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ARTICLE

The Association between Problematic Internet Use, Resilience, and Fatigue in First-Year Medical College Students in China: A Moderated Mediation Model

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ABSTRACT

Background: Resilience is crucial for medical college students to thrive in the highly stressful environment of medical education. However, the prevalence of problematic internet use (PIU) in this population may negatively impact their resilience. This study investigated the influence of problematic online gaming (PG) and problematic social media use (PSMU) on the resilience of medical college students in China. **Methods:** A sample of 5075 first-year medical college students from four Chinese universities was studied. PG served as the independent variable, resilience as the dependent variable, fatigue as the mediator, and PSMU as the moderator. Structural equation modeling was conducted using LISREL 8.80. Additionally, a moderated mediation model was evaluated using the jAMM module in jamovi 2.6.13. **Results:** The study's findings revealed significant negative correlations between resilience and the variables of PG, PSMU, and fatigue. Fatigue mediated the relationship between PG and resilience (B = −0.04, 95% CI = [−0.05, −0.03]). PSMU moderated the direct relationship between PG and resilience with the interaction term PG × PSMU significant (B = −0.004, t = −6.501, $p < 0.001$) and the first stage (PG → fatigue) of the mediation with PG × PSMU significant (B = 0.055, t = 8.351, $p < 0.001$). The detrimental effects of PG on resilience were more pronounced among individuals with lower levels of PSMU. **Conclusion:** This study concluded that addressing PIU, particularly PG, is essential for fostering resilience in medical college students. While PSMU itself is maladaptive, the underlying social media engagement may serve a protective role through social support in mitigating the adverse effects of PG on resilience.

KEYWORDS

Problematic internet use; problematic online gaming; problematic social media use; fatigue; resilience; structural equation modeling; conditional mediation

Introduction

Medical education creates a uniquely stressful environment [1,2], where students shoulder dual roles as learners and healthcare workers, particularly during the pandemic [3,4]. This stress can significantly compromise both their mental health and clinical competence development [5,6]. First-year medical college students are especially vulnerable, showing an elevated risk for mental health disorders [2,7,8]. A longitudinal analysis by McKerrow et al. demonstrated that first-year students reported the highest levels of depression and burnout across multiple time points [2]. Additionally, cross-sectional research has shown that first-year medical college students experience more mental health challenges compared to their senior peers [7]. This heightened vulnerability stems from multiple factors, including adaptation to a new environment, separation from established support systems, management of rigorous academic demands, and adjustment to unfamiliar teaching methodologies [7].

In response to these challenges, resilience—defined as the ability to adapt positively to stressful situations [9–11]—has emerged as a crucial factor in helping medical college students thrive during their educational journey [1,12,13]. However, a concerning trend has emerged: studies have revealed that first-year medical college students exhibit significantly lower average resilience scores compared to the general population [14]. This is particularly noteworthy since higher resilience levels are associated with more effective coping strategies when facing stressors [15]. This vulnerability in resilience is especially concerning given the increasing challenges posed by problematic internet use (PIU) among medical college students.

In recent years, PIU represents a significant concern among medical college students, who demonstrate notably higher prevalence rates compared to both the general population [16] and healthcare professionals [17]. This is especially troubling given PIU's established comorbidity with various psychiatric disorders [18–20]. Despite the heightened vulnerability of medical college students—especially first-year students—to PIU, research examining the relationship between resilience and PIU in this population remains scarce. A comprehensive meta-analysis by Hidalgo-Fuentes et al. [21] identified only one study focused on medical college students, which examined how resilience and self-esteem mediated the relationship between addictive behaviors (including internet use, smartphone use, and alcohol use) and stress [22].

To address this research gap and better understand how first-year medical college students' digital behaviors influence their resilience, this study examines two prevalent manifestations of PIU: problematic online gaming (PG) and problematic social media use (PSMU) [16,17]. This focus builds upon established research demonstrating negative associations between resilience and PIU [23–25]. Drawing from current academic consensus [26], problematic use is defined by three distinct criteria: (1) impaired behavioral control, (2) significant negative consequences across psychological, social, or occupational domains, and (3) persistent preoccupation when not engaging in the behavior. Within this framework, PG manifests as an uncontrollable and persistent pattern of gaming that impairs crucial areas of functioning [27], while PSMU represents excessive social media engagement that compromises personal, social, and professional well-being [28].

Notably, previous studies have primarily conceptualized resilience as an independent variable [23,25,29] or as a moderator/mediator [22,30,31], rather than examining it as a dependent variable. This limited perspective has obscured our understanding of how PIU might affect resilience. While resilience has traditionally been viewed as a stable trait, emerging evidence suggests it is also a dynamic process that can change over time [30,32,33]. Resilience Theory [34] supports this view, defining resilience as the capacity to withstand or recover from adversity, shaped by both risk and promotive factors, as well as the process of adapting to stress.

Various studies have demonstrated the malleability of resilience in response to environmental factors. For instance, Wu et al.'s longitudinal cross-lagged panel analysis revealed that mental health significantly predicts resilience over both short and long terms [35]. Similarly, Panourgia et al. [36] documented how pandemic-related stressors affected mental health professionals' resilience, while Wang et al. [37] identified person-focused factors as key determinants of teachers' resilience. Furthermore, Crowe et al.'s [38] focus group findings revealed complex interactions between help-seeking behaviors, stigma, and resilience, suggesting that prolonged environmental adversities can erode resilience over time.

Cassidy's research [39] emphasizes the crucial role of context in understanding resilience. In the digital age, persistent PIU may create ongoing stress that affects college students' resilience. This consideration is particularly relevant for first-year medical college students, who already face significant academic pressures [7]. The continuous presence of PIU may further compromise their resilience, warranting deeper investigation. Therefore, examining PIU's effects on first-year medical college students' resilience—considering it as a dependent variable subject to temporal changes—becomes essential for understanding and addressing this critical issue.

In addition to examining PIU's direct effects on resilience, understanding the underlying mechanisms of this relationship is crucial. Resilience is conceptualized as a capability [10,15,35], while fatigue—defined as a subjective and unpleasant experience ranging from tiredness to exhaustion [40–42]—can impair an individual's functional capacity and potentially influence their resilience. Notably, research has established associations between PIU and fatigue [43–45]. However, in the context of first-year medical college students, there is a lack of comprehensive research that simultaneously examines the interplay among PIU, fatigue, and resilience.

Therefore, this study addresses the question: what are the associations among PIU, fatigue, and resilience in first-year medical college students? Using a moderated mediation model, we examine how PIU affects these students' resilience. Specifically, we investigate how two forms of PIU—PG and PSMU—influence resilience, hypothesizing

that the relationship between PG and resilience varies with students' levels of PSMU, and that students' fatigue mediates this moderating effect.

This study offers two key innovations: First, it departs from existing literature by specifically examining PIU's influence on resilience among first-year medical college students, with resilience as the dependent variable. Second, it introduces fatigue as a mediator while simultaneously evaluating the interplay among PIU, fatigue, and resilience, thereby enriching our understanding of these constructs within this specific population. The conceptual model and associated hypotheses will be presented in detail in the following sections.

Conceptual Model

To explain the relationship between PIU and resilience, a moderated mediation model was proposed (see Fig. 1). Within this model, three hypotheses were tested and verified.

Hypothesis 1: The direct effect of PG on resilience

Previous research has suggested that resilience plays a protective role against PIU, including PG and PSMU [21,23,24]. These studies have found that low resilience are associated with a higher risk of PIU, and that resilience can moderate the relationship between stress and PIU [22,30]. This protective effect of resilience can be explained by the Interaction of Person-Affect-Cognition-Execution (I-PACE) model [46], which suggests that PIU may be a consequence of interactions between personal characteristics, affective and cognitive responses, and executive functions. Resilience, as the ability to adapt successfully to adversity and deal with stress [9,10], can help individuals avoid or reduce the adverse effects of negative emotions on PIU.

However, it is important to consider the possibility that the relationship between PIU and resilience may be bidirectional. Recent studies have suggested that PIU may contribute to psychiatric symptoms [47–49]. Additionally, an emerging body of work is exploring how PIU affects long-standing psychological attributes such as self-control and self-esteem [50,51]. Resilience, being another enduring psychological attribute, might also be affected by PIU. The ubiquity of smartphones among college students may make excessive use behavior more likely, potentially becoming risk factors according to Resilience Theory [34] to reduce resilience over time. The diagnostics of PIU, such as using the Internet to escape the real world and losing significant personal relationships [52,53], contradict the determinants of resilience [9,10,23], further supporting the notion that PIU may negatively impact resilience.

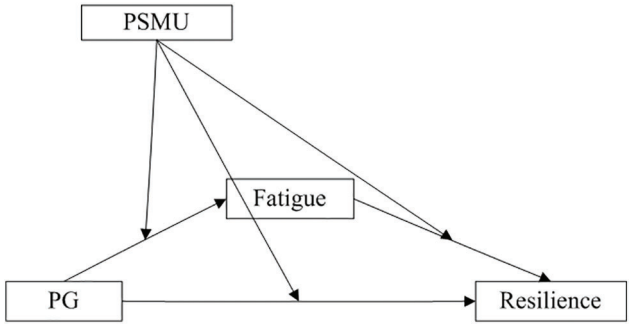

FIGURE 1. The framework of the conceptual model. Notes: PG = problematic online gaming, PSMU = problematic social media use.

To accurately reveal the influence of PIU on first-year medical college students' resilience, it is crucial to investigate specific PIU activities (e.g., PG and PSMU) rather than generalized PIU or smartphone addiction [54,55]. While Park et al. [56] investigated the influence of PIU on resilience, their study focused on middle school students and used the controversial concept of smartphone addiction, highlighting the need for more targeted research on the relationship between specific PIU activities and resilience among medical college students. In this study, we chose PG as the independent variable because it has been shown to have a higher association with people's resilience [24] or psychiatric symptoms [57] compared to PSMU.

Hypothesis 2: The indirect effect of PG on resilience through fatigue

Fatigue, characterized by a range of sensations from mild tiredness to extreme exhaustion [40–42], is closely related to PG and resilience. This relationship is complex and can be elucidated through various research findings. Firstly, fatigue is often provoked by extended participation in demanding mental activities, such as excessive gaming [58]. And research has consistently indicated that PG is associated with an increased level of fatigue, particularly among adolescents, young adults [43], and university students [44].

Secondly, resilience is viewed as a kind of ability [10,15,35], and fatigue can interfere with an individual's capacity [40–42], thus affecting their resilience. A longitudinal study on adults with physical disabilities found that changes in resilience over a one-year follow-up period were significantly associated with changes in fatigue [33]. Additionally, Alharbi et al. [59] found that nurses working 12-h shifts exhibited significantly higher levels of resilience compared to those working 8-h or other shift patterns. This observation suggests that longer periods of continuous rest away from the workplace could contribute to fostering resilience. These findings indicate that a high-demand work environment, when not complemented by sufficient restorative time, can erode workers' resilience, thereby supporting the established link between fatigue and resilience.

The Resource Model of Self-Control [60] provides a theoretical framework for understanding these relationships. According to this model, activities requiring self-control draw from a limited resource pool, and excessive demands can lead to ego depletion. PG, being a resource-intensive behavior, may deplete these self-control resources, resulting in mental fatigue [61]. This fatigue, a state characterized by diminished cognitive function and emotional regulation capabilities, as well as an impaired ability to employ positive coping strategies, could undermine an individual's resilience.

Based on these findings, we hypothesize that fatigue mediates the relationship between PG and resilience among medical college students. PG can lead to fatigue, which in turn, can weaken the resilience of students. Therefore, the indirect effect of PG on resilience through fatigue is a

pivotal consideration when examining the interplay between these variables within the context of medical education.

Hypothesis 3: The moderating effect of PSMU on the relationship between PG and resilience

Previous research has suggested that different forms of PIU may interact and exacerbate their negative consequences [57]. Given the high prevalence of both PG and PSMU among medical college students [16,17], it is important to investigate how these two specific forms of PIU may interact and influence resilience.

We hypothesize that PSMU may moderate the relationship between PG and resilience among medical college students. The rationale behind this hypothesis is based on the two potential pathways: First, PSMU and PG can exacerbate each other's symptoms [62], potentially leading to a greater negative impact on the mental health and resilience of students who engage in both forms of PIU compared to those who only engage in one. And according to the Resource Model of Self-Control, the combined effect of PG and PSMU consuming more self-control resources may lead to a more severe disruption of daily functioning, increased stress, and reduced ability to cope with adversity.

Moreover, PSMU may exacerbate the negative impact of PG on resilience by interfering with the development of protective factors. For instance, excessive social media use may limit face-to-face social interactions [63,64], which are crucial for building resilience. Additionally, the constant exposure to idealized images and experiences on social media may lead to feelings of inadequacy and lower self-esteem, further reducing an individual's ability to cope with stress and adversity [65].

Second, however, it is also plausible that PSMU could exert a protective effect on the relationship between PG and resilience. The social support buffering model [66], which posits that social support can ameliorate the adverse effects of stressors, provides a theoretical framework for understanding this relationship. While PSMU itself is a maladaptive behavior, it reflects underlying social media engagement. Studies have indicated that social media use can provide a sense of social connectedness and support [67,68], which in turn may help to mitigate the detrimental effects of PG on mental health.

Furthermore, while excessive use patterns characterize PSMU, the underlying social media engagement can serve as a way to manage stress or adverse life events [67]. This suggests that even in the context of PSMU, individuals might still benefit from the social support mechanisms inherent in social media use, potentially buffering against the negative impacts of PG on resilience. Therefore, the specific nature of the moderating effect of PSMU on the relationship between PG and resilience requires further investigation.

We propose that PSMU may also moderate the mediating effect of fatigue on the relationship between PG and resilience. As discussed in Hypothesis 2, PG can lead to increased fatigue, which in turn may negatively impact resilience. The moderating effect of PSMU on this mediation pathway may depend on how social media use influences fatigue. Excessive social media use has been associated with increased fatigue [69,70], which may exacerbate the negative impact of PG on resilience through increased fatigue. Conversely, if social media use provides a sense of social support and helps reduce stress, it may attenuate the mediating effect of fatigue on the relationship between PG and resilience.

Given the limited evidence on the specific interaction between PG and PSMU and their combined effect on resilience, this study aims to investigate the moderating role of PSMU on the direct relationship between PG and resilience, as well as on the mediating effect of fatigue. Understanding these complex relationships will provide valuable insights for developing targeted interventions to promote resilience among medical college students.

Method

Participant

Approved by the Jiangxi Psychological Consultant Association (IRB ref: JXSXL-2022-Jul13), this study employed a convenience sampling strategy. The researchers collaborated with the directors of mental health centers at four universities in central China, including one comprehensive university and three medical universities. The research aims were outlined to these directors, who were then asked to assist in administering an online questionnaire to first-year medical college students within their institutions.

The distribution of the questionnaire was strategically timed to coincide with mental health lectures conducted by faculty members of the mental health centers at the end of October. These lectures aimed to underscore the significance of mental well-being for the new medical college students. Prior to disseminating the questionnaire, the instructors emphasized that participation was completely voluntary and that students had the autonomy to discontinue the questionnaire at any point if they chose to do so.

The online questionnaire began with a consent form, which participants had to complete before proceeding to the main questions. The survey was optimized for completion on mobile devices, and due to the platform's functionality, participants were required to answer all questions before their responses could be submitted. To be included in the study, participants had to meet several criteria: a) provide consent by agreeing to the terms on the initial page of the online questionnaire; b) be enrolled as first-year students in a medical program; and c) have no prior diagnosis of a psychological disorder or be listed in the mental health center's records as having a psychiatric condition. An exclusion criterion was set for unreasonable social media and internet gaming usage time, with participants reporting more than 20 h per day being considered unreasonable and thus excluded from the study. In total, 5075 participants, comprising 20.9% males and 79.1% females with an age range of 17 to 18 years, were included in the analysis. Table 1 presents detailed demographic information of the participants, providing insights into the composition of the study group.

TABLE 1

Key characteristics for the participants of the study (n = 5075)

Participant characteristics	
Age in year; n (%)	
17 years	124 (2.44)
18 years	4951 (97.54)
Sex; n (%)	
Male	1061 (20.9)
Female	4014 (79.1)
Sibling; n (%)	
Yes	4512 (88.9)
No	563 (11.1)
Place of birth; n (%)	
Country	3355 (66.1)
Town	1056 (20.8)
City	664 (13.1)
Time internet gaming (hours a day); M (SD)	1.51 (2.19)
Time social media use (hours a day); M (SD)	3.70 (3.17)

Measures

To better align with the hypotheses in our conceptual model, the timeframes for measuring PIU (encompassing PG and PSMU) and fatigue were intentionally varied. Specifically, our hypotheses posited that long-term engagement in PG negatively impacts medical college students. Consequently, the assessment period for PIU symptoms was set to cover the past year, reflecting a long-term perspective. In contrast, the measurement of fatigue was confined to the more immediate past month. This distinction in timeframes was made to capture the potentially chronic nature of PIU and its contrast with the more transient nature of fatigue. The internal reliability of the instruments was evaluated using McDonald's omega [71]. And a confirmatory factor analysis (CFA) was conducted employing maximum likelihood with robust standard errors (MLR) [72] to enhance the reliability of hypothesis testing. Details on the measurement approaches for each construct were provided below, and the items of each construct were listed in Table S1.

PG

PG was assessed using the Internet Gaming Disorder-Short Form (IGDS-SF9) developed by Pontes and Griffiths [73] due to its widespread use and acceptance in the field, as well as its demonstrated sensitivity to detect PG behaviors [74]. This nine-item scale utilizes a five-point Likert scale, ranging from 1 (Never) to 5 (Very often), with higher scores indicating a more severe level of PG. A sample item is, "*Do you systematically fail when trying to control or cease your gaming activity?*" The IGDS-SF9 has consistently demonstrated a unidimensional structure and strong psychometric properties [74]. The Simplified Chinese version of the IGDS-SF9 [75], recently validated among Chinese university students, was used in this study. The validation process revealed factor loadings greater than 0.70 for all items, indicating high reliability and relevance [76]. In this study, the factor loading ranged from 0.740 to 0.878 (see Table S2), indicating the high factorial validity. The scale's reliability, measured using McDonald's omega, was exceptionally high at 0.96.

Fatigue

Fatigue, generally defined as a subjective feeling of tiredness, weakness, and extreme lack of energy (i.e., exhaustion) [41,42], was measured using Short FORM-36 Vitality Subscale of the short form health survey, developed by Ware et al. [77]. The vitality subscale consists of four items, each rated on a four-point Likert scale: 0 (not at all), 1 (less than once a week), 2 (1–2 times a week), and 3 (more than 3 times a week). Among these items, two require reverse scoring. However, as Wu et al. [78] highlighted potential cultural discrepancies in item interpretation, we chose to exclude these reverse-scored items from our analysis. A sample item retained in the study is: "*In the past month, do you often feel tired?*" The scale was chosen to tailor the assessment more closely to the unique context of our study population—first-year medical college students in China. We aimed to capture the immediate and subjective experience of fatigue in the last month in this specific group. The factor loading of two items were 0.728 and 0.857 (see Table S2), respectively, indicating high factorial validity. The internal reliability was acceptable, with a McDonald's omega of 0.77.

PSMU

PSMU was evaluated using the Bergen Social Media Addiction Scale (BSMAS) created by Andreassen et al. [79] in the light of its specificity in assessing problematic behaviors related to social media use. This six-item scale employs a five-point Likert scale for responses, ranging from 1 (Very rarely) to 5 (Almost always), with higher scores indicating an increased risk of PSMU. The BSMAS has demonstrated a unidimensional structure in previous studies [79,80]. The Simplified Chinese version of the BSMAS, validated by Chen et al. [75], was used in this study. A sample item is, "*You use social media in order to forget about personal problems*." This version has shown high factor loadings (0.69 to 0.82) among Chinese university students, indicating strong reliability and relevance [75]. In this current study, the factor loading (from 0.593 to 0.803) demonstrated acceptable validity (see Table S2). The internal consistency of the BSMAS in the current study was robust, with a McDonald's omega of 0.88.

Resilience

Resilience was measured using the Simplified Chinese version of the Connor-Davidson Resilience Scale (CD-RISC) [9] for its comprehensive assessment of resilience. The original CD-RISC consists of 25 items across five factors: "personal competence, high standards, and tenacity," "trust in one's instincts, tolerance of negative affect, and the strengthening effects of stress," "positive acceptance of change and secure relationships," "control," and "spiritual influences" [10]. However, research by Yu et al. [81] suggested that the Chinese version of the CD-RISC is better represented by a

three-factor structure: "Strength," "Tenacity," and "Optimism." Accordingly, the three-factor structure was employed in the current study. The CD-RISC uses a five-point Likert scale for responses, ranging from 0 (Not true at all) to 4 (True all the time). The reliability of the scale, as measured by McDonald's omega, was 0.87 for Strength, 0.94 for Tenacity, 0.79 for Optimism, and 0.96 for the overall scale. Sample items include: "*Things happen for a reason*" (Strength), "*Prefer to take the lead in problem-solving*" (Tenacity), and "*See the humorous side of things*" (Optimism). The factor loadings of the three indicators (means of the three subscales) exceeded 0.8 (see Table S2), indicating satisfactory construct validity.

Data analysis

Data analysis began with descriptive statistics, presenting means and standard deviations to summarize the levels of the variables of interest. Pearson correlation coefficients [82] were then calculated to examine the relationships among these variables. These initial statistical analyses were performed using SPSS version 27.0.

Structural Equation Modeling (SEM) was employed to evaluate the hypothesized conceptual model by using LISREL 8.80. First, the mediation model was tested, with PG as the independent variable, fatigue as the mediator, and resilience as the dependent variable. To facilitate model convergence, the mean scores of the three CD-RISC subscales were used as indicators of resilience. For latent variables other than resilience, raw item scores were used as indicators. Sex and age were included as control variables. Model fit was assessed using the following indices, as recommended by Hu et al. [83]: Comparative Fit Index (CFI) and Non-Normed Fit Index (NNFI) above 0.90, Root Mean Square Error of Approximation (RMSEA) below 0.06, and Standardized Root Mean Square Residual (SRMR) under 0.08.

To examine the moderating effect of PSMU on the direct relationship between PG and resilience, as well as on the first stage (PG → fatigue) and second stage (fatigue → resilience) of the mediation, the "jAMM" module in jamovi 2.6.13 (based on the Lavaan package in R) was utilized. This moderated mediation analysis employed the bias-corrected percentile bootstrap method with 5000 bootstrap samples. Sex and age were included as covariates to control for potential confounding effects.

Results

Before presenting the results of this study, the results of the CFA were presented in the Tables S2 and S3 and Fig. S1. Both the model fit (CFI = 0.957, NNFI = 0.950, RMSEA = 0.064, SRMR = 0.034) and the factor loadings (larger than 0.5) demonstrated acceptable factorial validity in this study [83]. Furthermore, the average variance extracted (AVE) values (see Table 2) are greater than 0.5, indicating satisfactory convergent validity [84].

Table 2 presents the descriptive statistics and Pearson correlations among the variables of interest and values of AVE. The means and standard deviations were as follows: PG (M = 18.21, SD = 7.22), fatigue (M = 4.00, SD = 1.60), PSMU (M = 14.54, SD = 4.09), and resilience (M = 57.62, SD = 16.62). According to the cutoff scores of 32 on the IGDS-SF9 [74] and 19 on the BSMAS [28], approximately 2.0% of participants (n = 98) were at risk for PG, while 9.6% (n = 485) met the criteria for PSMU. The Pearson correlation analysis revealed significant associations among the study variables. The analysis indicated that PG was positively correlated with fatigue ($r = 0.15$, $p < 0.001$) and PSMU ($r = 0.63$, $p < 0.001$), suggesting that as scores in one variable increased, scores in the other tended to increase as well. Similarly, a positive correlation emerged between fatigue and PSMU ($r = 0.19$, $p < 0.001$). Regarding resilience, the analysis showed significant negative correlations with all three variables: PG ($r = -0.13$, $p < 0.001$), fatigue ($r = -0.24$, $p < 0.001$), and PSMU ($r = -0.08$, $p < 0.001$), indicating that as resilience scores increased, scores in these variables tended to decrease. Notably, fatigue exhibited the most pronounced negative relationship with resilience among these variables.

The mediation model using SEM demonstrated a satisfactory fit to the data, with $\chi^2(df) = 1227.77$ (96), CFI = 0.978, NNFI = 0.972, RMSEA = 0.048, and SRMR = 0.020, while controlling for sex and age. All factor loadings exceeded 0.70, indicating good convergent validity in the measurement model. Examination of the path coefficients revealed that PG was positively associated with fatigue ($\beta = 0.19$, $t = 10.24$, $p < 0.001$) and negatively related to resilience ($\beta = -0.12$, $t = -6.89$, $p < 0.001$), which supported H1. Furthermore, fatigue exhibited a negative relationship with resilience ($\beta = -0.25$, $t = -13.49$, $p < 0.001$). The indirect effect of PG on resilience via fatigue was estimated at −0.04, with bootstrap lower and higher limits of 95% confidence interval (LLCI, ULCI) of [−0.05, −0.03], suggesting a significant mediation effect (H2 verified).

Table 3 presents the results of the moderated mediation model using the jAMM module in jamovi, controlling for sex and age. The direct effects of PG on resilience ($\beta = -0.204$), PG on fatigue ($\beta = 0.088$), and fatigue on resilience ($\beta = -0.211$) were all significant, consistent with the findings from the

TABLE 2

Descriptive statistics and Pearson correlations among the variables of interest (n = 5075)

	Mean (SD)	1	2	3	4	AVE
1. PG (range: 9–45)	18.21 (7.22)	1.00				0.700
2. Fatigue (range: 2–8)	4.00 (1.60)	0.15	1.00			0.609
3. PSMU (range: 6–30)	14.54 (4.09)	0.63	0.19	1.00		0.538
4. Resilience (range: 0–100)	57.62 (16.62)	−0.13	−0.24	−0.08	1.00	0.855

Note: All p-values < 0.001.

TABLE 3

Results of moderated mediation analysis (coefficient and bootstraps confidence interval)

	Mediator model					Dependent model				
			95% CI					95% CI		
	B (se)	*t*	LLCI	ULCI	*β*	B (se)	*t*	LLCI	ULCI	*β*
Sex (ref: Male)	−0.004 (0.001)	−6.436	−0.005	−0.003	−0.075	0.055 (0.007)	8.401	0.042	0.068	0.098
Age years (ref: 17 years)	0.129 (0.055)	10.134	0.104	0.155	0.143	−5.211 (0.562)	−9.275	−6.312	−4.109	−0.128
PG	0.078 (0.011)	7.131	0.057	0.100	0.088	−1.267 (0.114)	−11.136	−1.490	−1.044	−0.204
PSMU	0.129 (0.013)	10.134	0.104	0.155	0.143	−0.412 (0.167)	−2.476	−0.739	−0.086	−0.075
PG × PSMU	−0.004 (0.006)	−6.501	−0.005	−0.003	−0.075	0.055 (0.007)	8.351	0.042	0.068	0.098
Fatigue						−1.158 (0.488)	−2.372	−2.115	−0.201	−0.211
Fatigue × PSMU						−0.054 (0.031)	−1.724	−0.115	0.007	−0.025

Notes: PG = Problematic online gaming, PSMU = Problematic social media use. LLCI and ULCI refer to lower and higher limits of 95% confidence interval.

TABLE 4

Conditional effects of PG on fatigue and resilience, moderated by PSMU level

Moderator (PSMU) level	Effect	Estimate	SE	Lower	Upper	*p*
PG ⇒ Fatigue						
Mean −1 SD		0.034	0.005	0.024	0.045	<0.001
Mean		0.018	0.004	0.010	0.026	<0.001
Mean +1 SD		0.002	0.004	−0.007	0.009	0.718
PG ⇒ Resilience						
Mean −1 SD		−0.567	0.054	−0.675	−0.460	<0.001
Mean		−0.368	0.041	−0.449	−0.287	<0.001
Mean +1 SD		−0.169	0.043	−0.253	−0.086	<0.001
PG ⇒ Fatigue ⇒ Resilience						
Mean −1 SD		−0.068	0.011	−0.091	−0.046	<0.001
Mean		−0.043	0.010	−0.061	−0.024	<0.001
Mean +1 SD		−0.007	0.011	−0.028	0.014	0.495

Notes: PG = Problematic online gaming, PSMU = Problematic social media use.

SEM analysis. Furthermore, the moderated mediation analysis revealed significant moderating effects of PSMU on the first stage of mediation, specifically the association between PG and fatigue. The interaction term PG × PSMU was significant (B = −0.004, t = −6.501, p < 0.001). Additionally, the direct effect of PG on resilience was also moderated by PSMU, with the interaction term PG × PSMU being significant (B = 0.055, t = 8.351, p < 0.001), which partially confirmed H3.

LLCI and ULCI refer to lower and higher limits of 95% confidence interval.

Moreover, the results of the conditional effects (see Table 4 and Fig. 2) showed that the positive association between PG and fatigue is stronger at lower levels of PSMU. The negative indirect effect (PG → fatigue → resilience) is more pronounced at lower levels of PSMU. Specifically, the negative indirect effect is only significant at low (Mean −1 SD) and mean levels of PSMU, while not significant at high levels of PSMU (mean +1 SD), as indicated in Table 4.

Finally, the direct effect of PG on resilience was also stronger when PSMU was lower (see Table 4 and Fig. 3). These findings suggest that the detrimental effects of PG on resilience, both directly and indirectly through increased fatigue, are more pronounced among individuals with lower levels of PSMU.

Discussion

Overall, this study investigated the complex relationships between PG, PSMU, fatigue, and resilience among first-year medical college students in China. The findings revealed that PG was negatively associated with resilience, both directly and indirectly through increased fatigue. Additionally, PSMU moderated the direct relationship between PG and resilience and the first stage of the mediation (PG → fatigue). Interestingly, the detrimental effects of PG on resilience and fatigue were more pronounced among individuals with lower levels of PSMU.

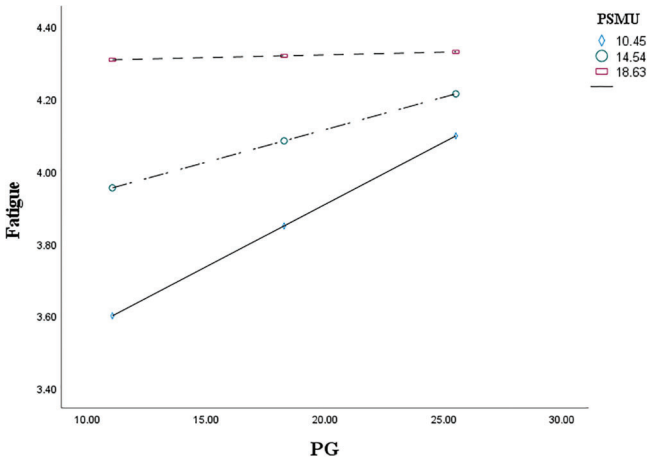

FIGURE 2. The association between PG and fatigue at different levels of PSMU. Notes: PG = Problematic online gaming, PSMU = Problematic social media use.

The study contributes to the understanding of the mechanisms through which PIU influences resilience in medical college students and highlights the importance of addressing these issues to promote mental well-being in this population.

The association among PG, fatigue and resilience

The results of the current study suggest a different mechanism for the relationship between PIU and resilience than previous studies that used resilience as a protective factor for PIU [21,23,24]. Based on the present study's findings, PG, as a specific form of PIU, served as the independent variable and negatively impacts first-year medical college students' resilience, which enriches the existing literature that suggested PIU contributed to psychiatric symptoms [47–49]. Similarly, PG positively affects fatigue, and fatigue negatively impacts resilience, which is consistent with previous literature [33,43,44,59]. Through this research mechanism, we can gain a deeper understanding of the relationship between PIU and resilience.

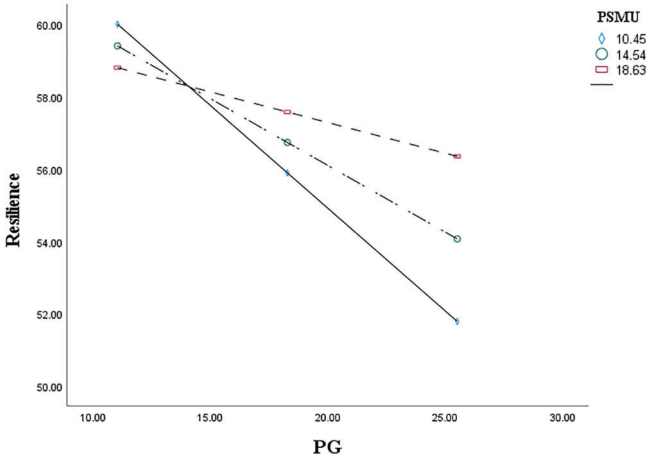

FIGURE 3. The association between PG and resilience at different levels of PSMU. Notes: PG = Problematic online gaming, PSMU = Problematic social media use.

The role of fatigue in the relationship between PG and resilience

The findings highlight the significant role of fatigue as a mediator in the relationship between PG and resilience among medical college students. This finding is consistent with previous research that has identified the detrimental effects of PG on fatigue and the subsequent impact on mental health and well-being [43,44]. For example, Männikkö et al. [43] conducted a cross-sectional study among Finnish adolescents and young adults, revealing a significant association between PG and fatigue.

However, the focus on the mediating role of fatigue in the context of resilience is relatively novel. Previous studies have investigated the relationship between fatigue and resilience [33,59]. However, they have not specifically examined this association in the context of PIU. The present findings suggest that the negative impact of PG on resilience can be partially explained by the increased levels of fatigue experienced by individuals engaging in excessive online gaming. This highlights the importance of addressing both PG and fatigue when designing interventions to promote resilience among medical college students.

The moderating effect of PSMU on PG and resilience

The findings regarding the moderating effect of PSMU on the relationship between PG and resilience are intriguing and somewhat inconsistent with existing literature. Previous research has suggested that different forms of PIU may be relatively independent [85] or interact and exacerbate their negative consequences [57,62]. However, the current study found that higher levels of PSMU did not worsen the detrimental effects of PG on resilience and fatigue. This inconsistency may be attributed to the demographic composition of the study sample, which was predominantly female (79.1%), and our specific focus on gaming and social media use rather than other forms of problematic internet behaviors.

This predominately female sample composition may help explain our findings, as research has indicated that females exhibit higher scores in PSMU compared to males [86] and are more inclined toward social media communication [87]. While PSMU represents excessive and maladaptive use patterns, the underlying social media engagement can provide a sense of social support and connectedness [67,68], particularly important in the context of rigorous academic stress faced by first-year medical college students. According to the social support buffering model, this social support derived from social media use could potentially mitigate the negative impact of PG on resilience. This model posits that social support can act as a buffer against stress, thereby reducing the adverse effects on psychological outcomes such as resilience.

Additionally, the motivations and gratifications associated with PG and PSMU may differ [68,88], leading to a more complex interplay between these behaviors and their impact on resilience among medical college students. Future research should aim to replicate these findings in diverse populations and explore the potential protective factors and underlying mechanisms associated with PSMU in the context of PIU and resilience.

The findings also highlight the need for a more nuanced understanding of the relationship between different forms of PIU and their consequences. While some studies have suggested that PIU should be conceptualized as a spectrum of related yet distinct conditions [85], others have emphasized the importance of examining the specific motivations and contexts associated with each behavior [68]. The present study's results support the latter perspective, indicating that the interactions between PG and PSMU and their impact on resilience may be more complex than previously thought.

Implications for intervention and prevention strategies

The findings underscore the significance of raising awareness among first-year medical college students regarding excessive internet gaming and social media use. The results also suggest that integrating resilience training and stress management workshops into the medical curriculum could be beneficial. Educators can foster an environment that promotes healthy coping mechanisms and digital literacy, equipping students with the skills to navigate the demands of medical education without resorting to PIU. Furthermore, the significant mediating role of fatigue in the relationship between PG and resilience highlights the need for interventions that target problematic gaming behaviors. Interventions should focus on promoting mindfulness and relaxation techniques to reduce fatigue, and raising awareness about the potential negative consequences of excessive gaming [89,90]. Additionally, establishing peer support groups and mentorship programs can provide students with a network of resilience.

The moderating effect of PSMU, although inconsistent with some previous findings [57,62], suggests a more nuanced approach to intervention and prevention strategies that takes into account the specific motivations and contexts associated with each behavior [68]. Moreover, interventions should promote protective factors, such as social support and connectedness [67,68], and be tailored to the specific needs and contexts of medical college students. A comprehensive and multifaceted approach to intervention and prevention strategies that addresses the complex interplay between PIU, fatigue, and resilience is essential for promoting mental well-being and academic success in this population.

Limitations and future research directions

While the current study contributes to the understanding of the complex relationships between PIU, fatigue, and resilience among medical college students, several limitations should be acknowledged. First, the cross-sectional design of the study precludes causal inferences, and future research should employ longitudinal designs to establish the temporal relationships between the variables of interest. Second, the reliance on self-report measures may be subject to response bias, and future studies should consider incorporating objective measures, such as time-tracking software, to provide more accurate assessments of fatigue and PIU. Third, our study employed only two items from the Short FORM-36 Vitality Subscale, which falls slightly below the conventional minimum of three items typically recommended for construct measurement. While this approach is acceptable within the SEM framework, it is recommended that future studies consider alternative fatigue measures that avoid the need for reverse scoring. Fourth, our study's sample, limited to first-year medical college students from four Chinese universities and exhibiting a notable gender imbalance with a predominance of female participants, who demonstrated higher levels of PSMU compared to their male counterparts, could restrict the generalizability and representativeness of our findings and potentially influence the study outcomes. To bolster the robustness and applicability of future studies, it is imperative to incorporate a more diverse student population. This should include individuals from a wider array of educational levels, and academic fields, as well as striving for a gender distribution that is more evenly balanced. Finally, to assess the enduring impacts of PIU, participants were queried regarding their internet use from the end of October through the preceding year. While this approach aimed to differentiate the temporal association between PIU and fatigue (with fatigue measurements confined to the more immediate past month to capture its transient nature), we acknowledge that this measurement timing presents a limitation. Since our first-year medical college students were surveyed about their internet use spanning both pre-college and early college periods, the PIU characteristics we observed may not fully represent their experience as medical college students. Future studies should consider alternative approaches to better capture PIU patterns specific to first-year medical college students, such as conducting follow-up assessments throughout their first academic year or implementing a longitudinal design that tracks changes in internet use patterns from pre-enrollment through the first year of medical school.

Conclusion

This study sheds light on the complex relationships between PIU, fatigue, and resilience among medical college students. The findings emphasize the mediating role of fatigue in the relationship between PG and resilience, highlighting the need to address both gaming behaviors and fatigue issues in interventions. The moderating effect of PSMU on the relationship between PG and resilience suggests a nuanced understanding of the interactions between different forms of PIU and their consequences. The implications of these findings point towards the development of comprehensive and multifaceted intervention and prevention strategies that target individual behaviors and broader contextual factors. By addressing the unique challenges faced by medical college students and promoting protective factors, such as social support and connectedness, interventions can effectively foster resilience and academic success. Considering the dynamic nature of digital behaviors and psychological resilience within the context of medical education, it is essential for future research to validate these findings across diverse cohorts. Additionally, incorporating longitudinal study designs would enhance the understanding of these phenomena over time.

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Availability of Data and Materials: The data supporting reported results are available from the corresponding author upon reasonable request.

Ethics Approval: The study was conducted in compliance with the principles outlined in the Declaration of Helsinki, and approved by the Jiangxi Psychological Consultant Association (IRB ref: JXSXL-2022-Jul13). Written informed consent has been obtained from all participants involved in the study.

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