



Problematic Smartphone Use and Its Relationship With Anxiety and Suicidal Ideation Among South Korean Adolescents

Mi-Sun Lee and Hooyeon Lee

Department of Preventive Medicine, College of Medicine, The Catholic University of Korea, Seoul, Republic of Korea

Objective This study aimed to investigate the prevalence of problematic smartphone use (PSU) among adolescents and its association with anxiety and suicidal ideation.

Methods The 16th cross-sectional, population-based Korea Youth Risk Behavior Web-Based Survey was administered in 2020 and included 54,948 adolescents. We used the Korean version of the smartphone overdependence scale and the 7-item Generalized Anxiety Disorder scale to assess PSU and anxiety. Suicidal ideation was assessed through responses to the self-report question. Multiple logistic regression analyses with complex sampling were conducted to identify the association of PSU with anxiety and suicidal ideation.

Results In total, 25.1% of the adolescents reported PSU, 33.2% had anxiety symptoms, and 10.9% had seriously considered suicide during the past 12 months. Girls with PSU had a higher risk of anxiety (adjusted odds ratio [aOR], 2.81; 95% confidence interval [CI], 2.65 to 2.97) and suicidal ideation (aOR, 1.77; 95% CI, 1.64 to 1.91) than non-PSU girls. Boys with PSU reported more anxiety (aOR, 2.89; 95% CI, 2.72 to 3.07) and suicidal ideation (aOR, 1.82; 95% CI, 1.66 to 1.99) than the non-PSU group. In addition, girls with the lowest household income reported more suicidal ideation than girls with the highest household income (aOR, 3.40; 95% CI, 2.69 to 4.28).

Conclusion This study demonstrated the prevalence of PSU among South Korean adolescents in 2020. The prioritization of the detection of PSU and the identification of psychological factors may help improve the diagnosis and management of mental health problems and potentially yield significant psychosocial benefits.

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Keywords Smartphone; Problematic smartphone use; Anxiety; Suicidal ideation; Adolescents.

INTRODUCTION

Globally, studies of smartphone use and mental health-related factors have received considerable attention.^{1,2} In particular, adolescents are the most vulnerable to smartphone addiction and are strongly attached to smartphones.³ The widespread availability of smartphones causes various behavioral problems among children and adolescents in South Korea,⁴ and the prevalence of psychosocial problems peaks during the adolescent years.^{5,6}

Problematic smartphone use (PSU) refers to symptoms of compulsive and dependent use that resemble those of addiction, including loss of control.⁷ PSU is notably referred to as

“smartphone addiction,” “smartphone use disorder,” or “compulsive smartphone use.” It could be also explained similarly to internet gaming disorder, which has an established diagnostic criterion.⁸ PSU involves preoccupation, neglect of other activities, and excessive or uncontrollable use despite potential harm.⁹ Risk factors for PSU by adolescents include low socioeconomic status, poor academic performance, social isolation, body mass index (BMI), alcohol or smoking use, being exposed to adverse experiences, and mental health issues.⁹⁻¹¹ When adolescents are at increased risk for PSU due to inadequate self-control and difficulties in self-regulation, they are more likely to develop symptoms of dependence and addictive tendencies into adulthood.¹²

According to recent reviews, adolescents with PSU experience greater negative effects on physical health, psychological state, and social interactions compared with normal smartphone users.^{13,14} Previous studies have shown that factors such as sex, household income level, BMI, and cigarette and alcohol use among adolescents are also associated with PSU, anxiety, and suicidal ideation.^{3,9} The prior study also reported the different propensities of addiction or usage smartphone use pat-

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Correspondence: Hooyeon Lee, MD, PhD

Department of Preventive Medicine, College of Medicine, The Catholic University of Korea, 222 Banpo-daero, Seocho-gu, Seoul 06591, Republic of Korea
Tel: +82-2-3147-8381, **Fax:** +82-2-532-3820, **E-mail:** hylee@catholic.ac.kr

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terns by sex.³ Thus, it is necessary to examine the PSU and related mental health factors according to the sex of adolescents.

Anxiety disorders are one of the most common psychiatric problems in adolescents, with rates ranging from 5% to 25%.^{15,16} Anxiety symptoms in adolescents could have long-term effects on their quality of life and are commonly comorbid with other mental illnesses, such as sleep disturbances and depression.¹⁷ PSU has been specifically associated with mental health problems such as anxiety symptom severity.^{18,19} It has been reported that adolescents with PSU have more mental health problems, such as higher levels of loneliness, nervousness, anxiety, and mental distraction.^{6,20} Recent studies also showed that PSU-related dysfunctional patterns and pathological traits were highly associated with anxiety symptoms and impacted psychological and subjective well-being.^{20,21}

PSU is correlated with suicidal ideation^{22,23} and life-long mental health issues.^{5,24} South Korea has had the highest suicide rate among Organization for Economic Co-operation and Development countries since 2003.²⁵ The leading cause of death in South Korean adolescents is suicide, and the prevalence of suicide among adolescents has increased significantly.²⁶ In addition, suicidal behaviors are adversely impacted by PSU leading to impaired social functioning and possibly causing psychiatric symptoms.²⁷

To the best of our knowledge, there have been few studies examining the prevalence of PSU using South Korean nationally representative data and the association between PSU, anxiety, and suicidal ideation. The association of PSU with anxiety and suicidal ideation rates may differ in different countries and cultures, and it could be meaningful to examine the prevalence of and risk factors for mental health issues among the South Korean adolescent population with high dependence on smartphones.^{28,29} Therefore, we investigated the prevalence of and risk factors for anxiety and suicidal ideation among South Korean adolescents.

METHODS

Study population and data collection

These data were drawn from the 2020 nationwide Korea Youth Risk Behavior Web-Based Survey (KYRBWS), which is administered annually by the Korea Centers for Disease Control and Prevention. The KYRBWS is a self-administered, anonymous, and structured questionnaire that includes stratification, clustering, and multistage sampling.³⁰ The self-reported KYRBWS online survey was conducted from August to November 2020. The survey was administered to 57,925 adolescents from a total of 800 schools (400 middle schools and 400 high schools). Finally, 54,948 adolescents (mean age=15.10 years, standard deviation=1.75 years; 51.6% were boys)

responded to the questionnaire (participation rate=94.9%).

Independent variable

We used the Korean-language smartphone overdependence scale to determine whether participants had PSU.³¹⁻³³ The Korean version of the smartphone overdependence scale was developed and validated to screen for PSU.³² Smartphone overdependence was characterized as “withdrawal symptom,” “excessive use of the smartphones that results in tolerance,” and “impairment in daily life.”³² The scale consists of 10 items, and the scale is rated on a 4-point Likert scale (1=“not at all,” 2=“disagree,” 3=“agree,” and 4=“always”). Total scores on the scale range from 10 points to 40 points, with higher scores indicating higher severity: high-risk (≥ 31), potential-risk (23–30), and general-use (≤ 22) groups.^{4,32} Participants were classified into two groups: the PSU group (high-risk and potential-risk groups) and the general-user group.

Dependent variables

We used the 7-item Generalized Anxiety Disorder scale (GAD-7) to assess anxiety symptoms.³⁴ The GAD-7 is one of the most frequently used diagnostic self-report scales for screening, diagnosis, and severity assessment of anxiety disorder. It is calculated by assigning scores of 0–3, and the total score for the seven items ranges from 0 points to 21 points, with higher scores indicating higher severity. The cutoff points of the scores are categorized as none/normal (0–4), mild anxiety (5–9), moderate anxiety (10–14), and severe anxiety (15–21).³⁴ In this study, the analysis was carried out by reclassifying the patients into two groups: the normal group and the anxiety group (mild, moderate, and severe anxiety). Suicidal ideation was assessed through responses to the question, “In the past 12 months, have you ever seriously considered suicide?”. The responses were either “yes” or “no.”

Covariate variables

Sex, age, area of residence, school grade, household income level, academic achievement, BMI, and cigarette and alcohol use were considered covariate variables. The area of residence was divided into three groups by administrative district: metropolitan area, urban area, and rural area. The school grade was classified as 7th to 12th grade. In addition, the self-reported household income level was assessed through responses to the question, “How is your household income level?”. Possible responses were “high,” “middle-high,” “middle,” “middle-low,” and “low.” The analysis reclassified the patients into three groups: high, middle, and low levels.

Self-reported academic achievement was assessed through responses to the question, “In the past 12 months, how has your average academic achievement been?”. Potential responses

were “high,” “middle-high,” “middle,” “middle-low,” and “low.” In this study, the analysis reclassified the patients into three groups: high, middle, and low levels.

Self-reported height and weight were used to calculate BMI as follows: low weight (<18.5 kg/m²), normal weight (<23 kg/m²), overweight (≥23 kg/m²), and obese (≥25 kg/m²).³⁵ Cigarette and alcohol use were assessed by responses to the question, “Have you ever drunk more than one glass of alcohol thus far?” and “Have you ever smoked at least one cigarette thus far?”. Responses were either “yes” or “no.”

Statistical analysis

All statistical analyses were performed with a multistage cluster sampling design. This study applied population weights to all statistical computations to represent the total population of South Korea.³⁶ Analyses were carried out separately for boys and girls. The chi-square test was conducted to estimate the difference in the relationship between general demographic and mental health-related characteristics by sex in the PSU group.

To evaluate the association between PSU and anxiety and suicidal ideation, multiple logistic regression was used, which consecutively adjusted for covariates. Adjusted odds ratios (aORs) and 95% confidence intervals were calculated by multiple logistic regression analysis with complex sampling after adjusting for covariates. All statistical analyses were performed using the SPSS Complex Sample, SPSS/WIN 25.0 program (IBM Corp., Armonk, NY, USA). The statistical significance level was based on $p < 0.05$.

Ethics statement

KYRBWS has been conducted since 2015, and the study used identified data on the 16th KYRBS as a government-approved statistical survey (Approval number: 117058).

This retrospective study was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Institutional Review Board (IRB) of the College of Medicine, The Catholic University of Korea (IRB approval number: MC22ZISI0048).

RESULTS

Table 1 describes the general characteristics and mental health factors of the 54,948 adolescents. A total of 51.6% were boys. Among all participants, 10.2% had used cigarettes, and 33.4% had used alcohol. A total of 22.1% reported a potential risk of PSU, and 3.0% reported a high risk of PSU. Furthermore, anxiety measured through the GAD-7 was reported by

33.2% of the respondents. In addition, 10.9% had seriously considered suicide during the previous 12 months.

Table 2 shows the characteristics of the adolescents with PSU ($n=13,775$). Of those with PSU, 57.7% were girls. Of the adolescents with PSU, 19.0% were 11th graders. Among all PSU groups, 13.5% had used cigarettes, 40.1% had used alcohol, 52.4% reported anxiety symptoms, and 16.8% reported suicidal ideation. The prevalence of both anxiety and suicidal ideation was higher in girls with PSU than in boys with PSU. The results of the chi-square test by sex difference for the PSU group showed a statistically significant difference in all variables ($p < 0.001$).

Table 3 summarizes the results from multiple logistic regression analyses with complex sampling performed to identify the association between PSU and anxiety. For boys and girls, the aOR of anxiety increased as the school grade increased. Lower levels of household income and academic achievement were associated with higher aOR of anxiety symptoms. Girls with cigarette and alcohol use experience had aOR for anxiety of 2.08 and 1.77, respectively. The boys in the PSU group had 2.89 times higher anxiety levels than those in the non-PSU group. In addition, the girls in the PSU group had 2.81 times higher aOR for anxiety symptoms than those in the non-PSU group.

Table 4 lists the results from multiple logistic regression analyses performed to identify the association between PSU and suicidal ideation. Girls with the lowest household income had an aOR of 3.40 for suicidal ideation. Girls who were obese had 1.42 times higher aOR for suicidal ideation than girls with normal weight. Girls with cigarette and alcohol use experience had aOR of 2.14 and 1.92 for suicidal ideation, respectively. The girls in the PSU group had 1.77 times higher suicidal ideation than those in the non-PSU group. In addition, the boys in the PSU group had 1.82 times higher aOR for suicidal ideation than those in the non-PSU group.

DISCUSSION

In total, 25.1% of adolescents reported PSU. The prevalence of PSU was higher in girls than boys. The overall prevalence of PSU is similar to findings from a previous study, which reported a 23.3% PSU prevalence in adolescence and young adulthood (range=10%–30%).^{5,13} In addition, the prevalence of both anxiety and suicidal ideation was significantly higher in girls with PSU than in boys with PSU.^{2,5,28} Prior studies on smartphone addiction in Austria showed that females were more dependent on smartphones than males.³⁷ It was reported that because girls mainly have more communication using social networking services desires than boys, they are becoming increasingly smartphone overdependence.¹⁰ Other studies

Table 1. Sociodemographic characteristics and mental health of the study population

Variables	Total	Boys	Girls
Total	54,948 (100.0)	28,353 (51.6)	26,595 (48.4)
Age (yr)	15.10±1.75	15.12±1.76	15.07±1.75
Area of residence			
Metropolitan area	23,621 (43.0)	12,553 (44.3)	11,068 (41.6)
Urban area	26,981 (49.1)	13,562 (47.8)	13,419 (50.5)
Rural area	4,346 (7.9)	2,238 (7.9)	2,108 (7.9)
School grade			
7th	10,005 (18.2)	5,098 (18.0)	4,907 (18.5)
8th	9,564 (17.4)	4,823 (17.0)	4,741 (17.8)
9th	9,392 (17.1)	4,909 (17.3)	4,483 (16.9)
10th	8,907 (16.2)	4,602 (16.2)	4,305 (16.2)
11th	8,907 (16.2)	4,631 (16.3)	4,276 (16.1)
12th	8,173 (14.9)	4,290 (15.1)	3,883 (14.6)
Household income level			
High	6,039 (11.0)	3,536 (12.5)	2,503 (9.4)
Middle	47,634 (86.7)	24,095 (85.0)	23,539 (88.5)
Low	1,275 (2.3)	722 (2.5)	553 (2.1)
Academic achievement			
High	6,736 (12.3)	3,853 (13.6)	2,883 (10.8)
Middle	42,679 (77.7)	21,400 (75.5)	21,279 (80.0)
Low	5,533 (10.1)	3,100 (10.9)	2,433 (9.1)
Body mass index*			
Low weight	11,226 (20.4)	4,636 (16.8)	6,590 (25.6)
Normal weight	25,777 (46.9)	11,997 (43.5)	13,780 (53.5)
Overweight	7,264 (13.2)	4,436 (16.1)	2,828 (11.0)
Obese	9,093 (16.5)	6,538 (23.7)	2,555 (9.9)
Cigarette use			
Never	49,318 (89.8)	24,448 (86.2)	24,870 (93.5)
Ever	5,630 (10.2)	3,905 (13.8)	1,725 (6.5)
Alcohol use			
Never	36,591 (66.6)	17,778 (62.7)	18,813 (70.7)
Ever	18,357 (33.4)	10,575 (37.3)	7,782 (29.3)
Smartphone overdependence			
General-use group	41,173 (74.9)	22,521 (79.4)	18,652 (70.1)
Potential-risk group	12,142 (22.1)	5,239 (18.5)	6,903 (26.0)
High-risk group	1,633 (3.0)	593 (2.1)	1,040 (3.9)
Generalized anxiety disorder			
No	36,711 (66.8)	20,880 (73.6)	15,831 (59.5)
Yes	18,237 (33.2)	7,473 (26.4)	10,764 (40.5)
Suicidal ideation			
No	48,969 (89.1)	26,099 (92.1)	22,870 (86.0)
Yes	5,979 (10.9)	2,254 (7.9)	3,725 (14.0)

Values are presented as mean±standard deviation or number (%). *there is some missing data as not all individuals responded

also found that girls or young women are more likely than boys to focus on social interactions on their smartphones.^{38,39} Since the prevalence of PSU differs according to the sex and characteristics of adolescents, PSU prevention policies and measures are required in consideration of their smartphone usage purpose and factors that induce overdependence.

Overall, anxiety and suicidal ideation increased as the grade level increased. The aOR of PSU among 7th grade adolescents was lowest,⁵ making it a prominent requirement for early intervention. The present study is consistent with previous findings that older adolescents might be at higher risk for poor mental health than younger adolescents.⁴⁰ Our results align

Table 2. Sociodemographic characteristics and mental health among adolescents with problematic smartphone use

Variables	Total	Boys	Girls	p
Total	13,775 (100.0)	5,832 (42.3)	7,943 (57.7)	
Area of residence				<0.001
Metropolitan area	5,597 (40.1)	2,438 (39.9)	3,159 (40.2)	
Urban area	7,094 (54.1)	2,933 (54.2)	4,161 (54.0)	
Rural area	1,084 (5.8)	461 (5.9)	623 (5.7)	
School grade				<0.001
7th	1,921 (13.2)	823 (13.3)	1,098 (13.1)	
8th	2,358 (15.6)	985 (15.7)	1,373 (15.6)	
9th	2,586 (17.2)	1,069 (16.5)	1,517 (17.7)	
10th	2,246 (17.0)	906 (16.1)	1,340 (17.8)	
11th	2,476 (19.0)	1,029 (19.0)	1,447 (19.1)	
12th	2,188 (18.0)	1,020 (19.5)	1,168 (16.8)	
Household income level				<0.001
High	1,137 (8.5)	569 (9.9)	568 (7.3)	
Middle	12,262 (88.9)	5,086 (87.2)	7,176 (90.2)	
Low	376 (2.6)	177 (2.9)	199 (2.4)	
Academic achievement				<0.001
High	1,281 (9.2)	611 (10.6)	670 (8.1)	
Middle	10,625 (77.5)	4,395 (75.2)	6,230 (79.3)	
Low	1,869 (13.3)	826 (14.2)	1,043 (12.7)	
Body mass index*				<0.001
Low weight	2,946 (21.6)	977 (16.8)	1,969 (25.3)	
Normal weight	6,611 (50.0)	2,526 (45.1)	4,085 (53.7)	
Overweight	1,750 (13.0)	892 (15.6)	858 (11.1)	
Obese	2,051 (15.4)	1,285 (22.5)	766 (10.0)	
Cigarette use				<0.001
Never	11,935 (86.5)	4,792 (81.7)	7,143 (90.1)	
Ever	1,840 (13.5)	1,040 (18.3)	800 (9.9)	
Alcohol use				<0.001
Never	8,300 (59.9)	3,326 (56.4)	4,974 (62.6)	
Ever	5,475 (40.1)	2,506 (43.6)	2,969 (37.4)	
Generalized anxiety disorder				<0.001
No	6,574 (47.6)	3,254 (55.1)	3,320 (42.0)	
Yes	7,201 (52.4)	2,578 (44.9)	4,623 (58.0)	
Suicidal ideation				<0.001
No	11,476 (83.2)	5,116 (87.5)	6,360 (79.9)	
Yes	2,299 (16.8)	716 (12.5)	1,583 (20.1)	

Values are presented as number (%). *there is some missing data as not all individuals responded

Table 3. Association between sociodemographic factors, problematic smartphone use, and anxiety

Variables	Anxiety (N=18,237, 33.2%)					
	Boys (N=7,473, 26.4%)			Girls (N=10,764, 40.5%)		
	aOR	95% CI	p	aOR	95% CI	p
Area of residence (ref=rural)						
Metropolitan area	0.95	(0.85–1.06)	0.740	0.92	(0.82–1.04)	0.150
Urban area	1.02	(0.91–1.13)	0.053	1.03	(0.92–1.15)	0.069
School grade (ref=7th)						
8th	1.10	(1.00–1.21)	0.018	1.19	(1.08–1.31)	0.017
9th	1.17	(1.06–1.29)	0.009	1.28	(1.17–1.41)	0.001
10th	1.28	(1.16–1.42)	0.003	1.23	(1.11–1.36)	0.005
11th	1.50	(1.37–1.65)	<0.001	1.43	(1.29–1.57)	<0.001
12th	1.78	(1.61–1.96)	<0.001	1.60	(1.45–1.77)	<0.001
Household income level (ref=high)						
Middle	1.38	(1.27–1.50)	<0.001	1.54	(1.40–1.69)	<0.001
Low	2.42	(2.02–2.89)	<0.001	3.67	(3.02–4.47)	<0.001
Academic achievement (ref=high)						
Middle	1.04	(0.96–1.12)	0.497	1.17	(1.08–1.27)	0.026
Low	1.38	(1.25–1.52)	0.002	1.94	(1.74–2.17)	<0.001
Body mass index (ref=normal weight)						
Low weight	0.91	(0.83–0.98)	0.010	0.95	(0.89–1.01)	0.089
Overweight	0.97	(0.90–1.05)	0.079	1.15	(1.06–1.26)	0.003
Obesity	1.12	(1.05–1.20)	<0.001	1.20	(1.10–1.31)	<0.001
Cigarette use (ref=never)						
Ever	1.55	(1.44–1.67)	<0.001	2.08	(1.88–2.30)	<0.001
Alcohol use (ref=never)						
Ever	1.49	(1.42–1.58)	<0.001	1.77	(1.68–1.87)	<0.001
Smartphone overdependence (ref=no)						
Yes	2.89	(2.72–3.07)	<0.001	2.81	(2.65–2.97)	<0.001

aOR, adjusted odds ratio; CI, confidence interval

with prior reports of familial socioeconomic factors and predictors of mental health difficulties. The present study showed that a low level of household income was associated with a high risk of anxiety and suicidal ideation. With regard to socioeconomic characteristics, the results of previous studies proved that lower parental income has been found to be associated with higher rates of poorer psychological well-being in adolescents.^{28,41}

This study demonstrated the association between PSU and anxiety symptoms. It was shown that adolescents who were over-dependent on their smartphones had a higher prevalence of anxiety. The findings of the present study are consistent with those of a previous study concerning PSU being associated with anxiety symptoms.⁴² During the coronavirus disease-2019 (COVID-19) pandemic, it was reported that adolescents with PSU increased globally.⁴³ Adolescents with

smartphones have become dependent on their devices or have formed the habit of checking their phones excessively without conscious self-control.⁴⁴ Excessive and uncontrolled smartphone use could give rise to affective, social, and behavioral problems.²⁰ In particular, adolescents with PSU may increase feelings of deprivation, loneliness, and alienation by comparing them with others. Adolescents with lower impulse control might be more vulnerable to the negative effects of media multitasking.⁴⁵ Excessive use of games and apps until late at night also causes sleep deprivation, stress, and anxiety symptoms.⁴⁶ Therefore, it needs to monitor the prevalence of PSU and risk factors to support the mental health of adolescents with PSU and to reduce its prevalence.

Additionally, our study showed the association between PSU and suicidal ideation. This finding parallels the increased odds of suicidal ideation among Korean college students with

Table 4. Association between sociodemographic factors, problematic smartphone use, and suicidal ideation

Variables	Suicidal ideation (N=5,979, 10.9%)					
	Boys (N=2,254, 7.9%)			Girls (N=3,725, 14.0%)		
	aOR	95% CI	p	aOR	95% CI	p
Area of residence (ref=rural)						
Metropolitan area	1.11	(0.93–1.32)	0.836	1.15	(0.91–1.46)	0.571
Urban area	1.08	(0.91–1.28)	0.519	1.23	(0.97–1.56)	0.189
School grade (ref=7th)						
8th	1.26	(1.08–1.49)	0.002	1.25	(1.10–1.42)	0.014
9th	1.20	(1.04–1.39)	0.019	1.37	(1.20–1.56)	0.003
10th	1.16	(0.98–1.37)	0.124	1.23	(1.07–1.40)	0.009
11th	1.49	(1.27–1.75)	<0.001	1.42	(1.26–1.61)	<0.001
12th	1.48	(1.26–1.74)	<0.001	1.32	(1.16–1.51)	<0.001
Household income level (ref=high)						
Middle	1.04	(0.91–1.20)	0.199	1.39	(1.21–1.61)	0.001
Low	2.44	(1.93–3.08)	<0.001	3.40	(2.69–4.28)	<0.001
Academic achievement (ref=high)						
Middle	0.91	(0.80–1.04)	0.087	1.02	(0.90–1.16)	0.278
Low	1.43	(1.22–1.68)	0.001	1.92	(1.65–2.24)	0.010
Body mass index (ref=normal weight)						
Low weight	1.08	(0.95–1.22)	0.060	0.92	(0.84–1.01)	0.053
Overweight	1.02	(0.90–1.16)	0.219	1.12	(1.01–1.25)	0.021
Obesity	1.16	(1.03–1.30)	<0.001	1.42	(1.27–1.59)	<0.001
Cigarette use (ref=never)						
Ever	1.46	(1.29–1.64)	<0.001	2.14	(1.89–2.42)	<0.001
Alcohol use (ref=never)						
Ever	1.63	(1.48–1.79)	<0.001	1.92	(1.77–2.08)	<0.001
Smartphone overdependence (ref=no)						
Yes	1.82	(1.66–1.99)	<0.001	1.77	(1.64–1.91)	<0.001

aOR, adjusted odds ratio; CI, confidence interval

PSU.³⁶ According to previous studies, self-harm has risen by 68% since the widespread introduction of smartphones in the United Kingdom.^{47,48} Adolescents who are exposed to indiscreet information through smartphones can easily access harmful content such as self-harm websites.⁴⁵ Of note, adolescents who spend a lot of time online may be at increased risk of cyberbullying, which can lead to suicidal behaviors. Prior research found that students' excessive smartphone use was significantly positively correlated with suicidal ideation.^{49,50} In addition, adolescents with PSU are less likely to maintain an appropriate pattern of smartphone use, and smartphone addiction might lead to suicidal ideation, plan, or attempts.⁵¹ As a result, increasing awareness about the severity of smartphone overdependence might help prevent suicide-related problems.²⁴

Of note, adolescents who were obese or experienced smok-

ing and alcohol had a higher risk of anxiety and suicidal ideation than those without obesity or the experience of smoking and alcohol. Recent findings have suggested that individuals with PSU may be more likely to develop eating disorders such as anorexia and bulimia.⁵² Additionally, social media may create a distorted perception of body image among adolescents, which could contribute to an unhealthy state.⁵³ This result indicates that BMI and negative health behaviors play an important role in the psychosocial consequences observed in adolescents.⁵⁴ With regard to suicidal ideation, while there were exceptions the aOR of anxiety and suicidal ideation increased with higher school grades due to academic stress. Academic stress is a significant factor for adolescents, particularly in South Korea, which leads to highly competitive university admissions.⁵⁵ Therefore, further studies are required on the association between academic stress pressures and mental health

difficulties in adolescents.

Furthermore, the prior study⁵⁶ showed the three pathways model of the PSU explained empirical and theoretical support for the role of emotion regulation and impulsivity difficulties.⁵⁶ Specifically, addictive-related behaviors mean a result of interactions between associated symptoms based on the Interaction of Person-Affect-Cognition-Execution (I-PACE) model.⁵⁷ Further research related to PSU is required for in-depth analysis and validation based on the I-PACE model, which is the basis of addictive behavior.

There are a few limitations to this study that should be mentioned. First, the present study used cross-sectional data, which excludes causal assumptions. Pre-2020 KYRBWS data did not have a PSU variable, therefore, we could not merge and analyze the before-2020 data. Second, adolescents have been especially affected by COVID-19 pandemic-related factors,⁴⁷ however, it was difficult to completely control for various factors in our study. Our study design did not examine variables that would be representative of the COVID-19 pandemic, therefore, the results could not be interpreted in a timely manner. Third, our study used South Korean nationally representative data including the smartphone overdependence scale. Based on this, it is possible to predict the prevalence of PSU. However, since it is not a diagnostic assessment by a doctor, it must be considered and interpreted. Fourth, this study could not be adjusted the number of household members for the household income variable. Therefore, in a follow-up study, it is necessary to classify the categories by dividing the total household income by family members living together. Fifth, the self-reported survey was conducted by an online system. Also, adolescents might have socially acceptable underreported or over reported personality characteristics. In addition, follow-up studies need to consider factors that can affect suicidal ideation and anxiety symptoms, such as biological factors and adverse childhood experiences. Nevertheless, these results could suggest an association between smartphone overdependence and mental health and health-risk indicators.

In summary, we found that the prevalence of PSU was 25.1% and that it was significantly related to higher levels of anxiety and suicidal ideation in South Korean adolescents. The results of this study might help evaluate and prevent smartphone overdependence and mental health issues in South Korean adolescents. Based on our results, it is necessary to understand the factors influencing anxiety and suicidal ideation among adolescents and to develop an appropriate screening system to intervene as soon as possible by continuously monitoring at-risk individuals. International initiatives should be also established to explore improvements in provide to mental health services, along with adolescents' constructive use of smartphones.⁵⁸ In conclusion, prevention and intervention services

for adolescents based on the appropriate strategies and resources to reduce PSU are recommended.

Availability of Data and Material

The data can be publicly downloaded at <https://www.kdca.go.kr/yhs/> after entering basic personal details. We used the SPSS dataset of KYRBWS in the year 2020. The authors do not possess the right to directly distribute the data.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: Mi-Sun Lee, Hooyeon Lee. Data curation: Mi-Sun Lee. Formal analysis: Mi-Sun Lee. Funding acquisition: Hooyeon Lee. Investigation: Hooyeon Lee. Methodology: Mi-Sun Lee, Hooyeon Lee. Project administration: Hooyeon Lee. Software: Mi-Sun Lee, Hooyeon Lee. Supervision: Hooyeon Lee. Validation: Mi-Sun Lee, Hooyeon Lee. Visualization: Mi-Sun Lee, Hooyeon Lee. Writing—original draft: Mi-Sun Lee. Writing—review & editing: Mi-Sun Lee, Hooyeon Lee.

ORCID iDs

Mi-Sun Lee <https://orcid.org/0000-0003-2918-0546>
Hooyeon Lee <https://orcid.org/0000-0002-8426-2045>

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