FEELINGS ABOUT BEING SOCIAL ONLINE: A CORRELATIONAL STUDY OF SOCIAL MEDIA USAGE, ANXIETY, SLEEP AND DIGITAL STRESS

MATHEMATICAL METHODS IN THE SOCIAL SCIENCES

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ABSTRACT

Social media has become increasingly influential in people’s life. Though the existing body of literature on how social media usage (SMU) can affect one’s mental well-being is already extensive, the results are not conclusive. While some argue the usage is detrimental, others argue that people can build effective support networks through social, thus improving mental health outcomes. The current research investigates how problematic SMU is associated with people’s anxiety levels among college students. In addition, the study aims to investigate the roles of sleep quality and digital stress as mediators in the relationship between anxiety and problematic SMU. Last, the study examines how these relationships differ among American and Chinese populations. Both American (N = 77) and Chinese (N = 144) college undergraduate students participated in the study. We found that excessive SMU is not a predictor of college students’ anxiety levels through Pearson correlation analysis and logit regression analysis with and without mediation effect. However, addictive SMU is a better predictor and positively correlates with anxiety. In addition, both sleep disturbance and digital stress serve as mediators in the relationship between anxiety and addictive SMU. Additionally, the mediation effect of digital stress is only manifest in the Chinese population, whereas the mediation effect of sleep disturbance is present in both populations. Further research should look into other mediators on the effect of SMU on anxiety to clarify the benefits or detriments of SMU, and how effect of SMU differs in various cultures.

INTRODUCTION

Social media usage (SMU) has become increasingly prevalent over the past decade. The Pew Research Center (2021) reports that more than 72% of the adult population in the United States have accounts on social media. Over the past decade, many studies have focused the effect of SMU as it dramatically increased over the years.
A large body of research has found several harms associated with problematic SMU. Hossain et al. (2020) infer from their study that people who browse social media more than 4 hours a day experience a higher level of anxiety than people who only spend less than 2 hours on social media. The role that social media plays in a person's life has rapidly expanded during the outbreak of Covid 19 over the past two years. Due to a lack of interpersonal face-to-face communication, people rely on social media to receive information and news. Unfortunately, the research suggests that the time spent on social media to obtain COVID-related information and social news is positively correlated to the likelihood of manifesting anxiety and depressive symptoms (Hossain et al., 2020; Bendau et al., 2021). Among all the populations, young adults are notably one the most studied population in the field since the majority have social media accounts and use social media daily. The youth population is not specifically immune from the influence of SMU, if not more vulnerable. It is reported that young males and females who browse social media more than an hour daily are 1.60 and 2.15 times more likely to have depressive symptoms (Mundy et al., 2021). Furthermore, the problematic usage of social media is also correlated to social anxiety (Yıldız Durak, 2020), eating disorders (Fitzsimmons-Craft, 2020), and substance abuse (Ng Fat, Cable, & Kelly, 2021).

Nonetheless, the existing body of literature does not reach a clear consensus regarding the benefits and detriments of SMU, even though the body of research on the topic has become relatively extensive. While some research suggests that online communication is favorable in terms of providing emotional support (Sharma, John, & Sahu, 2020), other research indicates the opposite that the sense of responsibility to reply to the messages is positively correlated the feeling of anxiety (Hall et al., 2021). The purpose behind the use of social media also matters. Brailovskaia, Schillack, & Margraf (2020) reports that the users who want to "escape from the negative emotions" and "beat of boredom and pastimes" have a
higher likelihood of exhibiting SMU addiction and mental illness symptoms. Meanwhile, users who utilize social media only for seeking positive emotions and social interaction have a lower likelihood of struggling with problematic SMU or mental disorders. In addition, while a single message on social media was sufficient to decrease the risk of mental illness, a message containing negative emotions and thoughts can also increase such a risk (Sharma, John, & Sahu, 2020). Finally, the platforms through which people collect information also matter. As mentioned previously, the pandemic has intensified the usage of social media. However, people use different resources to collect pandemic-related news and information. Social media users have a higher likelihood of expressing feelings of anxiety and depression than those who get information from official websites of government or health authorities (Bendau et al., 2021).

A potential explanation for the inconclusiveness of the existing body of research is that the definition of problematic SMU is not well operationalized. Unlike substance use disorders, problematic social media is not defined clinically. Some studies adopt a self-report questionnaire, such as Bergen Social media Addiction Scale, to measure the level of addiction to social media as the indicator of problematic SMU (Brailovskaia, Schillack, & Margraf 2020; Barbar et al., 2020). Others created their version of questionnaires or borrowed questionnaires from previous studies to directly measure the problematic usage (Hall et al., 2021; Yıldız Durak, 2020). Some other researchers define problematic SMU by examining how excessive the usage is, and these researchers tend to adopt either a frequency approach (i.e., how often the participant is exposed to the social media) or a direct self-report question of how many hours participants spend on social media daily (Bendau et al., 2021; Hossain et al., 2020; Mundy et al., 2021). Then, with the data collected, the researchers referred to previous literature and recommendations by organizations such as the Center for Disease Control and Prevention (CDC) to decide the cutoff for excessive and non-excessive
usage. As demonstrated by the existing literature, various ways are present to measure problematic usage. As a result, the problematic behaviors defined by one study may not necessarily be the same behaviors defined by the other study, thus creating difficulties in analysis across different research. Moreover, as most questions regarding the usage duration are self-reported, participants may underestimate or overestimate their time spent on social media if they must take a guess instead of relying on reports of actual usage by the third party or apps that track their usage, resulting in questionable accuracy.

Another reason for the widely variable findings regarding the impact of SMU is the study of different pathways mediating the correlation between SMU and its psychological impacts. For example, Ngien & Jiang (2021) find no direct correlation between SMU and psychological stress. However, when they add fatalism, which is defined as one’s belief that his or her health is predetermined by factors that beyond voluntary control, and the level of social media exhaustion as mediating factors, the correlation becomes a significantly positive one. Additionally, for college students, some research indicates that the SMU is positively correlated with the tendency of procrastination, thus potentially further contributing to their anxiety (Yıldız Durak, 2020). Other researchers also studied how SMU affects one’s mental state through disturbed sleep. They report that the usage of social media, especially right before sleep, is associated with decreased duration and quality of sleep, which weakens one's performance during the day (Godsell, & White, 2019; Murdock et al., 2019).

An additional potential mediator of the relationship between anxiety and problematic social media usage is digital stress. Digital stress is an emerging concept that attempts to capture the potentially negative behavioral and psychological response related to social media usage (Hall, Steele, Christofferson, & Mihailova, 2021; Nick et al., 2022). Since this is a nascent concept, there is not yet a precise operationalization of digital stress. Nevertheless, the existing digital stress scales pick up several common themes such as anxious feelings of
presenting oneself on social media, worries generated from being available online, uneasiness associated with being possibly left out by a friend group or society, etc. Nick et al. (2022) report that digital stress is a predictor of overall elevated social media social and is associated with several major mental health variables such as feeling of loneliness, depressive symptoms, and social anxiety. Given its direct association with both mental health outcomes and with social media usage, one reasonable possibility to consider is that digital stress may serve as a mediator in the relationship between anxiety and problematic SMU. The current study predominantly focuses on sleep quality and digital stress as mediators.

Finally, SMU is not only prevalent in Western society. Thomala (2021) reports that about 65% percent of the Chinese population were social media users in 2020, which suggests that there are 926 million social media users on the other side of the world. Given the high prevalence of SMU in China and other Eastern countries, there is good reason to believe that the effects of SMU are certainly not limited to Western societies. Some studies conducted based on the Chinese population already report similar results to those found with Western samples. According to these studies, an increase in SMU is associated with higher levels of interpersonal alienation and learning burnout among students (Wenkai et al., 2022), higher levels of overall stress (Yue, Zhang, & Xiao, 2022), and an increased risk of being diagnosed with depression (Zhong, Huang, & Liu, 2021). However, research with Chinese samples also indicates that social media platforms can benefit their users by increasing the diversity of their network (Pang, 2022). Results regarding the relationship between SMU and mental health is still largely inconclusive with the Chinese population, yet cultural differences may play a role in differences in the relationship between SMU and psychological well-being across cultural groups.

The purpose of the current research is to further explore the correlation between SMU and anxiety among college students. Particularly, while some previous works of literature
already point out a negative correlation between the two investigated variables, the current study will investigate the role of social-media specific stress and sleep in moderating the relationship between SMU and anxiety level (figure 1). In addition, since young adults are more likely to be heavy social media users, this research will contribute to exploring how SMU affects young adults’ lives in general, and also aspires to serve as inspiration for future work exploring potential interventions to ameliorate the negative impacts of SMU. Moreover, this paper aims to adopt measures for both addictive and excessive usage and collect data with the assistance of current technology to receive objective data on the measurements. Finally, this study is international in its focus, and the researcher will collect data from both the United States and China to investigate how SMU and anxiety might be related in different ways across different cultures. Four hypotheses are derived from the research aims:

1. Addictive SMU will be positively correlated with higher levels of anxiety.
2. Excessive SMU will be positively correlated with higher levels of anxiety.
3. Sleep disturbance will serve a mediator between addictive and excessive SMU and level of anxiety;
4. Digital stress will serve as a mediator between more addictive and excessive SMU and level of anxiety.

Besides the four hypotheses analysis, we also intend to look into how these relationships differ in two cultures. Thus, at the end of results section, we will take an exploratory approach and investigate the differences in correlations across two cultures.

Figure 1

Correlations and potential pathways
METHODS

The current research adopted a correlational approach to investigate the relationship between SMU and anxiety level. A survey was distributed as the measure to collect data points. Though correlational study cannot illustrate a causal relationship between the two investigated variables, the current study may point out a direction for future researchers who are interested in conducting an experimental study. Furthermore, certain variables, such as sleep duration and excessive usage of social media cannot be measured in an experiment setting. Thus, a survey is a better instrument in the way that current research can include all the relevant variables into one study.

Participants

The study enrolled students from a private Midwest university in Illinois, the United States and a public university in Shanxi, China. Students who were under 18 years of age were not eligible for the study since the study needed consent from the students' parents to collect the students' information. Participants were enrolled from different channels for this study. The researcher of the study asked University faculty to distribute the survey to students in their classes. The link to the survey was also posted on social media platforms. In other words, the current study adopted convenience sampling. Though convenience sampling often results in bias in data (Cardinal et al., 2015), it is however a more economical way to collect
data considering that a national-wide sampling may be out of the budget of the researcher’s funding and capability.

Since the current study aims to measure the correlation between the SMU and the anxiety level among young adults, college students are a suitable population for the researcher. In addition, the sample was strictly limited to undergraduate students, as graduate students, including master and doctor candidates, have more complicated backgrounds. For example, some master students who pursue an MBA degree may come back to school from a long period of work experience years after their undergraduate education, and it is unreasonable to identify all of them as young adults.

Materials

The study utilized a survey containing questions such as the level of anxiety, sleep quality and duration, time spent on social media, social interaction concerns regarding social media, and the level of addiction to social media to investigate how social media usage is related to the anxiety level directly and through different pathways.

Demographic information Participants answered questions about their age and gender. In terms of gender, participants had the options to identify as male or female or nonbinary genders. These variables are control variables, as previous studies report that higher age and being a male are both associated with a lower level of displaying mental illness (Murdock et al., 2019; Mundy et al., 2021).

Level of anxiety The Generalized Anxiety Disroder-7 (GAD-7) is a 7-item questionnaire that examines frequency of anxiety symptoms over past 2 weeks. Responses to the questions are as follows: 0 ("not at all"), 1 ("Several days"), 2 ("More than half the days"), and 3 ("Nearly every day"). In this study, we consider the average of the scores on 7 questions as an indicator of anxiety level, with the higher score indicating higher level of anxiety. The original GAD-7 has 4 cutoffs, with 0-4 indicating “minimal anxiety”, 5-9 “mild
anxiety”, 10-14 “moderate anxiety”, and 15-21 “severe anxiety” (Kroenke, Spitzer, Williams, & Löwe, 2010). For the logistic regression analysis in this study, we dichotomized the anxiety as the variable into either “minimal anxiety” (indicated by a “0”) if the average score is lower or equal to 4/7 or "beyond minimal anxiety” (indicated by a “1”) if the average score is higher than 4/7. The internal consistency of GAD-7 is high (α > 0.85), and it is one of the most widely adopted clinical anxiety measurements in the field. Considering its authority and high reliability, it would be a good fit to measure anxiety level in the current study.

For the Chinese population, the survey adopted the translated version of GAD-7 which was utilized in previous studies based on Chinese population and has a high internal consistency (α = 0.91) (Zeng et al., 2013).

**Social media usage** The survey directly asked how many hours participants spent on social media daily for the duration. Most smartphones with Android or IOS system provides such a report. Unlike previous studies, instead of asking participants to report these data intuitively, the survey asked participants to go to the "setting" of their phone and find the place where the phone reports the data. Most smartphones with Android or IOS system provides such a report. The survey asked participants from two different cultures to report their social media usage on two different sets of social media. The English version of the survey asked participants to report how much time they spent on social media platforms such as Twitter, Instagram, Facebook, YouTube, Snapchat, TikTok, and others (including Reddit, Pinterest, LinkedIn, etc). The set was selected from the most frequently used social media platforms disclosed in Pew Research Center (2021). The Chinese version of the survey asked participants to report their usage on platforms such as WeChat, Weibo, RED, Kuaishou, TikTok, Zhihu, Douban, Hupu and others. The set was selected from the most frequently uses social media disclosed in The China Social Media Landscape 2019. For the variable, we adopt a dichotomous measure to determine whether a participant is an excessive social media
user: participants who use more than 4 hours of social media daily for the past week are considered as excessive users (input as “1” in the dataset), while participant who spend less than 4 hours of social media daily for the past week are not (input as “0”).

_Bergen Social Media Addiction Scale (BSMAS)_ A brief version of BSMAS was adopted to assess the level of addiction to social media. The BSMAS measures the level of addiction to social media through 6 subcategories (salience, tolerance, mood modification, relapse, withdrawal, and conflict). The scale rates each question under each subcategory on a 5-point scale, with 1 indicating very rarely and 5 indicating very often. We again utilized the average score of 6 questions as the indicator of the addiction level, with a higher score indicating higher risk of social media addiction. The scale has relatively high reliability (α = 0.82) and thus is commonly used in measuring addiction. Several recent studies that focus on problematic usage of social media utilized BSMAS as its measurement for addictive SMU. For example, Chen et al. (2020) indicated that there is a direct relationship between the problematic SMU and psychological distress using BSMAS as the instrument. The results that based on BSMAS are sound especially among the population of adolescents and young adults (Shafi et al., 2021; Huang et al., 2021). Therefore, given its high reliability and common usage, BSMAS is used in the current study to measure the addictive usage of social media.

For the Chinese version, the survey adopted a translated version of BSMAS which was utilized in previous studies based on Chinese population and has a high internal consistency (α = 0.82) (Yam et al., 2019).

_Multidimensional Digital Stress Scale (MDSS)_ MDSS is a self-report questionnaire containing 24 items measuring social media usage-related stress. It consists of 5 categories of measures, including availability stress, approval anxiety, Fear of Missing Out (FoMO), connection overload, and online vigilance. For the current research, the MDSC was modified,
and questions regarding online vigilance were removed from the scale since it has a very high correlation with Fear of Missing Out, and prior research has also demonstrated that it has a weaker association with mental health outcomes (Hall, Steele, Christofferson, & Mihailova, 2021). The MDSC offers an overall stress level score, which is the average of the score for each subcategory, with higher scores indicating more severe addiction problems. The scale was developed through exploratory factor analysis with a young adult population and has high reliability (α = 0.85) and convergent and divergent validity.

For the Chinese version of the survey, the survey adopted a translated version of the Scale. The translator of the Scale is a native Chinese speaker who has 9 years of education in Chinese. Based on the factor analysis, four factors in the shortened version of MDSC in Chinese version have high internal consistence (availability stress α = 0.84; approval anxiety α = 0.88; FoMO α = 0.89; connection overload α = 0.85), and the scale overall also has a high internal consistency (α = 0.91).

Figure 1

*Factor Analysis Plot for Sub-factors of Multidimensional Digital Stress Scale and Overall Digital Stress Score*

*Pittsburgh Sleep Quality Index (PSQI)* The PSQI is a 22-item questionnaire that includes 7 parts: subjective sleep quality, latency, duration, habitual sleep efficiency, sleep
disturbances, use of sleeping medication, and daytime dysfunction. A raw score of 0-3 is rated for each part, and a final score is calculated by taking the average of sub raw scores, with a higher score indicating more disturbance during sleep. The Index has a high reliability ($\alpha = 0.83$) and is widely adopted to measure sleep quality and clinical insomnia (Morris, Rohay, & Chasens, 2018).

The current study adopted a translated version of PSQI in Chinese which was utilized in previous studies based on Chinese population and has reasonable internal consistency ($\alpha = 0.66$) (Guo, Sun, Liu, & Wu).

**Procedure**

*Pilot study* Before the official initiation of the data collection, the researcher asked several college students whose major is psychology or related to psychology and a psychology professor to fill out the survey to confirm the survey was working. After collecting data for the pilot study and affirmed that survey could perform as expected, the survey was then distributed to a larger scale.

*Formal study* Non-college students were excluded from the current study. For the questions related to time spent on social media and hours for sleep, the participants reported whether they have transcribed the data from their phone or provided their own estimation. At the end of the questionnaire, participants were debriefed with more information about the purpose of the survey and the potential harms of excessive and addictive social media usage. The specific procedure for research conduct is shown below (figure 2).

Notably, the contact information of the researcher was included at the beginning and the end of the survey. If a participant had any questions regarding the survey, the participant was encouraged to reach out to the researcher if there was any confusion or questions about
the survey. As the survey was closed for data collection, lists of participants were shuffled for a $5 gift card, and the chance of winning the gift card is about 50%.

![Procedure Diagram]

**Figure 3 Procedure**

**RESULTS**

**Analysis**

The study has three stages of analysis. First, the researchers ran a Pearson correlation among all the factors to demonstrate the direct correlations between anxiety level and independent variables for Chinese and American population separately. Next, a logistic regression model analysis was applied to two data sets separately. Finally, a logit model with mediating factors was applied to two data sets.

**Descriptive analysis**

The study collected 283 responses from the Chinese population and 131 responses from the American population. At the end, 144 responses from the Chinese population and 77 responses from American population were kept for data analysis, and the rest of response were excluded for the reason of incompletion (over 50% questions left unanswered) or for the
reason of plausibleness (e.g., some participants reported that on average they have slept for 24 hours daily for the past week). For the Chinese sample ($n = 154$), the average age of the population is 19.53 ($SD = 1.48$). 33.12% of the selected participants are cisgender males ($n = 51$), 64.94% are cisgender females ($n = 100$), and 1.95% define themselves with non-binary options ($n = 3$). For the American sample ($n = 77$), the average age of the population is 20.72 ($SD = 1.07$). 18.18% of the selected participants are cisgender males ($n = 14$), 75.32% are cisgender females ($n = 58$), and 5.19% define themselves with non-binary options ($n = 4$).

**Hypothesis 1** Positive correlation between anxiety and addictive SMU.

*Pearson Correlation Analysis*

In the American sample, the preliminary analysis shows significant positive correlations between anxiety and digital stress ($r(76) = .38$, $p < .01$) and anxiety and sleep disturbance ($r(76) = .50$, $p < .01$). However, the analysis does not demonstrate significant correlation between anxiety and addictive SMU. Nonetheless, the analysis indicates that addictive SMU has significant positive correlations with digital stress ($r(76) = .64$, $p < .01$) and sleep quality ($r(76) = .24$, $p < .05$), which suggests that addictive SMU may be associated with anxiety through the influence of digital stress and sleep quality.

**Table 1**

*Pearson Correlation Table for Preliminary Correlation Analysis of the American Sample*

<table>
<thead>
<tr>
<th>Variable</th>
<th>anxiety</th>
<th>age</th>
<th>gender</th>
<th>excessiveness</th>
<th>addiction</th>
<th>digital stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>anxiety</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age</td>
<td></td>
<td>.02</td>
<td>-.04</td>
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<td></td>
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<tr>
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<td></td>
<td></td>
<td>-.03</td>
<td>.09</td>
<td>.00</td>
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<tr>
<td>excessiveness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>addiction</td>
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<td></td>
<td>-.07</td>
<td>.08</td>
<td>.07</td>
<td></td>
</tr>
<tr>
<td>digital stress</td>
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<td>.06</td>
<td>-.08</td>
<td>.09</td>
<td>.64**</td>
<td></td>
</tr>
<tr>
<td>sleep disturbance</td>
<td>.50**</td>
<td>-.08</td>
<td>-.09</td>
<td>-.16</td>
<td>.24*</td>
<td>.35**</td>
</tr>
</tbody>
</table>

*Note.* * indicates $p < .05$. ** indicates $p < .01$. 
On the other hand, we found significant positive correlations between anxiety and addictive SMU ($r(153) = .27$, $p < .01$), anxiety and digital stress ($r(153) = .40$, $p < .01$), and anxiety and sleep disturbance ($r(153) = .41$, $p < .01$) in the Chinese sample. In addition, addictive SMU has significant positive correlations with both digital stress ($r(153) = .51$, $p < .01$) and disturbance in sleep ($r(153) = .29$, $p < .01$), and it is possible that the relationship between anxiety and addiction to SMU is mediated by digital stress and sleep quality.

Table 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>anxiety</th>
<th>age</th>
<th>gender</th>
<th>excessiveness</th>
<th>addiction</th>
<th>digital stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>anxiety</td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>gender</td>
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<tr>
<td>addiction</td>
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<td>.17*</td>
<td>.26**</td>
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<td></td>
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<tr>
<td>digital stress</td>
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<td>.15</td>
<td>.16*</td>
<td>.08</td>
<td>.51**</td>
<td>.26**</td>
</tr>
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<td>.05</td>
<td>.01</td>
<td>-.15</td>
<td>.29**</td>
<td>.26**</td>
</tr>
</tbody>
</table>

*Note. * indicates $p < .05$; ** indicates $p < .01$.

Logistic Regression Model

A logistic regression was performed to test the relationship between anxiety and addictive SMU in both populations. In the American population, the addictive SMU was not associated with an increase in likelihood of being more than minimally anxious ($OR = .32$, 95% CIs [-2.38, 0.027]), but increased digital stress ($OR = 4.88$ 95% CIs [0.41, 2.95]) and increased sleep disturbance ($OR = 37.65$, 95% CIs [1.58, 6.28]) are both associated with an increase in likelihood of being more anxious. Interestingly, another significant correlation is between anxiety and gender: in the American population, being female or gender-nonbinary increases the likelihood of being more than minimally anxious ($OR = 4.50$, 95% CIs [0.25, 2.97]).
In the Chinese population, again the addictive SMU was not associated with an increase in likelihood of being more than minimally anxious (OR = 1.62, 95% CIs [-0.23, 1.23]), but increased digital stress (OR = 2.72, 95% Cis [0.19, 1.91]) and increased sleep disturbance (OR = 4.08, 95% Cis [0.38, 2.51]) again are both associated with an increase in likelihood of being more anxious. The gender difference in the American population is not replicated in the Chinese population.

**Hypothesis 2 Positive correlation between excessive SMU and anxiety.**

*Pearson Correlation Analysis*

The analysis does not demonstrate significant correlation between anxiety and excessive SMU in either American or Chinese population. Additionally, the mediating factors (digital stress and sleep disturbance) do not show significant correlations with excessive SMU. The overall correlation between anxiety and excessive SMU is not significant based on the Pearson correlation analysis.

*Logistic Regression Model*

A logistic regression was performed to test the relationship between anxiety and excessive SMU in both populations. The excessive SMU has no significant relationship with anxiety in either American population (OR = 0.43, 95% Cis [-2.63, 0.79]) or Chinese population (OR = 2.72, 95% Cis [0.19, 1.91]).

Overall, the logistic regression model does not reflect significant relationships between anxiety and addictive SMU and between anxiety and excessive SMU. However, both digital stress and sleep disturbance have significantly positive association with anxiety in both populations, and we are going to investigate their role as mediators in the following sections.

**Hypothesis 3 Sleep disturbance as a mediator between excessive and addictive SMU and level of anxiety**
For the American population, based on the logistic regression, the mediation effect of sleep disturbance on the relationship between anxiety and excessive SMU is significantly negative (Difference = -0.81, 95% CIs [-2.13, 0.13]), meaning the more disturbed one’s sleep, the less likely the excessive SMU has a positive effect on anxiety. On the other hand, the mediation effect of sleep disturbance on the relationship between anxiety and addictive SMU is significantly positive (Difference = 0.52, 95% CIs [0.025, 1.39]), suggesting that the more disturbed one’s sleep, the more likely the addictive SMU has a positive effect on anxiety.

Table 3

*Differences of Coefficients of Linear Model Analysis with Mediators of the American Sample*

<table>
<thead>
<tr>
<th>Effect</th>
<th>Difference</th>
<th>SD</th>
<th>95% CI lower</th>
<th>95% CI upper</th>
</tr>
</thead>
<tbody>
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<td>excessiveness</td>
<td>2.27e+04</td>
<td>1.18e+06</td>
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<td>0.43</td>
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<tr>
<td>addiction</td>
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<td>0.40</td>
<td>0.34</td>
<td>1.66</td>
</tr>
<tr>
<td>excessiveness*sleep_disturbance</td>
<td>-0.81</td>
<td>0.51</td>
<td>-2.13</td>
<td>-0.13</td>
</tr>
<tr>
<td>addiction*sleep_disturbance</td>
<td>0.52</td>
<td>0.36</td>
<td>0.025</td>
<td>1.39</td>
</tr>
<tr>
<td>excessiveness*digital_stress</td>
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<td>0.11</td>
<td>-0.17</td>
<td>0.30</td>
</tr>
<tr>
<td>addiction*digital_stress</td>
<td>0.45</td>
<td>0.28</td>
<td>-0.064</td>
<td>1.07</td>
</tr>
</tbody>
</table>

For the Chinese population, the mediation effect of sleep disturbance on the relationship between anxiety and excessive SMU is also significantly negative (Difference = -0.37, 95% CIs [-0.7, 0.088]). The mediation effect of sleep disturbance on the relationship between anxiety and addictive SMU is again significantly positive (Difference = 0.33, 95% CIs [0.10, 0.66]).

Overall, sleep disturbance serves as a significant mediator in relationship between anxiety problematic SMU.

Table 4

*Differences of Coefficients of Linear Model Analysis with Mediators of the Chinese Sample*

<table>
<thead>
<tr>
<th>Effect</th>
<th>Difference</th>
<th>SD</th>
<th>95% CI lower</th>
<th>95% CI upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>excessiveness</td>
<td>0.45</td>
<td>0.28</td>
<td>-0.064</td>
<td>1.07</td>
</tr>
<tr>
<td>addiction*sleep_disturbance</td>
<td>0.52</td>
<td>0.36</td>
<td>0.025</td>
<td>1.39</td>
</tr>
</tbody>
</table>

For the Chinese population, the mediation effect of sleep disturbance on the relationship between anxiety and excessive SMU is also significantly negative (Difference = -0.37, 95% CIs [-0.7, 0.088]) . The mediation effect of sleep disturbance on the relationship between anxiety and addictive SMU is again significantly positive (Difference = 0.33, 95% CIs [0.10, 0.66]).

Overall, sleep disturbance serves as a significant mediator in relationship between anxiety problematic SMU.
Hypothesis 4 Digital stress as a mediator between more addictive and excessive SMU and level of anxiety.

For the American population, based on the logistic regression, the mediation effect of digital stress on the relationship between anxiety and excessive SMU is not significant (Difference = -0.053, 95% CIs [-0.17, 0.30]), and the mediation effect of digital stress on the relationship between anxiety and addictive SMU is also not significant (Difference = -0.053, 95% CIs [-0.064, 1.07]).

For the Chinese population, the mediation effect of digital stress on the relationship between anxiety and excessive SMU is again not significant (Difference = -0.050, 95% CIs [-0.30, 0.14]), but the mediation effect of digital on the relationship between anxiety and addictive SMU is positive (Difference = 0.36, 95% CIs [0.11, 0.67]).

Overall, digital stress is not as strong mediator as sleep disturbance, but it still has a significantly positive effect on relationship between anxiety and addictive SMU in the Chinese population.

Considering the combined mediation effects of sleep disturbance and digital stress, the combined mediation effect on correlation between anxiety and excessive SMU is not significant (difference = -2.39e+04, 95% CIs [-0.45, 0.42]), which suggests that excessive SMU is not associated with anxiety level even after considering the effect of digital stress and sleep disturbance as mediators in American population. The combined mediation effect on correlation between anxiety and excessive SMU is significant (difference = 0.96, 95% CIs [0.
More specifically, the combined mediation effect increased the odds ratio of effect of addictive SMU on anxiety from 0.40 ($p = .11$) to 1.31 ($p = .44$).

In the Chinese sample, the combined mediation effect on correlation between anxiety and excessive SMU is not significant (difference = -0.12, 95% CIs [-0.41, 0.51]), which suggests that excessive SMU is not associated with anxiety level even after considering the effect of digital stress and sleep disturbance as mediators in American population. The combined mediation effect on correlation between anxiety and excessive SMU is significant (difference = 1.25, 95% CIs [-0.25, 1.64]). More specifically, the combined mediation effect increased the odds ratio of effect of addictive SMU on anxiety from 1.53 ($p = .24$) to 2.67 ($p < .01$).

**Cross-cultural analysis: T-tests**

The 77 American participants ($M = 1.13$, $SD = .75$) demonstrated significantly higher anxious level than the 154 Chinese participants ($M = 0.49$, $SD = .59$), $t(125) < .001$.

In addition, the American participants ($M = 2.41$, $SD = .72$) also scored higher on digital stress scale than the Chinese participant ($M = 1.99$, $SD = .62$), $t(133) < .001$.

The last significant difference between two samples is that the American participants ($M = 0.10$, $SD = .31$) are less excessive users than the Chinese participants ($M = 0.54$, $SD = .50$). Notice since we adopt a dichotomous measure for excessive SMU with 1 being excessive and 0 being not excessive, the last statistics can be interpreted as 10% of the American sample population are excessive users, whereas that number is 54% for the Chinese sample population.

**CONCLUSION**

Based on the result of our three-stage analysis, across two populations, the overall analysis demonstrates that addictive SMU, but not excessive SMU, has a direct correlation with the anxiety level (Pearson correlation analysis), though the effect diminishes as we
control for other variables. Thus, our hypotheses 1) is only partially supported if at all, and we fail to reject null hypothesis for hypothesis 2).

Second, sleep disturbance and digital stress have more significant correlations with anxiety compared to excessive and addictive usage of social media overall. Several patterns are also consistent across to populations. First, excessive SMU and sleep disturbance have a negative correlation in both populations according to linear model analysis with mediation, though the correlation is only significant in the Chinese population. This finding intuitively makes sense as excessive social media users may spend time during which they should sleep for browsing social media. Second, addictive SMU and sleep disturbance have a significant positive correlation in both populations. Third, across two populations, a significant positive correlation exists between addictive SMU and digital stress. Finally, the mediation effect of both digital stress and sleep quality is significant on correlation between anxiety and addictive SMU across two sample populations, but only the mediation effect of sleep quality is significant on correlation between anxiety and excessive SMU. Therefore, we supported hypotheses 3) and partially supported hypothesis 4), and we need to further look into whether other mediators have influence on the correlation between anxiety and excessive SMU.

Last, compared to the Chinese sample population, the American populations are more anxious, more digitally stressed, but report less excessive social media usage. The correlation patterns are similar in two populations. However, the magnitude of significant correlations based on the American side of the analysis seem to be larger than the magnitude of significant correlations based on the Chinese side. Additionally, the combining mediation effect on relationship between anxiety and excessive SMU is only significant in the Chinese sample but not in the American sample. The latter two findings may be due to cultural differences, but the sample size may also create an illusion of the difference which we will discussion in next section.
DISCUSSION & STUDY LIMITATIONS

Based on the overall analysis, we partially supported hypothesis 1), 3), and 4). In addition, we find a consistent pattern of significant positive correlations between addictive SMU and digital stress and between anxiety and digital stress. The relationship between digital stress and mental disorders has been established by several studies (Reinecke et al., 2017; Hall, Steele, Christofferson, & Mihailova, 2021; Nick et al., 2022). Therefore, the field should be able to benefit from further looking into the relationship between digital stress and mental well-being and how that relationship may affect the relationship of addictive SMU and mental health.

Several limitations exist for this study. To begin with, the study has a correlational design and adopted convenience sampling for data collection stage. The design necessarily indicates that researchers would not be able to draw causal relationship from this study, and the sampling strategy can likely result in biased samples. In addition, since links to the survey were also distributed on social media platform, participants who gained access to the survey through online channel may be a naturally biased sample, i.e., they are more likely to use social media more often than other participants. Nevertheless, given the funding of the study, the strategies are the most suitable for research operation.

Second, the population of the American sample and that of the Chinese sample are drastically different in number: the size of the Chinese sample was almost three times the size of the American sample. The difference in number and thus the degrees of freedom in analysis may be the reason behind the difference in magnitude in coefficients for the analysis. The imbalance in the sample sizes across the two cultures is also the reason why we did present the analysis of two populations combined. The research team did find more significant results by combining the two samples, but the phenomenon might have occurred due to increased power of analysis instead of the nature of the relationships. Future studies
should incorporate more responses into the analysis. Furthermore, the survey did not set up a question for participant to indicate their ethnicity or whether they are international students. Consequently, when we say “American” and “Chinese” population, we do not know how what percentage of our study sample are Americans or Chinese by nationality, and future research should definitely include the ethnicity question in the data collection instruments.

Though the samples are biased, there were still a number of interesting findings. For example, based on t-test results, though American colleges students in our sample are less excessive social media users, they scored higher on digital stress compared to the Chinese college students in our sample. The differences potentially suggest that while American students on average spend less time on social media, their thoughts are more focused on social media and their presence on social media platforms. For future research, we can measure the level of individualism and collectivism of two cultures in attempt to explain the differences of the relationships between SMU and anxiety level. More specifically, past research suggests that social media users from individualistic culture are more prone to engage in self-enhancement in face of negative events online, whereas individuals from collectivistic culture do not demonstrate this tendency (Wenninger, Cheung, & Krasnova, 2019). However, the sample population from current study does not suggest the similar trend. Therefore, future studies should further investigate how the individualism-collectivism difference manifests itself through social media usage in different contexts.

Another potential bias originates from gender. The researchers were surprised to find that more 60% percent of the participants from both samples were cisgender female college students. While the researchers by no means intentionally excluded males from participating in the study, it seems certain procedures appealed more to female participants than to male participants for them to take part in this study. For future study, researchers should be
cautious about their recruitment material and how the research design speaks to only certain group of people.

Though the current study fails to establish relationships between excessive SMU and anxiety level, researchers should not give up investigating the topic. Projections indicate that the number of social media users by 2026 may top 1.3 billion people in China (Thomala, 2021). The number is also likely to increase in the United States. Thus, as social media becomes an even more inseparable part of daily life for people, the ongoing study of social media and its usage is increasingly crucial in understanding how humans develop and sustain their mental health, and the risk of leaving this area understudied is considerable.

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