health. She is on the board of the Smart Gen Society. Other authors do not have any other conflicts of interest to disclose.

Authors' Contributions

Mr. Lee contributed to the concept and design of study, conducted initial analyses and interpretation of results, drafted the initial manuscript, and reviewed and revised the manuscript. Dr. Domoff contributed to the data analysis and interpretation, drafted the initial manuscript, and reviewed and revised the manuscript. Dr. Janssen and Dr. Blebea contributed to the interpretation of data and results and critically reviewed the manuscript for important intellectual content. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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