Association between problematic Internet use, sleep disturbance, and suicidal behavior in Chinese adolescents

LAN GUO[1,2], MIN LUO[1,2], WAN-XIN WANG[1,2], GUO-LIANG HUANG[3], YAN XU[3], XUE GAO[3], CI-YONG LU[1,2]*
and WEI-HONG ZHANG[4,5]

[1]Department of Medical statistics and Epidemiology, School of Public Health, Sun Yat-sen University, Guangzhou,
People's Republic of China
[2]Department of Nutrition, Guangdong Engineering Technology Research Center of Nutrition Translation, Guangzhou,
People's Republic of China
[3]Department of Drug Abuse Control, Center for ADR monitoring of Guangdong, Guangzhou, People's Republic of China
[4]School of Public Health, Université Libre de Bruxelles (ULB), Bruxelles, Belgium
[5]Research Center for Public Health, Tsinghua University, Beijing, People's Republic of China

Background and aims: This large-scale study aimed to test (a) associations of problematic Internet use (PIU) and sleep disturbance with suicidal ideation and suicide attempts among Chinese adolescents and (b) whether sleep disturbance mediates the association between PIU and suicidal behavior. *Methods:* Data were drawn from the 2017 National School-based Chinese Adolescents Health Survey. A total of 20,895 students' questionnaires were qualified for analysis. The Young's Internet Addiction Test was used to assess PIU, and level of sleep disturbance was measured by the Pittsburgh Sleep Quality Index. Multilevel logistic regression models and path models were utilized in analyses. *Results:* Of the total sample, 2,864 (13.7%) reported having suicidal ideation, and 537 (2.6%) reported having suicide attempts. After adjusting for control variables and sleep disturbance, PIU was associated with an increased risk of suicidal ideation (AOR = 1.04, 95% CI = 1.03−1.04) and suicide attempts (AOR = 1.03, 95% CI = 1.02−1.04). Findings of the path models showed that the standardized indirect effects of PIU on suicidal ideation (standardized β estimate = 0.092, 95% CI = 0.082−0.102) and on suicide attempts (standardized β estimate = 0.082, 95% CI = 0.068−0.096) through sleep disturbance were significant. Conversely, sleep disturbance significantly mediated the association of suicidal behavior on PIU. *Discussion and conclusions:* There may be a complex transactional association between PIU, sleep disturbance, and suicidal behavior. The estimates of the mediator role of sleep disturbance provide evidence for the current understanding of the mechanism of the association between PIU and suicidal behavior. Possible concomitant treatment services for PIU, sleep disturbance, and suicidal behavior were recommended.

Keywords: problematic Internet use, sleep disturbance, suicidal behavior, mediation effects, adolescents

INTRODUCTION

Use of the Internet has dramatically increased, and has become an integral part of individuals' daily life worldwide (Lin, Wu, Chen, & You, 2018). Evidence suggests that appropriate or limited Internet use is beneficial, but excessive or uncontrolled Internet use has been reported to be associated with several maladaptive problems, and even can lead to Internet addiction, also termed "problematic Internet use (PIU)" and "pathological Internet use," which has been proposed to define Internet use that significantly interferes with daily life (Kuss & Lopez-Fernandez, 2016). Moreover, PIU has been included as diagnosable criteria in the fifth edition of *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 2013). Adolescence refers to the period of transition from childhood to adulthood, and is characterized by increased imitation and exploration along with a range of risky behaviors (Jaworska

& MacQueen, 2015). It seems that adolescents are at an elevated risk to develop PIU than other age range. According to the report of World Health Organization (2015), adolescent PIU has become a global public health issue, and China is no exception. In China, it was estimated that the prevalence rate of PIU among adolescents ranged from 8.1% to 26.5% (Cao, Sun, Wan, Hao, & Tao, 2011; Wu et al., 2013; Xin et al., 2018). Moreover, previous studies reported that PIU was associated with significant functional and psychosocial impairments (Kuss & Lopez-Fernandez, 2016), and could lead to impaired social relations (e.g., poor family relationship), social isolation, psychiatric disorders

---

* Corresponding author: Ci-Yong Lu, MD, PhD; Department of Medical Statistics and Epidemiology, School of Public Health, Sun Yat-sen University, 74 Zhongshan Rd 2, Guangzhou 510080, People's Republic of China; Phone: +86 20 87332477; Fax: +86 20 87331882; E-mail: luciyong@mail.sysu.edu.cn

(e.g., depression, anxiety, or bipolar disorder), sleep disturbance, and even suicidal behavior (Kormas, Critselis, Janikian, Kafetzis, & Tsitsika, 2011; Pan & Yeh, 2018; Park, Hong, Park, Ha, & Yoo, 2013).

Suicidal behavior (including suicidal ideation, suicide attempts, or completed suicide) in adolescents is reported to be associated with physical disorders and disability, and can result in a heavy economic, social, and psychological burden for the individuals, families, and communities (Meltzer et al., 2012). Although the overall rate of completed suicide in China has been significantly reduced over the past decade (from 9.78 to 5.01 per 100,000 per year in urban area and from 15.53 to 8.61 per 100,000 per year in rural area between 2004 and 2014) (Sha, Chang, Law, Hong, & Yip, 2018), suicidal ideation and suicide attempts are still a current problem among Chinese adolescents (Guo et al., 2017). Evidence suggests that psychiatric disorder is one the most important risk factors of suicidal behavior (Yoshimasu, Kiyohara, & Miyashita, 2008). Moreover, it is well known that sleep problems are common among individuals with psychiatric disorders, and are generally symptoms or harbingers of other psychiatric disorders (Khurshid, 2018; Krystal, 2012). Sleep disturbance is another vital public health problem in adolescents, and can reflect reduced quality, duration, and frequency of sleep (Tsai et al., 2005). Previous studies also demonstrated that sleep disturbance is a potential risk factor for suicidal behavior (Bernert, Kim, Iwata, & Perlis, 2015; Nrugham, Larsson, & Sund, 2008), and the inhibitory effects of serotonin system play a significant role in both suicidal behavior and sleep disorder (Kohyama, 2011).

In addition, sleep disturbance is one of the most frequent comorbid conditions of PIU. Previous studies report that PIU among adolescents usually occurs at night, and can disrupt adolescents' sleep–wake schedule, which may cause irregular sleep patterns or sleep disturbance. Excessive PIU among adolescents were also found to be associated with insomnia and the disturbance of sleep (Ekinci, Celik, Savas, & Toros, 2014; Islamie, Allahbakhshi, Valipour, & Mohammadian-Hafshejani, 2016). Although the underlying mechanism of the association between PIU and suicidal behavior is still unclear, evidence suggests that individuals with additive disorder share similar personality characteristics and reward-related neurocircuitry or genetic traits with those who possess psychiatric disorder (Hammond, Mayes, & Potenza, 2014; Ko et al., 2009). It is the fact that most Chinese families have only one child as a result of the government's prior one-child policy (Falbo & Poston, 1994); however, the relationship between PIU and suicidal behavior in Chinese adolescents has scarcely been studied.

Therefore, in the association between PIU and suicidal behavior among adolescents, sleep disturbance may play a potential mediator role. There have been no studies in China that have estimated the mediation effects of sleep disturbance on the associations of PIU with suicidal ideation and suicide attempts in general adolescents. Therefore, this study aimed to test the hypotheses that (a) PIU may be positively associated with suicidal ideation and suicide attempts; (b) sleep disturbance is also associated with

suicidal ideation and suicide attempts; and (c) the association of PIU with suicidal behavior is mediated by sleep disturbance.

METHODS

Participants and procedure

This study analyzed the data collected from the 2017 National School-based Chinese Adolescents Health Survey (SCAHS). SCAHS is an ongoing study about the risky health behaviors among Chinese adolescents (7th–12th grade), and conducts large-scale cross-sectional surveys every 2 years since 2007 (Guo, Deng, et al., 2016; Guo, Xu, et al., 2015; Wang et al., 2014). A multistage, stratified cluster, random sampling method is used in the 2017 SCAHS. Briefly, in Stage 1, Guangdong province was divided into three stratifications by gross domestic product (GDP) per capita (high-level, middle-level, and low-level) and geographic locations (Yue Dong, Yue Xi, Yue Bei, and Pearl River Delta) (Figure 1). In Stage 2, two representative cities were randomly selected from each stratification; four general high schools (focusing on educating students for entering college or university) and four vocational high schools (providing specific vocational training) were randomly selected from each representative city. In Stage 3, two classes were randomly chosen from each grade within the selected schools. We invited all available students to voluntarily participate in this study, and 20,895 students' questionnaires were qualified for analysis (resulting a response rate of 86.1%). Surveys were anonymous to increase the validity of self-reports of stigmatized behaviors (Ramo, Liu, & Prochaska, 2012), and the questionnaires were administered by research assistants in the classrooms without the presence of teachers (to avoid any potential information bias).

Measures

Dependent variable. Suicide ideation was assessed by the question "How many times did you seriously consider attempting suicide during the past year?" Available responses were zero and once or more times. Suicide attempt was defined as responding "one or more times" to the question "How many times did you actually attempt suicide during the past year?" (Guo, Xu, et al., 2016; Okan et al., 2016).

Independent variable. PIU was assessed using the Chinese version of the Young's Internet Addiction Test (IAT), and the IAT comprises 20 items rated in a 5-point Likert scale (from $1 = not\ at\ all$ to $5 = always$) (Young, 1998). The Chinese version has been validated in Chinese adolescents with satisfactory psychometric properties (Lai et al., 2013; Wang et al., 2011), and the Cronbach's α for IAT was .91 in this study. Total score of the IAT ranges from 20 to 100 and represents an individual's tendency to Internet addiction. The higher score suggests the greater level of PIU. In this study, we not only described the total IAT scores but also used the validated standard cut-off criteria proposed by Young [including "average online
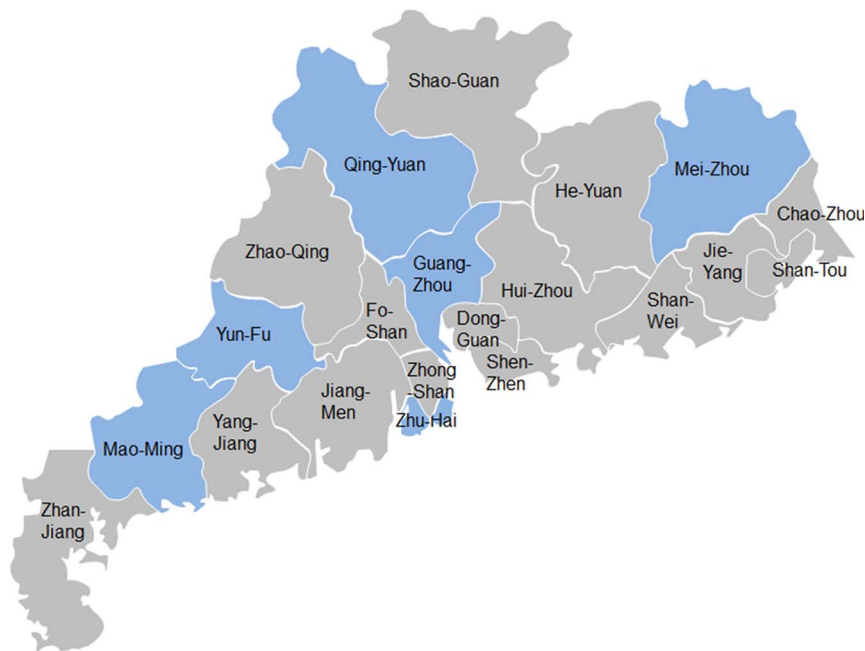
Figure 1. Selected cities of Guangdong Province

users" (20–49 points), "moderately addicted" (50–79 points), and "severely addicted" (80–100 points)] (Young & de Abreu, 2012).

Potential mediating factor. Level of sleep disturbance was measured by the Chinese version of the Pittsburgh Sleep Quality Index (PSQI), which is commonly used to assess sleep quality and disturbances over the past month. The Chinese version has been validated (Tsai et al., 2005), and has been extensively utilized in Chinese adolescents (Guo et al., 2014). The 19-item PSQI consists of seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. The sum of the scores for these seven components yields one global score with a range of 0–21 points in which higher scores indicate a higher level of sleep disturbance (Tsai et al., 2005).

Other variables. Demographic variables included sex (1 = male and 2 = female), age, living arrangement (responses were coded as "living with both parents" = 1, "living with a single parent" = 2, and "living with others" = 3), household socioeconomic status (HSS), relationships with teachers, classmate relations, smoking, and alcohol drinking. HSS was assessed by asking how students perceived their family's financial situation (responses were coded as "excellent or very good" = 1, "good" = 2, and "fair or poor" = 3). Classmate relations and relationships with teachers were measured by asking students to rate their perception of the relationships with classmates and teachers (available responses were "good" = 1, "average" = 2, and "poor" = 3). Smoking was assessed by asking the students the following question: "On how many days did you smoke cigarettes, during the past month (responses were coded as "0 day" = no, "1 or more days" = yes)?" Alcohol drinking was measured by the question: "On how many days did you drink alcohol, during the past month (responses were coded as "0 day" = no, "1 or more days" = yes)?"

Statistical analyses

All statistical analyses were conducted using SAS 9.2 (SAS Institute, Inc., Cary, NC, USA) and Mplus version 7.0 (Muthén & Muthén, Los Angeles, CA, USA). First, descriptive analyses were used to describe characteristics. Second, considering this study utilized a complex multistage sampling design, students were grouped into classes, and therefore might not be independent, and multilevel logistic regression models were fitted in which classes were treated as clusters. Multivariable multilevel logistic regression models simultaneously incorporating the variables that were significant in the univariate analyses or widely reported in the literature were performed to estimate the independent associations of PIU with suicidal ideation and suicide attempts. In these regression models, the outcome variables were the presence of suicidal ideation and suicide attempts. Firth's penalized likelihood approach was also used for the outcome with low event rates (Firth, 1993; Wang, 2014). Third, to estimate the mediation effects of sleep disturbance on the association between PIU and suicidal behaviors, path models utilizing the maximum likelihood (ML) approach were performed. We first ordered the variables as follows: "PIU sleep disturbance suicidal ideation/suicide attempts;" Next, we tested an alternative model with a different order of variables: "suicidal ideation/suicide attempts sleep disturbance PIU" (Figure 2). Considering that the variables of IAT score and PSQI score were continuous variables and the measures of suicidal behavior were dichotomized, standardized probit coefficients, standardized total effects, and standardized indirect effects were reported, and the bias-corrected 95% confidence intervals (CIs) were estimated using 1,000 bootstrap samples. There are several commonly applied model fit indices recommended to evaluate the models: the comparative fit index (CFI > 0.90 indicates good fit), the root mean square error of
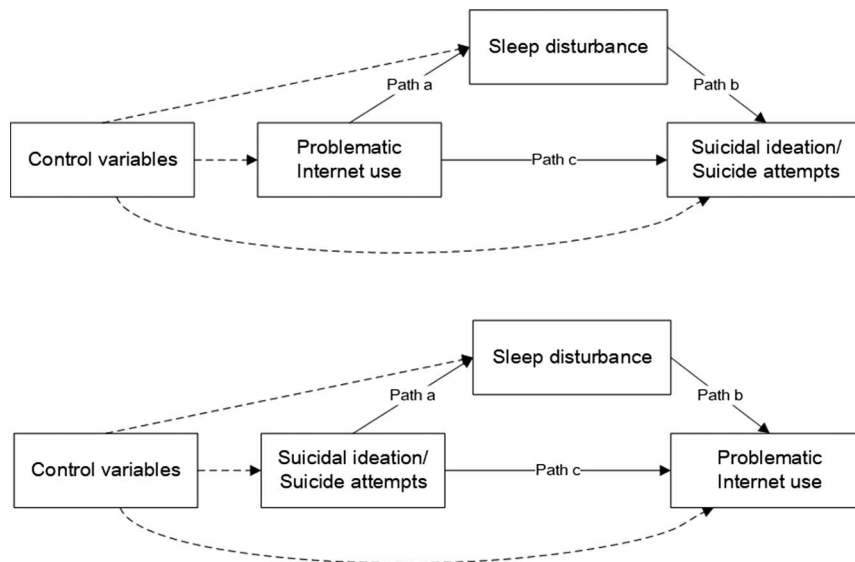
Figure 2. Hypothesized mediation effects of sleep disturbance on the association between problematic Internet use and suicidal behavior

approximation (RMSEA < 0.08 indicates acceptable fit), and the standardized root mean square residual (SRMR < 0.08 indicates goof fit). All statistical tests were two-sided, and *p* values less than .05 were considered statistically significant.

Ethics

The study procedures were carried out in accordance with the Declaration of Helsinki. This study received ethical approval from the institutional review board of Sun Yat-Sen University School of Public Health. Written informed consents explaining the study purposes, processes, benefits, and risks were obtained from each participant who was at least 18 years of age. If the student was under 18 years of age, a written informed consent letter was obtained from one of the student's parents (or legal guardian).

RESULTS

Sample characteristics

The sample characteristics are shown in Table 1. Of 20,895 eligible participants, 2,864 (13.7%) reported having suicidal ideation, and 537 (2.6%) reported having suicide attempts. The mean (*SD*) IAT scores was 35.81 (12.80). The IAT score revealed 14,423 (69.0%) students as average online users, 6,014 (28.8%) as moderately addicted to Internet use, and 458 (2.2%) as severely addicted. There were significant differences in IAT scores among the variables of sex, living arrangement, HSS, relationships with teachers, classmate relations, suicidal ideation, and suicide attempts (*p* < .05). Moreover, significant differences emerged the three groups (average online users, moderately addicted, and severely addicted) in the distribution of sex, age, living arrangement, HSS, relationships with teachers, classmate relations, the total PSQI scores, suicidal ideation, and suicide attempts (*p* < .05).

Associations between PIU, sleep disturbance, and suicidal behavior

Without adjusting for other variables, *Model 1* showed that PIU, sleep disturbance, sex, age, living arrangement, HSS, relationships with teachers, classmate relations, alcohol drinking, and smoking were significantly associated with suicidal ideation and suicide attempts (*p* < .05). *Model 3* demonstrated that after adjusting for sex, age, living arrangement, HSS, relationships with teachers, classmate relations, alcohol drinking, smoking, and sleep disturbance, PIU was associated with an increased risk of suicidal ideation [adjusted odds ratio (AOR) = 1.04, 95% CI = 1.03–1.04] and suicide attempts (AOR = 1.03, 95% CI = 1.02–1.04) (Table 2).

Path analysis showing the effects of PIU and sleep disturbance on suicidal behavior

As shown in Table 3, the standardized indirect effects of PIU on suicidal ideation (standardized β estimate = 0.092, 95% CI = 0.082–0.102) and suicide attempts (standardized β estimate = 0.082, 95% CI = 0.068–0.096) through sleep disturbance were statistically significant, suggesting that sleep disturbance partially mediated the associations between PIU and suicidal ideation/suicide attempts.

Path analysis showing the effects of suicidal behavior and sleep disturbance on PIU

The alternative model shown in Table 4 demonstrated that the standardized indirect effects of suicidal ideation on PIU (standardized β estimate = 0.256, 95% CI = 0.244–0.268) via sleep disturbance were significant, and there were significant standardized indirect effects of suicide attempts on PIU (standardized β estimate = 0.050, 95% CI = 0.044–0.056) through sleep disturbance; these results indicated that the associations of suicidal ideation/suicide attempts with PIU were partially mediated by sleep disturbance.

Table 1. Sample characteristics among 20,895 adolescents

Variable	Total	IAT scores [mean (SD)]	p value*	Problematic Internet use [n (%)]			p value*
				Average online users	Moderately addicted	Severely addicted	
Total	20,895 (100.0)	35.81 (12.80)		14,423 (69.0)	6,014 (28.8)	458 (2.2)	
Sex			<.001				<.001
Boys	10,615 (50.8)	36.20 (13.22)		7,153 (49.6)	3,186 (53.0)	276 (60.3)	
Girls	10,280 (49.2)	35.30 (12.29)		7,270 (50.4)	2,828 (47.0)	182 (39.7)	
Age [mean (SD)]	15.19 (1.84)	NA	<.001	15.10 (1.89)	15.41 (1.73)	15.10 (1.65)	<.001
Living arrangement			<.001				<.001
Living with both parents	15,716 (75.2)	35.47 (12.57)		10,982 (76.1)	4,424 (73.6)	310 (67.7)	
Living with a single parent	2,466 (11.8)	37.63 (13.63)		1,549 (10.7)	835 (13.9)	82 (17.9)	
Living with others	2,713 (13.0)	35.86 (13.07)		1,892 (13.1)	755 (12.6)	66 (14.4)	
HSS			<.001				<.001
Above average	6,023 (28.8)	34.42 (12.70)		4,421 (30.7)	1,476 (24.5)	126 (27.5)	
Average	12,054 (57.7)	36.15 (12.61)		8,196 (56.8)	3,604 (59.9)	254 (55.5)	
Below average	2,818 (13.5)	36.97 (13.45)		1,806 (12.5)	934 (15.5)	78 (17.0)	
Relationship with teachers			<.001				<.001
Good	13,807 (66.1)	34.36 (11.96)		10,148 (70.4)	3,451 (57.4)	208 (45.4)	
Average	6,629 (31.7)	38.26 (13.47)		4,028 (27.9)	2,402 (39.9)	199 (43.4)	
Poor	459 (2.2)	41.92 (17.97)		247 (1.7)	161 (2.7)	51 (11.1)	
Relationship with classmates			<.001				<.001
Good	17,059 (81.6)	35.06 (12.26)		12,166 (84.4)	4,586 (76.3)	307 (67.0)	
Average	3,530 (16.9)	38.53 (13.96)		2,104 (14.6)	1,311 (21.8)	115 (25.1)	
Poor	306 (1.5)	42.81 (18.70)		153 (1.1)	117 (1.9)	36 (7.9)	
Current smoking			<.001				<.001
No	19,862 (95.1)	35.59 (12.61)		13,835 (95.9)	5,623 (93.5)	404 (88.2)	
Yes	1,033 (4.9)	39.88 (15.53)		588 (4.1)	391 (6.5)	54 (11.8)	
Current drinking			<.001				<.001
No	17,613 (84.3)	35.17 (12.38)		12,497 (86.6)	4,794 (79.7)	322 (70.3)	
Yes	3,282 (15.7)	39.21 (14.36)		1,926 (13.4)	1,220 (20.3)	136 (29.7)	
Total PSQI scores [mean (SD)]	7.78 (2.25)	NA	<.001	7.23 (2.04)	8.89 (2.15)	10.32 (2.70)	<.001
Suicidal ideation			<.001				<.001
No	18,031 (86.3)	34.43 (11.76)		13,183 (91.4)	4,596 (76.4)	252 (55.0)	
Yes	2,864 (13.7)	44.21 (15.46)		1,240 (8.6)	1,418 (23.6)	206 (45.0)	
Suicide attempt			<.001				<.001
No	20,358 (97.4)	35.50 (12.51)		14,206 (98.5)	5,758 (95.7)	394 (86.0)	
Yes	537 (2.6)	45.97 (17.79)		217 (1.5)	256 (4.3)	64 (14.0)	

Note. IAT: Internet Addiction Test; HSS: household socioeconomic status; SD: standard deviation; PSQI: Pittsburgh Sleep Quality Index; NA: not applicable or no data available.
*T-tests or ANOVA tests were performed to test the differences in IAT score, and χ² tests or ANOVA tests were used to compare the differences in the three groups (average online users, moderately addicted, and severely addicted).

Table 2. Associations between problematic Internet use, sleep disturbance, and suicidal behavior

Variable	Suicidal ideation			Suicide attempts		
	Model 1 OR [95% CI]	Model 2 AOR [95% CI]	Model 3 AOR [95% CI]	Model 1 OR [95% CI]	Model 2 AOR [95% CI]	Model 3 AOR [95% CI]
Problematic Internet use (1-score increase)	1.05 [1.04–1.06]*	1.05 [1.05–1.06]*	1.04 [1.03–1.04]*	1.05 [1.04–1.05]*	1.04 [1.03–1.05]*	1.03 [1.02–1.04]*
Sleep disturbance (1-score increase)	1.33 [1.31–1.35]*	1.33 [1.31–1.36]*		1.34 [1.30–1.38]*	1.34 [1.29–1.39]*	
Sex (ref. = female)	0.61 [0.57–0.67]*			0.67 [0.56–0.79]*		
Age (1-year increase)	0.95 [0.3–0.97]*			0.86 [0.82–0.90]*		
Living arrangement (ref. = living with both parents)						
Living with a single parent	1.19 [1.06–1.33]*			1.52 [1.19–1.94]*		
Living with others	1.52 [1.36–1.70]*			1.70 [1.36–2.13]*		
HSS (ref. = above average)						
Average	1.20 [1.09–1.31]*			0.99 [0.82–1.22]		
Below average	1.54 [1.36–1.75]*			1.43 [1.09–1.85]*		
Relationships with teachers (ref. = good)						
Average	1.64 [1.51–1.78]*			1.57 [1.31–1.89]*		
Poor	3.53 [2.88–4.33]*			5.36 [3.87–7.43]*		
Classmate relations (ref. = good)						
Average	1.76 [1.60–1.93]*			1.82 [1.49–2.23]*		
Poor	4.97 [3.94–6.28]*			7.14 [5.05–10.08]*		
Smoking (ref. = no)	1.29 [1.06–1.56]*			1.43 [1.03–1.98]*		
Alcohol drinking (ref. = no)	1.49 [1.34–1.65]*			2.44 [2.00–2.97]*		

Note. Model 1: unadjusted logistic regression model. The univariable multilevel logistic regression model for suicide attempts used Firth's penalized likelihood approach for the low event rate; Model 2: the multivariable multilevel logistic regression models were adjusted for sex, age, living arrangement, HSS, relationships with teachers, classmate relations, smoking, and alcohol drinking. The multivariable multilevel logistic regression model for suicide attempts used Firth's penalized likelihood approach for the low event rate; Model 3: the multivariable multilevel logistic regression models simultaneously incorporated the control variables in Model 2 and sleep disturbance. The multivariable multilevel logistic regression model for suicide attempts used Firth's penalized likelihood approach for the low event rate; AOR: adjusted odds ratio; OR: odds ratio; CI: confidence interval.
*$p < .05$.

Table 3. Path analysis showing the effects of problematic Internet use and sleep disturbance on suicidal behavior

| Variable | Suicidal ideation[a] | | Suicide attempts[a] | |
| | Model 1 | | Model 2 | |
	Symbol	Standardized β estimate [95% CI]	Symbol	Standardized β estimate [95% CI]
Problematic Internet use	Predictor	0.239 [0.219–0.259]*	Predictor	0.158 [0.127–0.189]*
Sleep disturbance	Mediator	0.228 [0.206–0.250]*	Mediator	0.204 [0.173–0.235]*
Problematic Internet use→Sleep disturbance	Predictor → Mediator	0.404 [0.394–0.414]*	Predictor → Mediator	0.404 [0.394–0.414]*
Standardized effect				
Indirect		0.092 [0.082–0.102]*		0.082 [0.068–0.096]*
Total		0.331 [0.313–0.349]*		0.240 [0.212–0.267]*

Note. CI: confidence interval.
[a]The structural equation models were adjusted for sex, age, living arrangement, HSS, relationships with teachers, classmate relations, smoking, and alcohol drinking, respectively; model fit indices (suicidal ideation: CFI = 0.900, RMSEA = 0.053, 90% CI = 0.050–0.056, SRMR = 0.047; suicide attempts: CFI = 0.904, RMSEA = 0.051, 90% CI = 0.049–0.053, SRMR = 0.038).
*$p<0.05$.

Table 4. Path analysis showing the effects of suicidal behavior and sleep disturbance on problematic Internet use

| Variable | Problematic Internet use | | | |
| | Model 1 (suicidal ideation)[a] | | Model 2 (suicide attempts)[a] | |
	Symbol	Standardized β estimate [95% CI]	Symbol	Standardized β estimate [95% CI]
Suicidal behavior	Predictor	0.170 [0.158–0.182]*	Predictor	0.075 [0.063–0.087]*
Sleep disturbance	Mediator	0.388 [0.376–0.400]*	Mediator	0.419 [0.407–0.431]*
Suicide behavior → Sleep disturbance	Predictor → Mediator	0.221 [0.209–0.233]*	Predictor → Mediator	0.120 [0.106–0.134]*
Standardized effect				
Indirect		0.256 [0.244–0.268]*		0.050 [0.044–0.056]*
Total		0.086 [0.080–0.092]*		0.125 [0.111–0.139]*

Note. CI: confidence interval.
[a]The structural equation models were adjusted for age, sex, living arrangement, HSS, relationships with teachers, classmate relations, smoking, and alcohol drinking, respectively; model fit indices (suicidal ideation: CFI = 0.904, RMSEA = 0.052, 90% CI = 0.049–0.055, SRMR = 0.045; suicide attempts: CFI = 0.851, RMSEA = 0.055, 90% CI = 0.052–0.058, SRMR = 0.042).
*$p < .05$.

DISCUSSION

To the best of authors' knowledge, this is the first large-scale study aimed to estimate the association between PIU and sleep disturbance as well as suicidal behavior in the school-based sample of Chinese adolescents, and to estimate the mediation effects of sleep disturbance. This study found that 13.7% of students reported having suicidal ideation, and 2.6% reported having suicide attempts. This prevalence is parallel with our previous studies among Chinese adolescents (Guo et al., 2017, 2018), and is lower than that reported in a national study in the United States showing that 15.8% seriously considered attempting suicide and 7.8% attempted suicide one or more times (Kaslow, 2014). Moreover, this study also showed that 28.8% of students were moderate Internet users and 2.2% had severe Internet addiction. This prevalence is higher than that described in our previous study conducted in 2011 (Wang et al., 2011), and is similar to a recent study showing that the

overall prevalence of Internet addiction (also measured by the IAT) was 26.50% among adolescents in Guangzhou (Xin et al., 2018). These findings suggest that PIU is a growing problem among Chinese adolescents. In addition, previous studies estimated that the prevalence of PIU among adolescents ranged from 0% to 26.3% in the United States (Moreno, Jelenchick, Cox, Young, & Christakis, 2011), the prevalence among adolescents in Europe ranged from 7.9% to 36.7% (Durkee et al., 2012; Milani, Osualdella, & Di Blasio, 2009), and the prevalence ranged from 10.7% to 30% among South Korean adolescents (Mak et al., 2014; Park, Kim, & Cho, 2008). The differences in the reported prevalence of PIU in different countries may be related to the nature of the sample (e.g., age or sex), the sample size, or the criteria of PIU.

In line with previous studies (Bernert & Joiner, 2007; Guo et al., 2017; Kim et al., 2006), our univariable analyses first found that boys and older students were at a lower risk of suicidal ideation and suicide attempts. Adolescents who

lived in single-parent family or lived with others were at an increased risk of suicidal ideation and suicide attempts, and those who reported poor relationships with teachers or classmates were also at an elevated likelihood of suicidal behavior. Current smoking, drinking, and higher PSQI scores were positively associated with suicidal ideation and suicide attempts. These results are useful to identify adolescents at high risk of suicidal behavior, and special attention should be paid to those who present with the adverse characteristics mentioned above, and the confounding effects of those variables on the associations between PIU and suicidal behavior should also be considered.

After adjusting for the significant control variables, our multivariable multilevel logistic regression models first demonstrated that the likelihood of having suicidal ideation and suicide attempts increased with the PSQI scores, suggesting that sleep disturbance was positively associated with suicidal behaviors in adolescents. One explanation for these associations may be that sleep disturbance can have negative influences on adolescents' judgment, concentration, impulse control, and mental health (O'Brien, 2009); therefore, it might promote suicidal thoughts or attempts through impulsiveness, inhibitions loss, and/or hostility. In addition, sleep disturbance is reported to be a symptom or harbinger of other psychiatric disorders, and can also be comorbid with other psychiatric disorders (Khurshid, 2018; Krystal, 2012). It is well known that psychiatric disorder is one of the most vital risk factors with respect to suicidal behavior (Yoshimasu et al., 2008). Then, in this study, adolescents with sleep disturbance may be comorbid with other psychiatric disorders, which can increase the risk of suicidal behavior. Another explanation is that sleep disturbance and suicidal behavior may share a common neurobiological basis, and serotonin was reported to play a significant role in both the regulation of sleep and suicidal behavior (Kohyama, 2011). The final multivariable logistic regression models incorporating significant control variables and sleep disturbance found that PIU significantly increased the risk of suicidal ideation and suicide attempts among adolescents. Similarly, Fu, Chan, Wong, and Yip (2010) reported a significant positive relationship between the number of symptoms of PIU and 1-year changes in scores for suicidal ideation among adolescents in Hong Kong; Park et al. (2013) found that PIU was statistically associated with an increased risk of suicidal ideation in Korean adolescents; Pan and Yeh (2018) also reported that PIU is prospectively associated with the incidence of self-harm/suicidal behavior among adolescents in Taiwan. These results might be related to the fact that adolescents with PIU showed poorer self-control and higher levels of impulsivity than their corresponding group (Yau, Potenza, & White, 2013); risky decision-making (including suicidal behavior) was reported to be a vital behavioral personality of individuals with PIU (Seok, Lee, Sohn, & Sohn, 2015). Moreover, adolescents with PIU may have difficulty in fulfilling their social and academic responsibilities and may face more tension in their lives. However, they usually tended to adopted avoidant and inflexible coping style (e.g., suicidal behavior) when encountering stressful life events (Cheng, Sun, & Mak, 2015). Moreover, PIU is also reported to be positively associated with different psychiatric disorders (Ho et al., 2014;

Park et al. 2013), and individuals with psychiatric disorders are among the highest risk groups for suicidal behavior (Yoshimasu et al., 2008). In addition, Internet may be a major source of readily accessible information about suicide-related information (e.g., methods or communication), and excessive Internet use may also facilitate the implementation of suicidal behavior by vulnerable adolescents (Becker, Mayer, Nagenborg, El-Faddagh, & Schmidt, 2004; Wong et al., 2013).

In this study, considering the cross-sectional nature of data that makes the estimates of mediation effects may be biased when mediation occurs over time, two potential path processes were performed to test the potential mechanism of the association between PIU, sleep disturbance, and suicidal behavior. First, a novel finding of this study was that PIU directly increased the risk of suicidal behavior in adolescents, and the associations between PIU and suicidal ideation/suicide attempts were partially mediated through sleep disturbance. A plausible explanation for the mediation effects of sleep disturbance may be that PIU can disrupt adolescents' normal sleep patterns and contribute to a higher risk of sleep disturbance (Ekinci et al., 2014; Islamie et al., 2016), and then poor sleep quality or sleep disturbance is one of the most frequent risk factors for suicidal behavior (Bernert et al., 2015). Next, the findings of another path analyses models illustrated that suicidal behavior was directly associated with PIU, and sleep disturbance partially mediated the associations of suicidal ideation/suicide attempts with PIU. These results might be related to that adolescents with suicidal behavior may use Internet as a coping strategy to relieve stress, elevate mood, or alleviate unpleasant feelings. On the whole, there may be a complex transactional association between PIU, sleep disturbance, and suicidal behavior; for example, PIU can result in sleep disturbance and suicidal behavior, which in turn could worsen the situation of PIU in adolescents and vice versa. The estimates of the mediator role of sleep disturbance provide evidence for the current understanding of the mechanism of the association between PIU and suicidal behavior. Based on the findings of this study, the main recommendations are listed below: (a) schools and families should be aware of the negative effects of PIU, and special attention should be paid to the frequent Internet users; (b) family support (e.g., family communication) and school-based intervention (e.g., peer education and the curriculum about surfing the Internet healthly) are recommended to promote recovery in adolescents with sleep disturbance, PIU, or suicidal behavior; (c) effective education programs about developing healthy sleep habits and Internet use patterns are recommended to be provided to adolescents; (d) parents are recommended to limit their children's exposure to Internet at night or for a long time; (e) clinicians or related professionals who treat problematic Internet users should assess their histories of suicidal behavior or sleep quality in detail, and provide possible concomitant treatment services for PIU, sleep disturbance, and suicidal behavior; and (f) developing a national long-term surveillance system to monitor the risky health behaviors (e.g., PIU and suicidal behavior) among adolescents in China is also highly recommended.

This study has several limitations. First, due to the cross-sectional in design, no causal inference can be made regarding the observed associations. Therefore, the results should be interpreted with caution. Second, some adolescents who possessed suicidal behavior did not like to disclose such experiences for scaring social stigma; thus, the data may be subjected to potential bias. Third, the study sample only included school students and did not contain adolescents who had dropped out of school or were not present in school on the day when the survey was administered; PIU, suicidal behavior, and sleep disturbance may be more common among adolescents who were absent. Fourth, although this is a large-scale study, our sample was recruited only from China. Future studies are required to examine whether our findings can be generalized to a larger and more representative (e.g., cross-national) sample of adolescents. Fifth, the associations between PIU and suicidal behavior may be affected by other psychiatric disorders. Unfortunately, this study only considered the influence of sleep disturbance. Our future studies will take other psychiatric disorders into consideration to verify these findings. Despite these limitations, this large-scale study extends the previous evidence about the association between PIU, sleep disturbance, and suicidal behavior by estimating the mediation effects of sleep disturbance on the association between PIU and suicidal behavior among adolescents. In our future studies, we hope to address the mediation effects of sleep disturbance through a longitudinal study design.

CONCLUSIONS

This study found that 13.7% of students reported having suicidal ideation, and 2.6% reported having suicide attempts. This study found a 28.8% prevalence of moderately PIU and a 2.2% prevalence of severely PIU in general adolescents, indicating that PIU is a growing problem among Chinese adolescents. Sleep disturbance was positively associated with suicidal behavior. Students with moderately PIU and severely PIU were at a higher risk of suicidal ideation and suicide attempts than their corresponding group. Two potential path processes were performed to test the potential mechanism of the association between PIU, sleep disturbance, and suicidal behavior. The results of path models suggested that there may be a complex transactional association between PIU, sleep disturbance, and suicidal behavior; for example, PIU can result in sleep disturbance and suicidal behavior, which in turn could worsen the situation of PIU in adolescents, and vice versa. We recommend providing effective multidisciplinary health interventions to schools, families, clinicians, and students to increase their awareness of the adverse effects of PIU, sleep disturbance, and suicidal behavior, and to realize the complex transactional or concomitant association between PIU, sleep disturbance, and suicidal behavior.

Authors' contribution: The SCAHS was originally conceived by C-YL. The present survey was designed by LG, ML, W-HZ, G-LH, YX, and XG. Data analysis was performed by LG, ML, and W-XW. The manuscript was primarily prepared by LG and ML with a number of edits from C-YL and W-HZ. All authors were in agreement with the final submitted manuscript. LG and ML contributed equally to this work.

Conflict of interest: The authors declare no conflict of interest.

REFERENCES

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Association.

Becker, K., Mayer, M., Nagenborg, M., El-Faddagh, M., & Schmidt, M. H. (2004). Parasuicide online: Can suicide web-sites trigger suicidal behaviour in predisposed adolescents? *Nordic Journal of Psychiatry, 58*(2), 111–114. doi:10.1080/08039480410005602

Bernert, R. A., & Joiner, T. E. (2007). Sleep disturbances and suicide risk: A review of the literature. *Neuropsychiatric Disease and Treatment, 3*(6), 735–743. doi:10.2147/NDT.S1248

Bernert, R. A., Kim, J. S., Iwata, N. G., & Perlis, M. L. (2015). Sleep disturbances as an evidence-based suicide risk factor. *Current Psychiatry Reports, 17*(3), 554. doi:10.1007/s11920-015-0554-4

Cao, H., Sun, Y., Wan, Y., Hao, J., & Tao, F. (2011). Problematic Internet use in Chinese adolescents and its relation to psychosomatic symptoms and life satisfaction. *BMC Public Health, 11*(1), 802. doi:10.1186/1471-2458-11-802

Cheng, C., Sun, P., & Mak, K. K. (2015). Internet addiction and psychosocial maladjustment: Avoidant coping and coping inflexibility as psychological mechanisms. *Cyberpsychology, Behavior and Social Networking, 18*(9), 539–546. doi:10.1089/cyber.2015.0121

Durkee, T., Kaess, M., Carli, V., Parzer, P., Wasserman, C., Floderus, B., Apter, A., Balazs, J., Barzilay, S., Bobes, J., Brunner, R., Corcoran, P., Cosman, D., Cotter, P., Despalins, R., Graber, N., Guillemin, F., Haring, C., Kahn, J. P., Mandelli, L., Marusic, D., Meszaros, G., Musa, G. J., Postuvan, V., Resch, F., Saiz, P. A., Sisask, M., Varnik, A., Sarchiapone, M., Hoven, C. W., & Wasserman, D. (2012). Prevalence of pathological Internet use among adolescents in Europe: Demographic and social factors. *Addiction, 107*(12), 2210–2222. doi:10.1111/j.1360-0443.2012.03946.x

Ekinci, O., Celik, T., Savas, N., & Toros, F. (2014). Association between Internet use and sleep problems in adolescents. *Nöro Psikiyatri Arşivi, 51,* 122–128. doi:10.4274/npa.y6751

Falbo, T., & Poston, D. L. (1994). How and why the one-child policy works in China. *Advances in Population, 2,* 205–229.

Firth, D. (1993). Bias reduction of maximum likelihood estimates. *Biometrika, 80*(1), 27–38. doi:10.1093/biomet/80.1.27

Fu, K. W., Chan, W. S., Wong, P. W., & Yip, P. S. (2010). Internet addiction: Prevalence, discriminant validity and correlates among adolescents in Hong Kong. *The British Journal of Psychiatry, 196*(06), 486–492. doi:10.1192/bjp.bp.109.075002

Guo, L., Deng, J., He, Y., Deng, X., Huang, J., Huang, G., Gao, X., & Lu, C. (2014). Prevalence and correlates of sleep disturbance and depressive symptoms among Chinese adolescents: A cross-sectional survey study. *BMJ Open, 4*(7), e5517. doi:10.1136/bmjopen-2014-005517

Guo, L., Deng, J., He, Y., Deng, X., Huang, J., Huang, G., Gao, X., Zhang, W. H., & Lu, C. (2016). Alcohol use and alcohol-related problems among adolescents in China: A large-scale cross-sectional study. *Medicine (Baltimore), 95*(38), e4533. doi:10.1097/MD.0000000000004533

Guo, L., Wang, W., Gao, X., Huang, G., Li, P., & Lu, C. (2018). Associations of childhood maltreatment with single and multiple suicide attempts among older Chinese adolescents. *The Journal of Pediatrics, 196,* 244–250.e1. doi:10.1016/j.jpeds.2018.01.032

Guo, L., Xu, Y., Deng, J., He, Y., Gao, X., Li, P., Wu, H., Zhou, J., & Lu, C. (2015). Non-medical use of prescription pain relievers among high school students in China: A multilevel analysis. *BMJ Open, 5,* e7569. doi:10.1136/bmjopen-2014-007569

Guo, L., Xu, Y., Deng, J., Huang, J., Huang, G., Gao, X., Li, P., Wu, H., Pan, S., Zhang, W. H., & Lu, C. (2017). Association between sleep duration, suicidal ideation, and suicidal attempts among Chinese adolescents: The moderating role of depressive symptoms. *Journal of Affective Disorders, 208,* 355–362. doi:10.1016/j.jad.2016.10.004

Guo, L., Xu, Y., Deng, J., Huang, J., Huang, G., Gao, X., Wu, H., Pan, S., Zhang, W. H., & Lu, C. (2016). Association between nonmedical use of prescription drugs and suicidal behavior among adolescents. *JAMA Pediatrics, 170,* 971–978. doi:10.1001/jamapediatrics.2016.1802

Hammond, C. J., Mayes, L. C., & Potenza, M. N. (2014). Neurobiology of adolescent substance use and addictive behaviors: Treatment implications. *Adolescent Medicine: State of the Art Reviews, 25*(1), 15–32.

Ho, R. C., Zhang, M. W., Tsang, T. Y., Toh, A. H., Pan, F., Lu, Y., Cheng, C., Yip, P. S., Lam, L. T., Lai, C. M., Watanabe, H., & Mak, K. K. (2014). The association between Internet addiction and psychiatric co-morbidity: A meta-analysis. *BMC Psychiatry, 14*(1), 183. doi:10.1186/1471-244X-14-183

Islamie, F. S., Allahbakhshi, K., Valipour, A. A., & Mohammadian-Hafshejani, A. (2016). Some facts on problematic Internet use and sleep disturbance among adolescents. *Iran Journal of Public Health, 45*(11), 1531–1532.

Jaworska, N., & MacQueen, G. (2015). Adolescence as a unique developmental period. *Journal of Psychiatry & Neuroscience, 40*(5), 291–293. doi:10.1503/jpn.150268

Kaslow, N. J. (2014). *Suicidal behavior in children and adolescents.* In Presentation of American Psychological Association.

Khurshid, K. A. (2018). Comorbid insomnia and psychiatric disorders: An update. *Innovations in Clinical Neuroscience, 15,* 28–32.

Kim, K., Ryu, E., Chon, M. Y., Yeun, E. J., Choi, S. Y., Seo, J. S., & Nam, B. W. (2006). Internet addiction in Korean adolescents and its relation to depression and suicidal ideation: A questionnaire survey. *International Journal of Nursing Studies, 43*(2), 185–192. doi:10.1016/j.ijnurstu.2005.02.005

Ko, C. H., Liu, G. C., Hsiao, S., Yen, J. Y., Yang, M. J., Lin, W. C., Yen, C. F., & Chen, C. S. (2009). Brain activities associated with gaming urge of online gaming addiction. *Journal of Psychiatric Research, 43*(7), 739–747. doi:10.1016/j.jpsychires.2008.09.012

Kohyama, J. (2011). Sleep, serotonin, and suicide in Japan. *Journal of Physiological Anthropology, 30*(1), 1–8. doi:10.2114/jpa2.30.1

Kormas, G., Critselis, E., Janikian, M., Kafetzis, D., & Tsitsika, A. (2011). Risk factors and psychosocial characteristics of potential problematic and problematic Internet use among adolescents: A cross-sectional study. *BMC Public Health, 11*(1), 595. doi:10.1186/1471-2458-11-595

Krystal, A. D. (2012). Psychiatric disorders and sleep. *Neurologic Clinics, 30*(4), 1389–1413. doi:10.1016/j.ncl.2012.08.018

Kuss, D. J., & Lopez-Fernandez, O. (2016). Internet addiction and problematic Internet use: A systematic review of clinical research. *World Journal of Psychiatry, 6,* 143–176. doi:10.5498/wjp.v6.i1.143

Lai, C. M., Mak, K. K., Watanabe, H., Ang, R. P., Pang, J. S., & Ho, R. C. (2013). Psychometric properties of the Internet Addiction Test in Chinese adolescents. *Journal of Pediatric Psychology, 38*(7), 794–807. doi:10.1093/jpepsy/jst022

Lin, M. P., Wu, J. Y., Chen, C. J., & You, J. (2018). Positive outcome expectancy mediates the relationship between social influence and Internet addiction among senior high-school students. *Journal of Behavioral Addictions*. Advance online publication. doi:10.1556/2006.7.2018.56

Mak, K. K., Lai, C. M., Watanabe, H., Kim, D. I., Bahar, N., Ramos, M., Young, K. S., Ho, R. C., Aum, N. R., & Cheng, C. (2014). Epidemiology of Internet behaviors and addiction among adolescents in six Asian countries. *Cyberpsychology, Behavior and Social Networking, 17*(11), 720–728. doi:10.1089/cyber.2014.0139

Meltzer, H., Brugha, T., Dennis, M. S., Hassiotis, A., Jenkins, R., McManus, S., Rai, D., & Bebbington, P. (2012). The influence of disability on suicidal behaviour. *ALTER – European Journal of Disability Research/Revue Européenne de Recherche sur le Handicap, 6*(1), 1–12. doi:10.1016/j.alter.2011.11.004

Milani, L., Osualdella, D., & Di Blasio, P. (2009). Quality of interpersonal relationships and problematic Internet use in adolescence. *CyberPsychology & Behavior, 12*(6), 681–684. doi:10.1089/cpb.2009.0071

Moreno, M. A., Jelenchick, L., Cox, E., Young, H., & Christakis, D. A. (2011). Problematic Internet use among US youth: A systematic review. *Archives of Pediatrics & Adolescent Medicine, 165*(9), 797–805. doi:10.1001/archpediatrics.2011.58

Nrugham, L., Larsson, B., & Sund, A. M. (2008). Specific depressive symptoms and disorders as associates and predictors of suicidal acts across adolescence. *Journal of Affective Disorders, 111*(1), 83–93. doi:10.1016/j.jad.2008.02.010

O'Brien, L. M. (2009). The neurocognitive effects of sleep disruption in children and adolescents. *Child and Adolescent Psychiatric Clinics of North America, 18,* 813–823. doi:10.1016/j.chc.2009.04.008

Okan, I. A., Atli, A., Demir, S., Gunes, M., Kaya, M. C., Bulut, M., & Sir, A. (2016). The investigation of factors related to suicide attempts in Southeastern Turkey. *Neuropsychiatric Disease and Treatment, 12,* 407–416. doi:10.2147/NDT.S97471

Pan, P. Y., & Yeh, C. B. (2018). Internet addiction among adolescents may predict self-harm/suicidal behavior: A

prospective study. *The Journal of Pediatrics, 197,* 262–267. doi:10.1016/j.jpeds.2018.01.046

Park, S., Hong, K. E., Park, E. J., Ha, K. S., & Yoo, H. J. (2013). The association between problematic Internet use and depression, suicidal ideation and bipolar disorder symptoms in Korean adolescents. *The Australian and New Zealand Journal of Psychiatry, 47,* 153–159. doi:10.1177/0004867412463613

Park, S. K., Kim, J. Y., & Cho, C. B. (2008). Prevalence of Internet addiction and correlations with family factors among South Korean adolescents. *Adolescence, 43*(172), 895–909.

Ramo, D. E., Liu, H., & Prochaska, J. J. (2012). Reliability and validity of young adults' anonymous online reports of marijuana use and thoughts about use. *Psychology of Addictive Behaviors, 26*(4), 801–811. doi:10.1037/a0026201

Seok, J. W., Lee, K. H., Sohn, S., & Sohn, J. H. (2015). Neural substrates of risky decision making in individuals with Internet addiction. *The Australian and New Zealand Journal of Psychiatry, 49,* 923–932. doi:10.1177/0004867415598009

Sha, F., Chang, Q., Law, Y. W., Hong, Q., & Yip, P. S. F. (2018). Suicide rates in China, 2004–2014: Comparing data from two sample-based mortality surveillance systems. *BMC Public Health, 18*(1), 239. doi:10.1186/s12889-018-5161-y

Tsai, P. S., Wang, S. Y., Wang, M. Y., Su, C. T., Yang, T. T., Huang, C. J., & Fang, S. C. (2005). Psychometric evaluation of the Chinese version of the Pittsburgh Sleep Quality Index (CPSQI) in primary insomnia and control subjects. *Quality of Life Research, 14*(8), 1943–1952. doi:10.1007/s11136-005-4346-x

Wang, H., Deng, J., Zhou, X., Lu, C., Huang, J., Huang, G., Gao, X., & He, Y. (2014). The nonmedical use of prescription medicines among high school students: A cross-sectional study in Southern China. *Drug and Alcohol Dependence, 141,* 9–15. doi:10.1016/j.drugalcdep.2014.04.004

Wang, H., Zhou, X., Lu, C., Wu, J., Deng, X., & Hong, L. (2011). Problematic Internet use in high school students in Guangdong Province, China. *PLoS One, 6*(5), e19660. doi:10.1371/journal.pone.0019660

Wang, X. (2014). Firth logistic regression for rare variant association tests. *Frontiers in Genetics, 5,* 187. doi:10.3389/fgene.2014.00187

Wong, P. W., Fu, K. W., Yau, R. S., Ma, H. H., Law, Y. W., Chang, S. S., & Yip, P. S. (2013). Accessing suicide-related information on the Internet: A retrospective observational study of search behavior. *Journal of Medical Internet Research, 15*(1), e3. doi:10.2196/jmir.2181

World Health Organization. (2015). *Public health implications of excessive use of the Internet, computers, smartphones and similar electronic devices meeting report*. Main Meeting Hall, Foundation for Promotion of Cancer Research National Cancer Research Centre, Tokyo, Japan.

Wu, X., Chen, X., Han, J., Meng, H., Luo, J., Nydegger, L., & Wu, H. (2013). Prevalence and factors of addictive Internet use among adolescents in Wuhan, China: Interactions of parental relationship with age and hyperactivity-impulsivity. *PLoS One, 8*(4), e61782. doi:10.1371/journal.pone.0061782

Xin, M., Xing, J., Pengfei, W., Houru, L., Mengcheng, W., & Hong, Z. (2018). Online activities, prevalence of Internet addiction and risk factors related to family and school among adolescents in China. *Addictive Behaviors Reports, 7,* 14–18. doi:10.1016/j.abrep.2017.10.003

Yau, Y. H., Potenza, M. N., & White, M. A. (2013). Problematic Internet use, mental health and impulse control in an online survey of adults. *Journal of Behavioral Addictions, 2*(2), 72–81. doi:10.1556/JBA.1.2012.015

Yoshimasu, K., Kiyohara, C., & Miyashita, K. (2008). Suicidal risk factors and completed suicide: Meta-analyses based on psychological autopsy studies. *Environmental Health and Preventive Medicine, 13*(5), 243–256. doi:10.1007/s12199-008-0037-x

Young, K. S. (1998). *Caught in the Net: How to recognize the signs of Internet addiction and a winning strategy for recovery*. New York, NY: John Wiley & Sons.

Young, K. S., & de Abreu, C. N. (2012). *Internet addiction: A handbook and guide to evaluation and treatment* (Vol. 1). New York, NY: John Wiley & Sons, Inc.