RESEARCH ARTICLE

Problematic internet use and suicidal ideation: The mediating role of sleep problems and depression

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ABSTRACT

Suicidal Ideation (SI) is the thoughts and planning steps of ending one's life. Prior studies have proved the relationships between Problematic Internet Use (PIU) and SI in the adolescents. However, how Sleep Problems and Depression work as the mediating mechanism is necessary to be investigated. This study explores the chain mediated role of Sleep Problems and Depression in the relationship between PIU and SI in college students using cross-sectional data. A cross-sectional design was implemented with 579 Chinese undergraduates (M_{age}=18.43±0.45). Validated instruments assessed: Problematic internet use severity, sleep problem, depressive symptoms, and suicide ideation. PROCESS Macro v4.0 (Model 6) with 5,000 bootstrap samples tested the hypothesized chain mediation, controlling for gender and academic year. Sleep Problems and Depression have a significant chain mediation effect on Problematic Internet Use and Suicidal Ideation (PIU → PQSI → BDI → BSI). Our findings establish sleep problems induced depression as a critical mechanistic pathway translating PIU to SI. The results advocate for integrated prevention programs combining PIU screening (using IAT cutoff ≥ 40), cognitive-behavioral therapy for insomnia (CBT-I), and depression monitoring.

Keywords: problematic internet use; sleep problems; depression; suicidal ideation

1. Introduction

Contemporary epidemiological surveillance documents a 36% surge in adolescent suicide rates since 2000 [1], with suicide ideation (SI) prevalence exceeding 19% in Asian youth cohorts [2]. This developmental period constitutes a neurobiological "perfect storm"—characterized by prefrontal cortical immaturity, heightened limbic reactivity, and increased social-evaluative stress—creating critical windows for psychopathological cascades.

Problematic internet use (PIU) acts as a key risk factor for adolescent SI that is receiving increasing attention from researchers and practitioners [3]. Contemporary extensions identify PIU as a novel capability accelerator through digital self-harm normalization. PIU prevalence now affects 23.8% of Chinese adolescents, defined by: (1) Compulsive online engagement with a loss of control (Young's IAT≥70). (2) Withdrawal symptoms during abstinence. (3) Functional impairment across academic/social domains (DSM-

5 behavioral addiction criteria).

The most well-known comorbid condition of PIU is Sleep Problems and Depression. One of the most serious adverse events of PIU is suicide. However, scant studies have examined whether depression played a mediating role in the association between PIU and SI. Understanding the potential mediating role of depression is essential, as it may constitute a primary pathway through which problematic Internet use (PIU) contributes to elevated suicide risk. Moreover, given the well-documented bidirectional relationship between sleep problems and depression, sleep problems may further amplify the influence of PIU on suicidal ideation. However, existing research has largely overlooked this interconnected framework, particularly in culturally specific contexts such as Chinese university students. Addressing these gaps could provide valuable insights into targeted interventions aimed at mitigating suicide risk among individuals with PIU.

1.1. Suicidal ideation

According to Reynold [4], SI includes thoughts about death, suicide, major self-harm, and planning steps resulting in the actual act of suicide. In the opinion of Heckler, De, and Barbosa (2022), the initial phase of the risk scale is SI, which might serve as a gateway for suicide [5].

Brand et al [6] propose the I-PACE model for PIU, which comprises four components: P (person's characteristics), A (affective responses), C (cognitive responses), and E (executive functions and internet usage decisions). The model's interaction occurs in three stages: individual factors initially influence affect, cognition, and executive functions; repeated internet use reinforces behavior through cognitive evaluations and emotions; and addiction leads to increased affective swings and cognitive biases, making quitting difficult.

1.2. The impact of PIU on SI

PIU has been identified as a key risk factor for SI among adolescents. It is generally characterized by excessive, risky, or impulsive internet use that leads to negative consequences in various aspects of life, including psychological health, social functioning, learning, and work [7][8]. Their heightened impulsivity, combined with the stressors of PIU, can contribute to increased suicidal thoughts and behaviors. These behaviors result in a range of negative outcomes, including neglect of social activities, relationships, health, and academic or work responsibilities, as well as disruptions to sleep and eating habits [3].

With the rapid advancement of Internet technologies, increasing attention has been paid to the relationship between PIU and SI. Prior research indicates that individuals with higher levels of PIU exhibit a greater frequency of SI compared to control groups. Lin et al. [9] conducted a study with 9,510 adolescents in southern Taiwan, finding that 18.7% of adolescents met the criteria for internet addiction, while 18.03% reported SI.

1.3. PIU affects SI through sleep problems

Extensive evidence identifies Sleep Problems as a robust predictor of SI [10]. Defined as clinically significant disturbances in sleep initiation, maintenance, or quality, chronic sleep impairments exert detrimental effects on adolescent neurodevelopment [11] and psychological functioning [12], constituting a critical public health concern [13].

Empirical findings from Chinese adolescents reveal a dose-response relationship: 23% reported persistent sleep difficulties, with those experiencing problems falling asleep (PFA) demonstrating 3.5-fold increased odds of SI [14]. A meta-analytic U-curve association further indicates optimal suicide risk reduction at 8-hour nightly sleep duration [15].

Notably, Guo et al. [16] identified Sleep Problems as a significant mediator between PIU and SI. This suggests that PIU-induced circadian disruption and hyperarousal states may potentiate suicidality through neurocognitive pathways. Complementary evidence implicates fear of missing out (FoMO) – defined as persistent anxiety about missing rewarding social experiences – as a catalyst for compulsive digital engagement. Such technology-driven sleep displacement likely initiates cascading effects on emotional regulation and executive functioning.

1.4. PIU affects SI through sleep problems and depression

Major depressive disorder (MDD), characterized by persistent feelings of hopelessness and anhedonia, constitutes a critical risk factor for SI. Emerging evidence posits depression as a potential mediator between PIU and SI through neurocognitive and psychosocial mechanisms.

Davis's cognitive-behavioral model posits that pre-existing depression amplifies maladaptive Internet-related cognitions (e.g., "Online interactions are safer than face-to-face communication"), thereby reinforcing PIU behaviors. Empirical studies consistently demonstrate bidirectional associations between PIU and depression severity, with longitudinal data indicating PIU predicts subsequent depressive symptoms. Notably, technology-mediated depression expression – particularly public disclosure of depressive effect on social media – correlates with subclinical depression levels among college populations.

The PIU-depression-SI pathway may involve three key mechanisms: First, neurobiological vulnerability[16], involving reward circuit dysregulation that predisposes compensatory internet overuse. Second, stress potentiation, where genetic risks interact with digital stressors (e.g., cybervictimization), leading to ACC hypoactivation impairing emotional regulation. Last, cognitive-behavioral entrapment via algorithm-driven negative content reinforced Beck's triad while online social withdrawal sustained maladaptive rumination-avoidance cycles.

Emerging evidence identifies PIU as a significant predictor of SI, with Sleep Problems and depression constituting potential mediating pathways [17]. Neurobehavioral models posit that PIU-induced circadian rhythm disruption dysregulates hypothalamic-pituitary-adrenal (HPA) axis activity, thereby elevating depressive symptomatology and subsequent SI risk.

1.5. Gaps in the literature

Emerging evidence suggests two critical pathways linking PIU to SI: First, sleep problems act as a mediator between PIU and SI[17], potentially through circadian rhythm disruption and hyperarousal mechanisms. Second, the sleep problem-depression-SI pathway is well-established: chronic sleep problems predict depressive symptom onset, which subsequently elevates SI risk[10]. Neuroimaging studies further indicate shared neural substrates (e.g., prefrontal-amygdala dysconnectivity) between sleep problem-depression comorbidity and SI[17].

Two research gaps merit attention: First, cultural specificity deficit existing models predominantly derive from Western populations[17], despite China's adolescent internet penetration rate reaching 87.3% and documented cultural variations in digital engagement patterns. Second, the dose-response relationship between PIU severity and pathway dynamics remains unexamined.

The study aimed to explore the relationship between PIU and SI, as well as the mediating role of sleep problems and depression. Our hypotheses are as follows:

Hypothesis 1: PIU positively predicts SI.

Hypothesis 2: Sleep Problems mediates the relationship between PIU and SI.

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Hypothesis 3: Depression mediates the relationship between PIU and SI.

Hypothesis 4: Sleep Problems and Depression are the sequential mediators between PIU and SI.

Hypothesis 5: PIU severity positively predicts SI through serial mediation by sleep problem and depression.

2. Methods

2.1. Subjects

Based on the empirical rule of parameter estimation quantity, Wolf stated that the minimum sample size should be 200 for robust model fitting analysis [18]. Therefore, the optimal sample size range for this experiment is 300-500.

Patients with severe mental disorders and substance abuse will not be included in the admission criteria for this participant. The participants are from grades 1 to 4 of university and come from various social classes, but the economic status of the subjects has not been collected for this time.

This multicenter study investigates 579 freshmen of a university in Guangdong Province through ecological momentary assessment to test. The average age of the participants was 18.43±0.45 years. A total of 579 valid surveys were gathered, yielding a 100% effectiveness rate. All participants must read and sign an informed consent form. The university's ethics committee authorized the study.

2.2. Measures

2.2.1. Problematic internet use (IAT)

Based on the diagnostic criteria for compulsive gambling outlined in the DSM-IV, Young [19] developed the 20-item Internet Addiction Test (IAT). The IAT consists of three subscales: reality substitution, time management and performance, and retreat and social problems [19]. Respondents rate each item on a 5-point Likert scale ranging from 0 ("not applicable") to 5 ("always"), with higher scores indicating greater severity of Internet addiction symptoms. According to Young [20], a total score of 70 or above denotes severe compulsive Internet use, characterized by substantial disruptions to daily functioning. Scores between 40 and 69 indicate moderate problematic Internet use (PIU), while scores below 40 reflect mild levels of use, often involving only minor self-regulation issues. In the present study, the IAT demonstrated excellent internal consistency, with a Cronbach's alpha coefficient of 0.93.

2.2.2. Sleep problems (PSQI)

The present study utilized the 19-item self-reported Pittsburgh Sleep Quality Index (PSQI) to assess multiple dimensions of sleep quality. The PSQI measures seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. Each component is rated on a scale from 0 (no difficulty) to 3 (severe difficulty), with higher global scores indicating poorer overall sleep quality. According to Buysse [21], a global PSQI score greater than 5 is indicative of poor sleep quality, whereas scores of 5 or below reflect good sleep quality. In the current study, the PSQI demonstrated acceptable internal consistency, with a Cronbach's alpha coefficient of 0.74.

2.2.3. Depression (BDI)

The 21-item Beck Depression Inventory (BDI), developed by Beck [22], is a widely used self-report measure for assessing the severity of depressive symptoms and related cognitive and affective attitudes. Each item is rated on a 4-point scale ranging from 0 (no symptoms) to 3 (severe symptoms), resulting in a total

score between 0 and 63, with higher scores indicating more severe depressive symptomatology. The BDI evaluates symptoms experienced over the past week. In the present study, the BDI exhibited excellent internal consistency, with a Cronbach's alpha coefficient of 0.94.

2.2.4. Suicidal ideation (BSI-CV)

Suicidal ideation severity over the past week was assessed using the revised Chinese version of the Beck Suicide Intention Scale (BSI), developed by the Beijing Psychological Crisis Research and Intervention Center. This 19-item self-report instrument comprises two dimensions: suicidal ideation (items 1–5) and suicidal propensity (items 6–19). Higher total scores indicate greater severity of suicidal ideation. The overall score is obtained by summing all item scores. In the current study, the BSI demonstrated acceptable internal consistency, with a Cronbach's alpha coefficient of 0.73.

2.3. Data analysis

This study used Suicidal Ideation (BSI) as the ultimate dependent variable, Problematic Internet Use (PIU) as the independent variable, Sleep Problems (PSQI), and Depression (BDI) as mediating variables to analyze the influencing factors of Suicidal Ideation. Firstly, a stratified linear regression analysis model was used for main effect testing, where the independent variable problem internet use (PIU) was classified into three levels of mild, moderate, and severe according to scores, and the mediating and dependent variables were continuous variables of actual scores.

To further examine the indirect relationship between Sleep Problems and Depression in the impact of Problematic Internet Use on Suicidal Ideation, this study used the SPSS Macro Plugin PROCESS 4.1 to test the mediating mechanism. The mediating effect was examined using the bootstrap method, following the recommendations of Hayes and Preacher. To evaluate the significance of the mediation effects, a chained mediation model (Model 6) was implemented via the PROCESS macro. The Bootstrap 95% confidence interval (5000 iterations) was used to determine whether it included 0. If the mediating effect was significant, the 95% confidence interval did not include 0. Since the independent variable problematic network was used as a categorical variable (1=mild, 2=moderate, 3=severe), relative indirect effects and relative direct effects were introduced. Effect and relative total effect, with 1=mild as the reference group, Set dummy variables for 2=moderate and 3=severe, with sleep problems and Depression as mediating variables, to further test the chain mediation mechanism.

3. Results

3.1. Descriptive statistics

The results showed that gender had significant differences in PIU ($p < .05$). Female students had a higher degree of SI than male students. It also indicated significant differences in PSQI across grade levels ($p < .05$), with higher-grade students experiencing greater levels of sleep problems compared to their lower-grade counterparts (**Table 1**). All variables were significantly correlated with each other (see **Table 2**).

Table 1. Descriptive statistics of the variables

Demographic indicators	Options	N	t/F	IAT (M±SD)	PQSI (M±SD)	BDI (M±SD)	BSI (M±SD)
	Male	175		47.02±16.76	5.58±3.51	10.91±12.44	11.92±13.29
Gender	Female	404		50.57±14.03	5.52±3.10	9.74±9.90	13.31±13.82
			t	-2.637***	0.222	1.207	-1.126

Demographic indicators	Options	N	t/F	IAT (M±SD)	PQSI (M±SD)	BDI (M±SD)	BSI (M±SD)
	2023	491		49.26±14.60	5.36±3.09	10.08±10.75	12.90±13.70
	2021	22		55.59±16.69	6.09±3.24	8.64±9.21	14.23±15.01
Grade	2022	66		49.23±16.90	6.64±3.98	10.73±11.18	12.36±13.09
			F	1.896	4.932***	0.318	-1.126

Table 1. (*Continued*)

***P<0.001,**P<0.01,*P<0.05.

Table 2. Spearman correlations among variables.

	1	2	3	4	5	6
1. PIU (mild)						
2. PIU (moderate)	-.82**					
3. PIU (severe)	-.19**	-.41**				
4. PQSI	-.31**	.17**	.21**			
5. BDI	-.39**	.20**	.27**	.60**		
6. BSI	-.29**	.14**	.21**	.37**	.59**	
M	.27	.64	.09	5.54	10.10	12.89
SD	.45	.48	.28	3.23	10.73	13.66
F	849.24***			14.44**	11.16**	5.71**
Cronbach's alpha	0.93			0.74	0.94	0.73

***P<0.001,**P<0.01,*P<0.05.

3.2. Regression analysis

3.2.1. The effect of predictors on suicidal ideation (BSI)

Model 1 categorial PIU as the independent variable(mild as reference group), SI as the dependent variable. The results showed that model 1 had a good model fit (R =0.31, R^2 = 0.10, and F = 30.13, p <.001). Relative to mild PIU, moderate and severe PIU have a stronger impact on Suicidal Ideation (relative total effect).

Model 2 is based on Model 1 and incorporates the mediator variable Sleep Problems (PSQI) to jointly regress the dependent variable (SI). The results showed that model 2 had a good model fit (R =0.39, R^2 = 0.15, and F = 34.03, p <.001). The mediating variable Sleep Problems (PSQI) also had a significant positive effect on Suicidal Ideation (B=1.062, p <.001)

Model 3 is based on Model 2 and incorporates the mediator variable Depression (BDI) to jointly regress the dependent variable (SI). The results showed that model 3 had a good model fit (R =0.56, R^2 = 0.32, and F = 66.99, p <.05). Compared to mild PIU, severe PIU remained a significant positive predictor of SI (B = 4.341, p < .05). In contrast, moderate PIU (B = 1.896, p > .05) did not exhibit a statistically significant association with SI. Additionally, the mediating variable sleep problems, as measured by the PSQI, was not significantly related to SI (B = –0.185, p > .05). However, depression, assessed via the BDI, showed a significant positive effect on SI (B = 0.697, p < .001). These results suggest that, after controlling for the mediating effect of depression, only severe PIU and depression remained significant predictors of SI (see **Table 3**).

3.2.2. The effect of predictors on sleep problems (PSQI) and depression (BDI)

Model 1 categorial PIU as the independent variable (mild as reference group), PSQI as dependent variable. The results showed that model 1 had a good model fit (R =0.33, R^2 = 0.11, and F = 1.70, p < .001). relative to mild PIU, moderate PIU (B=1.704, p < .001) and severe PIU (B=3.92, p < .001) had a significant positive relationship with Sleep Problems.

Model 2 categorial PIU as independent variable (mild as reference group), BDI as dependent variable. The results showed that model 2 had a good model fit (R =0.43, R^2 = 0.19, and F = 65.19, p <.001). relative to mild PIU, moderate PIU (B=6.60, p < .001) and severe PIU (B=17.29, p < .001) had a significant positive relationship with Sleep Problems.

Model 3 is based on Model 2 and adds Sleep Problems (PSQI) to jointly regress the dependent variable (BDI). The results showed that model 3 had a good model fit (R =0.67, R^2 = 0.44, and F = 151.79, p < .001). The mediating variable Sleep Problems (PSQI) also has a significant positive effect on Suicidal Ideation (B=1.06, p <.001).

Compared to mild problematic Internet use (PIU), both moderate PIU (B = 3.56, p < .001) and severe PIU (B = 10.29, p < .001) were significantly positively associated with increased levels of depression, as measured by the Beck Depression Inventory (BDI). Furthermore, the mediating variable—sleep problems, assessed using the PSQI—also significantly predicted higher levels of depression (B = 1.79, p < .001) (see **Table 3**).

Table 3. The effect of predictors on Suicidal Ideation (BSI).

Model		Model 1 (Y:BSI) Coefficient (SE)	Model 2 (Y:BSI) Coefficient (SE)	Model 3 (Y:BSI) Coefficient (SE)	Model 1 (Y:PQSI) Coefficient (SE)	Model 2 (Y:BDI) Coefficient (SE)	Model 3 (Y:BDI) Coefficient (SE)
Constant		7.56*** (1.04)	3.20** (1.23)	5.28*** (1.12)	4.10*** (0.24)	4.35*** (0.77)	-2.98*** (0.78)
X	Indicator: PIU（mild）	-	-	-	-	-	
	PIU(moderate)	6.19*** (1.24)	4.38*** (1.24)	1.90 (1.13)	1.70*** (0.29)	6.60*** (0.92)	3.56*** (0.79)
	PIU(severe)	15.68*** (2.10)	11.52*** (2.14)	4.34* (2.01)	3.92*** (0.49)	17.29*** (1.56)	10.29*** (1.36)
M1	PQSI	-	1.06*** (0.17)	-0.19 (0.19)	-	-	1.79*** (0.11)
M2	BDI	-	-	0.70*** (0.06)	-	-	-
R		0.31	0.39	0.56	0.33	0.43	0.67
R^2		0.10	0.15	0.32	0.11	0.19	0.44
$\triangle R^2$		-	0.06	0.17	-	-	0.26
F		30.13***	34.03***	66.99***	35.83***	65.19***	151.79***

***P<0.001,**P<0.01,*P<0.05.

3.3. Mediation analysis

The results of the chain mediation effect are shown in **Table 4**.

First, the theomni total effect was significant with F (2576) =30.13, p <.001, indicating that the relative total effects of moderate and severe PIU are not all zero. Specifically, the effect of moderate and severe PIU on SI was [6.19, (3.76, 8.62)] and [15.68, (11.56, 19.80)]. Neither level of confidence intervals includes 0, indicating that the overall relative total effect is significant.

Second, the relative direct effect test showed F (2574) =2.59, *p* > .05. Specifically, the relative direct effect of moderate PIU on SI was significant [1.90, (-0.31, 4.11)], and the effect value of severe PIU was [4.34, (0.39, 8.30)], the confidence interval didn't include 0, indicating that the relative direct effect of severe PIU is significant.

Third, the relative indirect effects test, the mediating effect of (PIU → PSQI → BSI), taking mild PIU as the reference level, the relative indirect effect value of moderate PIU [-0.32, (-1.07, 0.35)] and severe PIU was [-0.72, (-2.42, 0.83)], both including 0, indicating that the relative mediating effect of moderate and severe PIU was not significant relative to mild PIU. The mediating effect of Sleep Problems (PSQI) on Problematic Internet Use (PIU) and Suicidal Ideation (BSI) is not significant.

The mediating effect of (PIU → BDI → BSI) showed that the relative indirect effect value of moderate PIU was [2.48, (1.57, 3.46)] and severe PIU was [7.18, (4.82, 9.97)], both excluding 0. That is, Depression (BDI) has a significant mediating effect on Problematic Internet Use (PIU) and Suicidal Ideation (BSI). From the effect values, depression has a stronger mediating effect on SI in severe PIU than in moderate PIU.

The results of the chain mediation effect of (PIU → PSQI → BDI → BSI) showed that the relative indirect effect value of moderate and severe PIU was [2.125, (1.37, 2.98)] and [4.89, (3.15, 6.85)], both excluding 0, indicating that compared to mild Problematic Internet Use, the relative chain mediation effect of moderate and severe PIU was significant. That is, Sleep Problems (PSQI) and Depression (BDI) have a significant chain mediation effect on Problematic Internet Use (PIU) and Suicidal Ideation (BSI). From the effect values, sleep problems and Depression have a stronger chain mediation effect on Suicidal Ideation in severe PIU than in moderate PIU.

Table 4. Mediation effect results.

Model		Model 1 (Y:BSI)	Model 2 (Y:BSI)	Model 3 (Y:BSI)	Model 1 (Y:PQSI)	Model 2 (Y:BDI)	Model 3 (Y:BDI)
		Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
Constant		7.56*** (1.04)	3.20** (1.23)	5.28*** (1.12)	4.10*** (0.24)	4.35*** (0.77)	-2.98*** (0.78)
	Indicator: PIU（mild）	-	-	-	-	-	
X	PIU(moderate)	6.19*** (1.24)	4.38*** (1.24)	1.90 (1.13)	1.70*** (0.29)	6.60*** (0.92)	3.56*** (0.79)
	PIU(severe)	15.68*** (2.10)	11.52*** (2.14)	4.34* (2.01)	3.92*** (0.49)	17.29*** (1.56)	10.29*** (1.36)
M1	PQSI	-	1.06*** (0.17)	-0.19 (0.19)	-	-	1.79*** (0.11)
M2	BDI	-	-	0.70*** (0.06)	-	-	-
R		0.31	0.39	0.56	0.33	0.43	0.67
R²		0.10	0.15	0.32	0.11	0.19	0.44
△R²		-	0.06	0.17	-	-	0.26
F		30.13***	34.03***	66.99***	35.83***	65.19***	151.79***

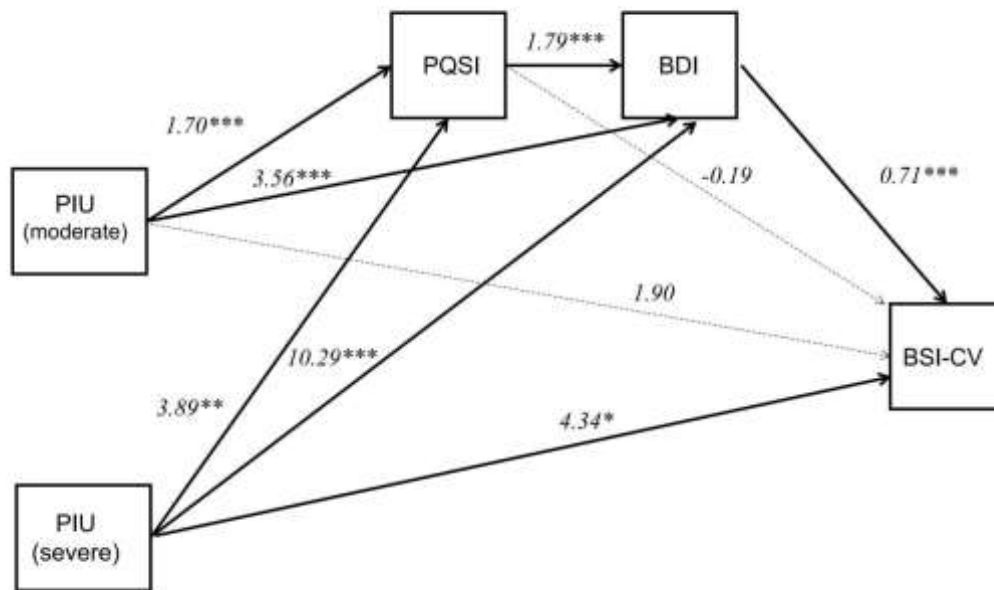****P<0.001,**P<0.01,*P<0.05.*

Figure 1. Chain mediation model diagram.

4. Discussion

The present study investigated the relationships among PIU, sleep problem, depression, and SI, with results showing that sleep problem and depression sequentially mediate PIU and SI.

Our study reveals two key findings with theoretical and clinical implications. First, PIU exhibits a significant positive association with SI, which is consistent with previous research findings. The impact of PIU on SI can be explained by the Steinberg's "dual system model" proposed in 2010, which suggests that the cognitive control system and social emotional system of the brain mature at different times, leading to adolescents being more prone to emotional impulses and risky behaviors when facing virtual stimuli on the internet, and unable to control them as adults do. The higher the degree of PIU by individuals, the stronger their SI. This, to some extent, explains the dual system that generates SI.

Second, our current results show a serial mediation pathway: PIU → Sleep Problems → Depression → SI. Two mechanisms may explain this cascade: First is circadian disruption, PIU induced circadian disruption and hyperarousal states may potentiate suicidality through neurocognitive pathways [17], the fear of missing out (FoMO) as a catalyst for compulsive digital engagement. Such technology-driven sleep displacement likely initiates cascading effects on emotional regulation and executive functioning. The second is behavioral reinforcement. According to the I-PACE model and Beck's cognitive triad[23], algorithm-curated nocturnal content exposure sustains maladaptive cognitive triads (e.g., "I am worthless") through attentional bias toward negative stimuli, while sleep problem diminishes coping resources.

4.1. Limitations and future studies

Certain limitations in the current study must be addressed. First, our data's cross-sectional nature makes causation difficult to detect. According to our theoretical model, suicide ideation is one of the numerous distressing effects that persons with PIU experience. According to subjective assessments, young individuals with suicidal ideation often seek treatment through social media [19]. Future research should aim to replicate

this study using a prospective design to more precisely elucidate the temporal relationship between problematic Internet use (PIU) and suicidal ideation.

Although a large sample was employed, a potential limitation lies in its homogeneity—participants were predominantly adolescents from eastern and southern China, with nearly twice as many females as males. Future studies utilizing a more diverse sample, including a broader age range and varying socioeconomic backgrounds, would enhance the generalizability of the findings.

Suicidal ideation among college students in China represents a significant public health concern that warrants urgent attention. The present findings may contribute to the development of more effective psychological crisis intervention services within universities. In this context, early identification and timely intervention are critical for safeguarding the mental health of adolescents to the greatest extent possible.

Regarding ethical issues, for participants with high BDI and SI scores in this experiment, we have recommended referring them to specialized psychological hospitals after the end of the experiment. At the same time, we will contact teachers from the students' colleges to monitor their situation in a timely manner and determine whether psychological counseling services or crisis intervention procedures are needed.

5. Conclusion

This study highlights the pivotal role of depression, mediated by sleep problems, as a core mechanism linking problematic Internet use (PIU) to suicidal ideation (SI). Based on these findings, we recommend the adoption of multimodal prevention strategies, including: (1) systematic screening of adolescents for PIU using validated instruments such as the Internet Addiction Test (IAT $\geqslant$ 40; Young, 1998); (2) implementation of circadian-aligned Cognitive Behavioral Therapy for Insomnia (CBT-I) to restore healthy sleep architecture; and (3) deployment of dynamic monitoring systems to track depressive symptoms using the Beck Depression Inventory (BDI), applying a clinical intervention threshold of BDI $\geqslant$ 15 [22]. These integrated approaches are essential for targeting the underlying mechanisms of PIU and mitigating its detrimental effects on adolescent mental health, thereby reducing the risk of suicidal ideation.

Acknowledgments

Conflict of interest

The authors declare no conflict of interest.

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