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Association between smartphone overdependence and alcohol and tobacco use behaviors among adolescents in Korea

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Abstract

Smartphone overdependence among adolescents is rising, prompting concern about its link to alcohol and tobacco use. While adolescent substance use has been widely studied, the impact of excessive smartphone use remains unclear. This study examined the association between smartphone overdependence and alcohol and tobacco use among Korean adolescents. This cross-sectional study analyzed data from the 2020 and 2023 Korean Youth Risk Behavior Web-based Survey and included 107,606 adolescents (54,985 males, 52,621 females). Smartphone dependence was measured with the Adolescents'

Smartphone Overdependence Scale categorizing participants as general, potential-risk, or high-risk users. Multivariable logistic regression analyses adjusted for demographic and socioeconomic factors, perceived health, stress, sleep duration, and academic performance. Compared with general users, potential-risk users had higher odds of alcohol consumption (Odds Ratio=1.22; 95% Confidence Interval: 1.19–1.26) and smoking (OR=1.26; 95% CI: 1.20–1.32). High-risk users showed even greater odds of alcohol use (OR=1.65; 95% CI: 1.53–1.77) and smoking (OR=2.32; 95% CI: 2.11–2.56). A dose-response relationship was observed, with greater dependence linked to earlier initiation and heavier use. These findings highlight a significant positive association and underscore the need for longitudinal research and targeted prevention strategies.

Keywords: smartphone overdependence; smoking; alcohol consumption; substance use; adolescents

1 Introduction

Rapid technological advancements have led to the widespread integration of smartphones into our daily lives, providing users with gratification through entertainment, social media engagement, information search, and online shopping. Between 2016 and 2021, the number of smartphone owners increased by 73.9%. Currently, over 7.2 billion smartphones exist worldwide, representing approximately 90% of the global population [1]. The widespread popularity of smartphones and users' strong attachment to them have raised concerns about smartphone overdependence

[2, 3]. This issue is particularly significant among adolescents worldwide who have demonstrated increasing levels of smartphone dependence [4, 5]. In 2022, the Ministry of Science and Information and Communication Technology of Korea reported that 40.1% of Korean adolescents exhibited the highest level of smartphone dependence among all age groups, reflecting a substantial increase compared with the overall average of 23.6% observed over the previous 2 years [6]. Adolescents often rely on smartphones to manage peer relationships and address social and emotional challenges, including self-esteem concerns, which may further increase their dependence on smartphones [7, 8]. Additionally, adolescents are more likely to be vulnerable to addictive behaviors than adults because of their developmental and neurological characteristics [9].

Various studies have linked smartphone overdependence to adverse mental health outcomes, including anxiety, depression, and suicidal behaviors [10-12], as well as other behavioral addictions, such as internet addiction and excessive social media use [13, 14]. Although previous studies have demonstrated strong associations among various addictive behaviors, relatively little attention has been given to the potential relationship between smartphone overdependence and alcohol and tobacco use. Despite its high prevalence, limited research has examined whether smartphone overdependence is associated with alcohol and tobacco use among adolescents.

From a developmental and behavioral perspective, adolescence is

characterized by ongoing maturation of the prefrontal cortex (PFC) and heightened sensitivity of reward-related neural systems [15]. This developmental profile has been associated with increased impulsivity and stronger reward-seeking tendencies during adolescence [16]. In this context, smartphone overdependence may involve neural reward and self-regulatory mechanisms that overlap with those implicated in substance use. Furthermore, smartphone overdependence may contribute to behavioral and environmental changes, such as reduced sleep duration and increased exposure to peer norms in digital environments, both of which have been associated with alcohol and tobacco use [17, 18]. These considerations provide a theoretical basis for investigating the association between smartphone overdependence and adolescent substance use.

Therefore, this study aims to examine the relationship between smartphone overdependence and alcohol and tobacco use among Korean adolescents using data from the Korean Youth Risk Behavior Web-based Survey (KYRBS). Compared with previous studies that have primarily focused on simple correlations between problematic smartphone use and substance use, this study extends the literature by (1) using a large, nationally representative sample of Korean adolescents with a standardized smartphone overdependence scale; (2) examining not only lifetime alcohol and tobacco use but also age of initiation, frequency, and intensity of consumption; and (3) assessing dose-response patterns and the consistency of associations across 2 survey years (2020 and 2023).

2 Results

A total of 107,606 adolescents (54,985 males and 52,621 females) were included in the study. Table 1 presents the general characteristics of participants according to their alcohol consumption experience. Of these, 35,504 (34%) reported having consumed alcohol. Compared with those without alcohol consumption experience, participants who had consumed alcohol were more likely to be male, aged 16–18 years, from “low” household income backgrounds, and to perceive their health as “very unhealthy.” They also tended to report “very high” stress levels, “very inappropriate” sleep durations, and “low” academic grades. Across the overall sample, 30.98% of general users, 36.42% of potential-risk users, and 45.3% of high-risk smartphone overdependence users reported alcohol consumption experience.

Table 2 shows the general characteristics of participants based on their smoking history. Among all participants, 10,104 (9.39%) reported smoking experience. Similar to the findings for alcohol consumption experience, participants with smoking experience were more likely to be male, aged 16–18 years, from “low” household income backgrounds, and to report “very high” stress levels and “low” academic grades. Within the overall sample, 8.44% of general users, 10.59% of potential-risk users, and 19.18% of high-risk smartphone overdependence users reported smoking experience.

The logistic regression analysis results (Table 3) revealed that adolescents classified as potential-risk users were 22% more likely to report alcohol consumption experience (OR = 1.22; 95% CI: 1.19–1.26) and 26%

more likely to report smoking experience (OR = 1.26; 95% CI: 1.20–1.32) compared with general users. Adolescents classified as high-risk were 65% more likely to report alcohol consumption experience (OR = 1.65; 95% CI: 1.53–1.77), and 132% more likely to report smoking experience (OR = 2.32; 95% CI: 2.11–2.56) compared with general users. In Model 1 (crude), higher levels of smartphone overdependence showed strong positive associations with both alcohol consumption and smoking. After adjusting for sex, age, household income, and academic grade in Model 2, and further adjusting for perceived health status, stress level, and sleep duration in Model 3, the ORs were only modestly attenuated, and the associations remained statistically and clinically meaningful. Sensitivity analyses stratified by survey year showed consistent associations in both 2020 and 2023 (Supplementary Table S2).

Figure 2 illustrates the dose-response associations between substance use characteristics and high-risk smartphone overdependence. Among adolescents with alcohol consumption experience, an earlier age at first alcohol consumption was associated with a higher adjusted probability of high-risk smartphone overdependence, whereas later initiation was associated with a lower probability. The predicted probability of high-risk smartphone overdependence also increased steadily with greater monthly alcohol consumption frequency, higher average alcohol consumption per occasion, and more frequent monthly binge drinking episodes. A similar pattern was observed among adolescents with smoking experience. Earlier

age at first smoking and earlier initiation of daily smoking were associated with higher probabilities of high-risk smartphone overdependence. Additionally, the probability of high-risk smartphone overdependence increased with more smoking days per month and a higher average number of cigarettes smoked per day.

3 Discussion

This study revealed a significant positive association between smartphone overdependence and alcohol and tobacco use among Korean adolescents. A clear dose-response relationship was also identified, indicating that higher levels of smartphone overdependence were associated with earlier initiation, increased frequency, and greater intensity of alcohol and tobacco consumption. These findings suggest that excessive smartphone use is associated with more frequent and intensive substance use patterns, underscoring smartphone overdependence as a relevant correlate within adolescent health and prevention frameworks. Collectively, these findings extend the existing literature by demonstrating graded associations between smartphone overdependence and multiple dimensions of alcohol and tobacco use in a large, nationally representative adolescent sample and by confirming the consistency of these associations across 2 survey years.

Notably, the magnitude of the association differed by substance. The adjusted OR for alcohol use in the high-risk group was 1.65, whereas the corresponding estimate for smoking was substantially higher at 2.32, indicating more than a twofold increase in the likelihood of the outcome. An

OR of this magnitude represents a substantial elevation in risk for adolescent behavioral outcomes, suggesting that the observed association with smoking is unlikely to be trivial despite the large sample size. Although smaller in magnitude, the association with alcohol use also reflects a clinically relevant increase in risk. Nicotine is known to produce rapid dopaminergic reinforcement and strong habit-forming effects through mesolimbic reward pathways, which contribute to repetitive and compulsive use patterns [24]. These reinforcement mechanisms resemble the reward-driven behavioral patterns observed in problematic smartphone engagement. In contrast, adolescent alcohol use has been consistently shown to be more strongly embedded in peer and social contexts rather than driven solely by repetitive individual reinforcement processes [25]. These differences in neurobehavioral and social mechanisms may partly explain the stronger association observed for smoking compared with alcohol use in this study. Despite the increasing prevalence of smartphone overdependence, research on its potential association with other addictive behaviors, particularly alcohol and tobacco use, remains limited. However, multiple studies on other behavioral addictions suggest that such conditions are often associated with substance use or related addictive behaviors. Internet addiction, for instance, may induce permanent changes in neural networks, leading to impaired executive functions and alterations in the reward system [26]—effects commonly observed in individuals with addictive behaviors and considered essential for understanding addiction mechanisms. Additionally, exposure to

alcohol- and tobacco-related content through the internet and smartphones may influence substance use behaviors, reinforce risky actions, and potentially shape adolescents' attitudes and susceptibility toward substance use [27, 28]. Research also suggests that social networking sites may increase the risk of alcohol and tobacco use, primarily through peer influence, where individuals are exposed to their peers' substance-using behaviors and events involving substance use [29, 30]. Furthermore, previous studies have reported associations between social media use and addictive behaviors, including increased alcohol, tobacco, and drug use [31, 32]. Similar correlations have also been observed between gaming disorder [33] and gambling disorder [34] with substance use, suggesting that these behavioral addictions may share common risk factors and underlying mechanisms with substance-related addictions. These findings can be interpreted within a broader framework of shared vulnerability between behavioral and substance-related addictions. Previous studies on internet addiction, gaming disorder, and gambling disorder have demonstrated associations with alcohol and tobacco use, suggesting the presence of overlapping psychological and neurobiological characteristics rather than direct causal pathways. Given that smartphone overdependence encompasses elements of internet use, social media interaction, gaming, and gambling-related behaviors, it may exert a similarly complex influence on user behavior. In this context, smartphone overdependence may reflect underlying traits such as heightened reward sensitivity, impulsivity, and impaired self-regulation,

which are also implicated in substance use behaviors. These overlapping features have also been discussed within neurobiological models of addiction.

In addition to these regression estimates, the generalized additive models revealed clear dose-response patterns between the intensity of alcohol and tobacco use and high-risk smartphone overdependence. Among adolescents who had initiated alcohol consumption or smoking, earlier onset age, more frequent monthly use, and greater consumption were associated with progressively higher adjusted probabilities of belonging to the high-risk smartphone overdependence group. These gradients indicate that smartphone overdependence is associated not only with substance use status but also with more intensive and earlier-emerging patterns of alcohol and tobacco use within these behaviors. Understanding the biological mechanisms underlying these associations provides important theoretical context, as prior research suggests that both behavioral and substance-related addictions involve dopaminergic reward circuitry implicated in reinforcement and reward sensitivity [35]. Repeated engagement with rewarding stimuli, including digital media, has been discussed as potentially engaging similar neural systems. Behavioral addictions have also been associated with dysfunction of the PFC, which plays a crucial role in impulse control, decision-making, and executive function [19, 34]. Studies have shown that individuals with smartphone overdependence exhibit higher impulsivity and poorer decision-making performance associated with prefrontal dysfunction [36]. These findings suggest that impairments in executive

control may represent a shared neurocognitive vulnerability across behavioral and substance-related addictions [37]. Impulsivity has been consistently linked to the development and progression of substance use disorders, with individuals exhibiting higher impulsivity levels being more likely to initiate substance use, escalate consumption, and experience difficulties in abstinence and relapse prevention [38]. These findings suggest that impulsivity observed in behavioral addiction may represent a shared vulnerability factor for substance use disorders, potentially through maladaptive reward-seeking patterns and impaired self-regulation. However, this study did not directly assess neural function or biomarkers. Therefore, these neurobiological interpretations should be considered theoretical explanations derived from prior literature rather than empirically tested mechanisms within our dataset. Beyond neurobiological and psychological pathways, socio-behavioral mechanisms may further explain the observed associations. Smartphone overdependence may displace protective behaviors such as adequate sleep, regular physical activity, and face-to-face social interaction [39, 40], all of which are known to reduce substance use risk during adolescence [41-43]. Furthermore, increased exposure to alcohol- and tobacco-related content, online peer norms, and social networking environments may influence attitudes toward and perceived acceptability of substance use. Although these pathways were not directly measured in the current dataset, they provide a complementary framework for understanding how digital engagement may be associated with substance use behaviors.

However, it is important to note that not all individuals who frequently use smartphones develop problematic or addictive behaviors. The key distinction lies in whether individuals can regulate their smartphone use without experiencing significant distress or functional impairment. Smartphone overdependence refers to cases in which individuals exhibit compulsive use, withdrawal symptoms, and impaired control—characteristics commonly observed in addictive behaviors, such as gambling disorder [44]. Studies have indicated that smartphone overdependence is not merely a function of screen time but rather reflects dysfunction in self-regulation and impulsivity, which are also core features of substance use disorders [45, 46]. These characteristics suggest that smartphone overdependence represents more than just a habit; rather, it can significantly impact brain function and behavior in ways similar to other addictive disorders when compared with general smartphone users [47]. Notably, these addictive behaviors often emerge during adolescence, a critical developmental period during which alterations in brain function can have long-term consequences for addiction vulnerability [48]. A critical factor contributing to adolescents' susceptibility to risky behaviors, including substance use, pertains to the incomplete maturation of PFC circuitry, which is essential for self-regulation and does not fully develop until early adulthood [49]. Due to the relative immaturity of reward-processing and inhibitory control systems, adolescents tend to exhibit heightened reward sensitivity and reactivity, which collectively increase vulnerability to reward-biased and developmentally immature decision-

making [50]. Therefore, discussions on excessive smartphone use among adolescents should consider their vulnerability to addictive behaviors, and greater caution should be exercised when interpreting such patterns.

International research suggests that adolescent smartphone overdependence is a growing concern worldwide, although cultural and regulatory differences may influence substance use patterns. Studies conducted in North America and Europe have reported associations between excessive digital engagement and substance use, often mediated by social and environmental factors [51, 52]. In contrast, some Asian countries, including Korea, report higher rates of smartphone overdependence, potentially amplifying the risks associated with substance use [53, 54]. This study contributes to the global literature by providing evidence from Korean adolescents and underscores the need for comparative research across different sociocultural contexts.

This study has several limitations. Given the large sample size and cross-sectional design of the KYRBS, statistically significant differences observed in descriptive analyses may not necessarily reflect meaningful practical differences. Accordingly, the primary interpretation of the findings is based on multivariable regression analyses that provide estimates of effect magnitude. Additionally, the cross-sectional nature of the data limits the ability to determine temporal and causal relationships between smartphone overdependence and alcohol and tobacco use behaviors. Although existing research indicates that the average age of first smartphone use is

approximately 12 months [55, 56], whereas the average age of initiating substance use is approximately 15 years [57], population-level differences in exposure timing do not establish temporal ordering at the individual level. Therefore, longitudinal studies are needed to clarify the temporal sequence and causal relationships between smartphone overdependence and substance use behaviors. Additionally, data from the 2021 and 2022 KYRBS were excluded due to changes in survey questions regarding smartphone overdependence. Unlike earlier surveys, the 2021-2022 dataset measured only total smartphone usage time rather than employing a validated index of overdependence. This limitation may have reduced the ability to capture the most recent trends in adolescent smartphone usage and substance use behaviors. However, smartphone overdependence is not solely determined by usage duration but is also defined by psychological dependence and functional impairment. Consequently, the dataset lacked essential components required for this study, which may have affected the continuity and validity of the analysis. Furthermore, the KYRBS does not collect data on specific smartphone activities (e.g., gaming or social media use), which may limit the ability to distinguish between smartphone overdependence and internet addiction. Given the established relationship between certain behavioral addictions and substance use disorders, future studies should consider a broader range of smartphone-related activities. In addition, the KYRBS excludes adolescents who are long-term absentees or unable to complete the survey independently, including some students with special

needs. These groups may have greater vulnerability to both behavioral addictions and substance use. As a result, the observed associations in this study may represent conservative estimates, and the true magnitude of the relationship in the broader adolescent population may be larger. Furthermore, several potentially important confounders could not be directly accounted for in this analysis. The KYRBS does not include detailed information on peer substance use, parental monitoring or supervision, or specific psychiatric diagnoses such as attention-deficit/hyperactivity disorder or clinical depression/anxiety. Since these factors are known to be associated with both problematic smartphone and substance use among adolescents, their omission may have introduced residual confounding and may have led to either overestimation or underestimation of the observed associations. Although we adjusted for related psychosocial indicators, including perceived stress, self-rated health, sleep duration, and suicidal ideation or behaviors, these variables only partially capture broader mental health and social contexts. Therefore, our findings should be interpreted with caution. Future studies incorporating more comprehensive measures of family environment, peer influences, and clinically assessed mental health conditions are warranted. Furthermore, alcohol and tobacco use were assessed as lifetime ever-use, which does not distinguish between brief experimentation and more sustained or heavy use. Therefore, our findings should be interpreted as reflecting any initiation of substance use rather than clinically defined addictive behavior patterns. Finally, because the study variables were

assessed using self-reported measures, the data may be subject to biases such as recall bias and social desirability bias. Therefore, clinical validation studies are required to confirm these associations and to fully understand the implications of smartphone overdependence in relation to other behavioral outcomes.

In conclusion, this study provides evidence of a significant association between smartphone overdependence and increased alcohol and tobacco use among adolescents. Higher levels of smartphone dependence were consistently associated with earlier onset, greater frequency, and increased intensity of substance use. These findings provide empirical evidence that smartphone overdependence is significantly correlated with alcohol and tobacco use during adolescence. These results offer a scientific basis for future research and may inform adolescent public health discussions by identifying smartphone overdependence as a relevant factor in the development of preventive health strategies and interventions. Although causal relationships cannot be established, the findings may have practical implications. For example, assessment of problematic smartphone use could be considered as part of existing screening efforts for adolescent risk behaviors. Additionally, promoting digital literacy and healthy smartphone use habits should be integrated into alcohol and tobacco education programs. Such approaches may help address multiple potentially interconnected risk behaviors within adolescent health frameworks.

4 Methods

4.1 Data collection and study participants

The data presented in this study were obtained from 2020 to 2023 through the KYRBS. Data were downloaded from the KYRBS website (<https://www.kdca.go.kr/yhs/>) on October 23, 2024. The survey, an anonymous, self-reported online survey conducted annually among middle and high school students to assess the current status and trends in health behaviors among Korean youth, has been conducted since 2005 by the Korea Disease Control and Prevention Agency. The survey employs a stratified, multistage cluster sampling approach to collect a nationally representative sample of middle and high school students in Korea. Long-term absentees, students with special needs who could not participate independently, and those with literacy difficulties were excluded from participation [19]. A measure of smartphone overdependence was introduced in the 2020 KYRBS and assessed using the same validated tool in both the 2020 and 2023 surveys. Conversely, the 2021–2022 KYRBS waves did not include this standardized overdependence scale and only measured total smartphone usage time, which was not directly comparable to our primary exposure. Therefore, we restricted the analysis to 2020 and 2023, when the same validated overdependence instrument was used. In total, 107,606 complete cases with sociodemographic variables were selected for the final analysis (217 adolescents had missing age data, and five had missing data on

socioeconomic status and academic performance) (Fig. 1).

4.2 Main variables

Smartphone overdependence was assessed using the Adolescents' Smartphone Overdependence Scale developed by the Korean National Information Society Agency, a 10-item, 4-point Likert scale with total scores ranging from 10 to 40 (Supplementary Table S1). Previous studies in Korean adolescents have reported good internal consistency for this scale, with Cronbach's alpha values around 0.84 in the original development work and up to 0.86–0.92 in large nationwide samples, supporting its reliability for population-based research [20, 21]. Factor-analytic studies further support a multidimensional structure (e.g., salience, loss of control, negative consequences) with acceptable model fit, as well as convergent validity, as evidenced by expected positive associations with depression, anxiety, stress, and loneliness [22, 23]. Responses were scored as follows: 4 points for "very much," 3 points for "yes," 2 points for "not," and 1 point for "not at all." Total scores ranged from 10 to 40 points, with each respondent classified as either a general user (≤ 22), potential-risk user (23–30), or high-risk user (≥ 31). The response categories and scoring used in this study followed the original Korean scale as developed by the National Information Society Agency, in which the four options form an ordered Likert continuum and have been applied consistently in national monitoring and validation studies [20, 21].

Lifetime alcohol consumption experience was assessed using the question: "Aside from taking a few sips during ancestral rites, memorial

services, or religious ceremonies, have you ever consumed more than one full drink of alcohol?" Lifetime smoking experience was evaluated using the question: "Have you ever smoked, even a few puffs of a conventional cigarette?" Both alcohol consumption and smoking experiences were categorized as either "yes" or "no." Characteristics related to alcohol consumption (age at first alcohol consumption experience, number of alcohol consumption days per month, average amount of alcohol consumed at once (grams), and number of binge-alcohol consumption days per month) and smoking (age at first smoking experience, age at daily smoking onset, number of days of smoking per month, and average number of cigarettes smoked per day) were also surveyed.

4.3. Covariates

The sociodemographic characteristics measured included sex (male/female), age (13-15/16-18), household income (high/upper-middle/middle/lower-middle/low), perceived health status (very healthy/healthy/moderate/unhealthy/very unhealthy), self-rated stress level (very high/high/moderate/low/very low), sleep duration (very appropriate/appropriate/moderate, inappropriate/very inappropriate), and academic grade (self-rated academic performance during the past 12 months: high/upper-middle/middle/lower-middle/low). Household income was assessed using a self-rated item in which adolescents classified their family's economic status as high, upper-middle, middle, lower-middle, or low. Therefore, this variable reflects perceived household socioeconomic status

rather than objective income data.

4.4 Statistical analysis

Chi-square tests were used to evaluate participants' general characteristics and to assess differences in the frequency and proportions of categorical variables. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated using a multivariable logistic regression model to evaluate the associations between smartphone overdependence and alcohol consumption and smoking behaviors. To adjust for potential confounders, covariates were selected a priori based on previous literature and their conceptual relevance to adolescent substance use and smartphone overdependence. All selected covariates were simultaneously included in the fully adjusted models. Sensitivity analyses were conducted separately for the 2020 and 2023 survey waves to examine potential period effects. To evaluate dose-response relationships between substance use characteristics and smartphone overdependence, generalized additive models with a binomial distribution and logit link were fitted, using high-risk smartphone overdependence as the outcome and each alcohol- and smoking-related variable as the main predictor (age at first consumption, monthly consumption days, average amount of consumption at once, monthly binge consumption days, age at first smoking, monthly smoking days, age at daily smoking, and average number of cigarettes smoked per day). The smartphone overdependence score was dichotomized into a high-risk group using a validated cutoff of ≥ 31 points on the Adolescents' Smartphone

Overdependence Scale. All models were adjusted for sex, school grade, household income, perceived health status, self-rated stress levels, sleep duration, and academic grade. Adjusted predicted probabilities and 95% CIs for high-risk smartphone overdependence were plotted across the observed ranges for each alcohol- and smoking-related variable. As the KYRBS uses a stratified, multistage cluster sampling design, all analyses applied the survey sampling weights, strata, and cluster variables provided by the Korea Disease Control and Prevention Agency. This approach enabled us to obtain population-representative estimates and correct standard errors that account for the complex survey design. Statistical analyses were conducted using SAS (version 9.4; SAS Institute, Cary, NC, USA), and statistical significance was defined as a two-sided P-value < 0.05.

4.5 Ethical information

The study procedures adhered to the tenets of the Declaration of Helsinki. Ethical approval and consent to participate were obtained from the Institutional Review Board (IRB) of the Korea Centers for Disease Control and Prevention (IRB approval number: 2014-06EXP-02-P-A).

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Author contributions

Suhha Park performed formal analysis, data curation, writing—original draft, and visualization. Sunho Lee contributed to methodology and validation. Wanhyung Lee was responsible for conceptualization, resources, and supervision. Jung-Eum Lee contributed to methodology, validation, and writing—review & editing.

All authors have approved the submitted version (and any substantially modified version involving their contributions to the study) and agreed to be personally accountable for their respective contributions and to ensure that any issues related to the accuracy or integrity of the work, even those in which they were not personally involved, are appropriately investigated, resolved, and documented in the scientific literature.

Data availability statement

The data used in this study are publicly available on the Korea Youth Risk Behavior Survey (KYRBS) website (<https://www.kdca.go.kr/yhs/>).

Competing interests

The authors declare no conflicts of interest.

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Figure legends

Figure 1. Flow chart depicting the study population

Figure 2. Dose-response associations between alcohol and smoking characteristics and high-risk smartphone overdependence among Korean adolescents.

Panels A–D show the adjusted predicted probabilities of high-risk smartphone overdependence according to age at first alcohol consumption (years) (A), monthly alcohol consumption frequency (days) (B), average alcohol consumption (grams) (C), and monthly binge drinking frequency (days) (D) among adolescents with alcohol consumption experience. Panels E–H present the adjusted predicted probabilities of high-risk smartphone overdependence according to age at first smoking (E), monthly smoking frequency (days) (F), age at initiation of daily smoking (years) (G), and average daily cigarette consumption (H) among adolescents with smoking experience. Smooth curves and 95% confidence intervals were estimated using generalized additive models with a binomial distribution and logit link function, in which high-risk smartphone overdependence (≥ 31 points on the Adolescents' Smartphone Overdependence Scale) was modeled as the outcome variable, and each alcohol- or smoking-related characteristic was included as the primary predictor. All models were adjusted for sex, school grade, household income, perceived health status, self-rated stress level, sleep duration, and academic performance.

Tables

Table 1. General characteristics of participants according to the alcohol consumption experience.

	Alcohol consumption experience, n (%)		P-value	Cramer's V
	Yes	No		
Total Participants	35,504 (33.99)	72,102 (67.01)		
Sex			< 0.0001	0.0937
Male	20,513 (37.31)	34,472 (62.69)		
Female	14,991 (28.49)	37,630 (71.51)		
Age (years)			< 0.0001	0.2233
13-15	15,007 (24.06)	47,377 (75.94)		
16-18	20,497 (45.33)	24,725 (54.67)		
Household income			< 0.0001	0.0879
High	3,454 (28.15)	8,814 (71.85)		
Upper-middle	9,553 (30.44)	21,828 (69.56)		
Middle	16,667 (33.13)	33,640 (66.87)		
Lower-middle	4,740 (41.79)	6,603 (58.21)		
Low	1,090 (47.25)	1,217 (52.75)		
Perceived health status			< 0.0001	0.0536
Very healthy	8,323 (32.29)	17,451 (67.71)		
Healthy	14,773 (31.73)	31,788 (68.27)		
Moderate	8,547	17,286		

	(33.09)	(66.91)		
Unhealthy	3,597	5,245		
	(40.68)	(59.32)		
Very unhealthy	264 (44.15)	334 (55.85)		
Self-rated stress level			< 0.0001	0.0824
Very high	4,004	5,390		
	(42.62)	(57.38)		
High	10,314	18,551		
	(35.73)	(64.27)		
Moderate	15,130	33,055		
	(31.40)	(68.60)		
Low	5,061	12,590		
	(28.67)	(71.33)		
Very low	995 (28.32)	2,518		
		(71.68)		
Sleep duration			< 0.0001	0.1143
Very appropriate	2,392	7,373		
	(24.50)	(75.50)		
Appropriate	5,707	15,296		
	(27.17)	(72.83)		
Moderate	11,692	24,693		
	(32.13)	(67.87)		
	10,437	17,689		
Inappropriate	(37.11)	(62.89)		
Very inappropriate	5,276	7,051		
	(42.80)	(57.20)		
Academic grade			< 0.0001	0.1270
High	3,313	10,168		
	(24.58)	(75.42)		
Upper- middle	7,568	19,042		
	(28.44)	(71.56)		
Middle	10,369	21,707		
	(32.33)	(67.67)		
Lower-middle	9,483	15,547		
	(37.89)	(62.11)		
Low	4,771	5,638		

	(45.84)	(54.16)		
Smartphone overdependence			< 0.0001	0.0712
General user	22,662 (30.98)	50,492 (69.02)		
Potential-risk user	11,335 (36.42)	19,790 (63.58)		
High-risk user	1,507 (45.30)	1,820 (54.70)		

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Table 2. General characteristics of participants according to smoking experience

	Smoking experience, n (%)		P-value	Cramer's V
	Yes	No		
Total Participants	10,104 (9.39)	97,502 (90.61)		
Sex			< 0.0001	0.1058
Male	6,832 (12.43)	48,153 (87.57)		
Female	3,272 (6.22)	49,349 (93.78)		
Age(years)			< 0.0001	0.1475
13-15	3,573 (5.73)	58,811 (94.27)		
16-18	6,531 (14.44)	38,691 (85.56)		
Household income			< 0.0001	0.0785
High	1,132 (9.23)	11,136 (90.77)		
Upper-middle	2,531 (8.07)	28,850 (91.93)		
Middle	4,467 (8.88)	45,840 (91.12)		
Lower-middle	1,474 (12.99)	9,869 (87.01)		
Low	500 (21.67)	1,807 (78.33)		
Perceived health status			< 0.0001	0.0450
Very healthy	26,921 (10.44)	23,083 (89.56)		
Healthy	3,906 (8.39)	42,655 (91.61)		
Moderate	2,364 (9.15)	23,467 (90.85)		
Unhealthy	1,024	7,818		

	(11.58)	(88.42)		
Very unhealthy	119	479 (80.10)		
Self-rated stress level	(19.90)		<	0.0740
			0.0001	
Very high	1,470	7,924		
	(15.65)	(84.35)		
High	2,966	25,899		
	(10.27)	(89.73)		
Moderate	3,970	44,213		
	(8.24)	(91.76)		
Low	1,369	16,282		
	(7.76)	(92.24)		
Very low	329 (9.37)	3,184		
		(90.63)		
Sleep duration			<	0.0800
			0.0001	
Very appropriate	639 (6.54)	9,126		
		(93.46)		
Appropriate	1,414	19,589		
	(6.73)	(93.27)		
Moderate	3,274	33,111		
	(9.00)	(91.00)		
	3,005	25,121		
Inappropriate	(10.68)	(89.32)		
Very inappropriate	1,772	10,555		
	(14.37)	(85.63)		
Academic grade			<	0.1527
			0.0001	
High	770 (5.71)	12,711		
		(94.29)		
Upper-middle	1,587	25,023		
	(5.96)	(94.04)		
Middle	2,539	29,537		
	(7.92)	(92.08)		
Lower-middle	3,029	22,001		
	(12.10)	(87.90)		
Low	2,179	8,230		
	(20.93)	(79.07)		
Smartphone			<	0.0709

overdependence			0.0001
General	6,171	66,983	
user	(8.44)	(91.56)	
Potential-risk user	3,295	27,830	
	(10.59)	(89.41)	
High-risk user	638	2,689	
	(19.18)	(80.82)	

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Table 3. Logistic regression analysis based on smartphone overdependence.

Smartphone overdependence	Prevalence (%)	Odds ratio (95% confidence interval)		
		Model 1	Model 2	Model 3
Alcohol Consumption				
Normal	30.98	Reference	Reference	Reference
Potential-risk	36.42	1.31 (1.27-1.35)	1.32 (1.28-1.36)	1.22 (1.19-1.26)
High-risk	45.30	1.83 (1.71-1.96)	1.85 (1.72-1.99)	1.65 (1.53-1.77)
Smoking				
Normal	8.44	Reference	Reference	Reference
Potential-risk	10.59	1.35 (1.29-1.42)	1.38 (1.32-1.45)	1.26(1.20-1.32)
High-risk	19.18	2.57 (2.35-2.82)	2.64 (2.40-2.90)	2.32(2.11-2.56)

Prevalence indicates the percentage of adolescents within each smartphone overdependence group who reported lifetime alcohol consumption or smoking experience. Statistical significance was determined based on whether the 95% confidence interval excluded one.

Model 1: crude (unadjusted) model.

Model 2: adjusted for sex, age, household income, and academic grade.

Model 3: additionally adjusted for perceived health status, self-rated stress level, and sleep duration.



