Types of problematic smartphone use based on psychiatric symptoms

Mi Jung Rho[a], Jihwan Park[a,h], Euihyeon Na[b], Jo-Eun Jeong[c], Jae Kwon Kim[d], Dai-Jin Kim[e,f,1,*], In Young Choi[g,h,1,*]

[a] Catholic Cancer Research Institute, The Catholic University of Korea, Seoul, Republic of Korea
[b] Department of Psychiatry, Incheon Chamsarang Hospital, Republic of Korea
[c] Department of Psychiatry, Daejeon St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Daejeon, Republic of Korea
[d] Department of Computer Science and Information Engineering, Inha University, Nam-gu, Incheon, Republic of Korea
[e] Department of Psychiatry, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Republic of Korea
[f] Addiction Research Institute, Department of Psychiatry, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Republic of Korea
[g] Department of Medical Informatics, College of Medicine, The Catholic University of Korea, Seoul, Republic of Korea
[h] Department of Biomedicine & Health Sciences, College of Medicine, The Catholic University of Korea, Seoul, Republic of Korea

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ABSTRACT

To provide appropriate solutions for problematic smartphone use, we need to first understand its types. This study aimed to identify types of problematic smartphone use based on psychiatric symptoms, using the decision tree method. We recruited 5,372 smartphone users from online surveys conducted between February 3 and February 22, 2016. Based on scores on the Korean Smartphone Addiction Proneness Scale for Adults (S-Scale), 974 smartphone users were assigned to the smartphone-dependent group and 4398 users were assigned to the normal group. The data-mining technique of C5.0 decision tree was applied. We used 15 input variables, including demographic and psychological factors. Four psychiatric variables emerged as the most important predictors: self-control (Sc; 66%), anxiety (Anx; 25%), depression (Dep; 7%), and dysfunctional impulsivities (Imp; 3%). We identified the following five types of problematic smartphone use: (1) non-comorbid, (2) self-control, (3) Sc + Anx, (4) Sc + Anx + Dep, and (5) Sc + Anx + Dep + Imp. We found that 74% of smartphone-dependent users had psychiatric symptoms. The ratio of participants belonging to the non-comorbid and self-control types was 64%. We proposed that these types of problematic smartphone use may be used for the development of an appropriate service for controlling and preventing such behaviors in adults.

1. Introduction

In today's world, smartphones are valuable for work and social relationships and are not simply IT devices that provide support (Schadler and McCarthy, 2012). A billion global users spend almost half their time on a mobile device such as a smartphone or tablet. Global smartphone penetration is growing rapidly, reaching up to over 71.5% in 2017 in South Korea (Newzoo, 2017). Specifically, it has been reported that smartphone penetration is higher than desktop penetration in several countries (Kakihara, 2016).

However, as smartphone use has increased rapidly, negative consequences of problematic smartphone use are also increasing, leading to several social problems (Kim et al., 2016). It is therefore important to identify appropriate solutions for problematic smartphone use. To do so, it is necessary to first understand the types of problematic

smartphone use and their relationship with psychiatric symptoms, among other diverse factors.

Problematic smartphone use is considered a behavioral addiction, much like Internet gaming, social media and, gambling (Van Deursen et al., 2015). Some researchers have reported that behavioral addiction could coexist with mental health problems such as anxiety, depression, fatigue, loneliness, negative self-esteem, and impulsivity-type attention deficit hyperactivity disorder (ADHD) (Elhai et al., 2017,2018; Han et al., 2017; Ostovar et al., 2016; Park et al., 2016; Wolniewicz et al., 2018). Some researchers have reported that mental health problems lead to problematic smartphone use (Kim, 2017; Van Deursen et al., 2015). Accordingly, the present study attempted to identify the types of problematic smartphone use based on psychiatric symptoms, and to explore the predictors of problematic smartphone use.

A decision tree analysis is a useful method for discovering patterns

and regularities in diverse data. It splits a complex decision into several decisions (De Ville, 2006) and expresses results easily. It is simple to understand, explain, and apply, as it presents data in a tree form. It has been used in the healthcare industry (Kim et al., 2017; Na et al., 2017; Shariat et al., 2008), as is an appropriate method for the prediction and classification of problematic smartphone use based on psychiatric symptoms.

2. Methods

2.1. Participants

We recruited 5372 smartphone users from online surveys conducted between February 3 and February 22, 2016. Participants were recruited randomly from an online panel of a professional polling company that offers candidates for diverse surveys. Informed consent was obtained online from all participants prior to participation. Those who refused to provide consent were excluded. All participants completed an anonymous web-based survey conducted by the polling company. They received incentives for their participation. Based on their scores on the Korean Smartphone Addiction Proneness Scale for Adults (S-scale), 974 participants met the criteria for the problematic smartphone use group, while the remaining 4398 participants were assigned to the normal group. The study procedures were carried out in accordance with the Declaration of Helsinki. The Institutional Review Board of Catholic University (IRB number: KC15EISI0103) approved the study. Participant's data were de-identified.

2.2. Measures and procedure

We used a total of 16 variables in this study. One variable was the target variable, which classified participants into normal and smartphone-dependent groups. It was represented using numeric data in the C5.0 analysis. Additionally, we used 15 input variables; 7 comprising numeric data and 8 comprising nominal data, as presented in Table 1.

First, the target variable was problematic smartphone use based on scores on the Korean Smartphone Addiction Proneness Scale for Adults (S-Scale) (Shin et al., 2011). The S-Scale consists of 15 items with a four-point Likert scale ranging from 1 (not at all) to 4 (always), as presented in Appendix. It is composed of the following four categories: daily life disturbance (5 items), virtual world orientation (2 items), withdrawal (4 items), and tolerance (4 items). The total score is categorized into three subgroups (15–39: none, 40–43: potential risk group, and over 44: risk group). In this study, smartphone users with S-scores

Table 1
Final input variables for the C5.0 algorithm.

Number	Variables	Category	Data Type
1	Age	Demographic factors	Numeric
2	Gender		Nominal
3	Marital status		Nominal
4	Job		Nominal
5	Academic background		Nominal
6	Income level		Nominal
7	Game		Nominal
8	Total sleeping time		Numeric
9	Smartphone usage time (weekday)	Smartphone usage factors	Numeric
10	Smartphone usage time (weekend)		Numeric
11	Brief Self-Control Scale (BSCS)	Psychological factors	Numeric
12	Generalized Anxiety Disorder (GAD)		Nominal
13	Patient Health Questionnaire (PHQ)		Nominal
14	Functional impulsivities		Numeric
15	Dysfunctional impulsivities		Numeric

above 40 were assigned to the smartphone-dependent group, which included both risk and potential risk groups from the original classification. Thus, the final target variable comprised two groups, normal and smartphone-dependent groups.

Second, we used 15 input variables, including demographic, smartphone usage, and psychological factors, as shown in Table 1.

Demographic factors included age, gender, marital status, job, academic background, income level, and engaging in gaming. Smartphone usage factors included total sleep duration, smartphone usage duration on weekdays, and smartphone usage duration on weekends. The following six variables involved nominal data: gender, marital status, job, academic background, income level, and engaging in gaming. The remaining four variables contained numeric data. All variables were measured using self-report items.

Psychological factors were assessed using the following four psychiatric scales: the Brief Self-Control Scale (BSCS), Generalized Anxiety Disorder (GAD)-7, Patient Health Questionnaire-9 (PHQ-9), and Dickman Impulsivity Inventory-Short Version (DII).

The BSCS assesses dispositional self-control (Tangney et al., 2004). It comprises 13 items that are rated on a five-point scale assessing the level of distress from 1 (strongly disagree) to 5 (strongly agree). There is no cut off criterion for the BSCS. Therefore, we used the BSCS score as numeric data in the C5.0 analysis.

The GAD-7 scale is a tool used to assess the severity of GAD symptoms (Wild et al., 2014). GAD is characterized by excessive and inappropriate worrying that is persistent and not restricted to a particular circumstance (Lader, 2015). The GAD-7 comprises 7 items that are rated on a 0–3 Likert scale, with higher scores indicating higher severity. The total scores are categorized into four subgroups (0–4: none, 5–9: mild, 10–14 moderate, and 15–21: severe). Thus, we used is the GAD-7 score as nominal data in the C5.0 analysis.

The PHQ-9 assesses the severity of depression. It comprises 9 items that are rated on a 0–3 Likert scale ranging from 0 (not at all) to 3 (nearly every day), with higher scores indicating higher severity (Kroenke et al., 2001). Scores are categorized into five subgroups (0–4: none, 5–9: mild, 10–14 moderate, 15–19: moderately severe, and 20–27: severe).). Accordingly we used is the PHQ-9 score as nominal data in the C5.0 analysis.

The DII is a useful tool to assess personality traits pertaining to impulsivity (Dickman, 1990). The response options for each item are true (1) or false (0). The DII-short form comprises 23 self-report items that evaluate functional (11 items) and dysfunctional (12 items) impulsivities (Dickman, 1990). We used all 23 items in the present study. Dysfunctional impulsivity is the tendency to act with less forethought, leading to maladaptive performance and negative consequences (Na et al., 2017). The DII does not have a cutoff criterion. Therefore, we used the DII score as numeric data in the C5.0 analysis.

Decision tree analysis models are effective for classifying the types of problematic smartphone use. There are diverse analysis methods such as C5.0, Classification and Regression Tree (CART), CHi-squared Automatic Interaction Detection (CHAID) and Quick, Unbiased, Efficient, Statistical Tree (QUEST). These methods have different accuracy depending on variables' characteristics.

Among these decision tree methods, we used the C5.0 algorithm because it is used when the target variable is binary. It uses both numeric and nominal data as input to generate rules. In the present study, the target variable was binary (normal and smartphone-dependent groups), while the 15 input variables were numeric or nominal, as presented in Table 1.

The C5.0 algorithm is a variant of the C4.5 algorithm developed by Quinlan in 1993 (Quinlan, 2014). It improves the rule generation of the C4.5. The C5.0 is a tree structure constructed by a recursive divide-and-conquer algorithm (Chen and Howard, 2016). Additionally, the C5.0 algorithm has noticeably lower error rates and is faster and more memory efficient than the C4.5 is, due to boosting of the method adoption (Chen, 2011). The C5.0 algorithm has balanced performance,

Table 2
Participants' characteristics.

	Characteristics	Frequency	%
Age	19 years	386	7.2
	20–29 years	3363	62.6
	30–39 years	1623	30.2
Mean (SD)	26.43 (5.954)		
Gender	Male	2443	45.5
	Female	2929	54.5
Marital status	Single[a]	4419	82.3
	Couple[a]	953	17.7
Location	Capital area (including Seoul)	2589	48.2
	Non-capital area	2783	51.8
Job	Office worker, etc.[b]	2525	47.0
	Student	2120	39.5
	Housewife, unemployed, and other	727	13.5
Academic background	Undergraduate or less	2565	47.8
	College graduate	2436	45.3
	Graduate school	371	6.9
Income level	Poor	2161	40.2
	Fair	2467	45.9
	Good	744	13.8
Engaging in gaming	Yes	3752	69.8
	No	1620	30.2
Condition	Normal group	4398	81.9
	SD group	974	18.1
Total		5372	100

Note:

SD: Smartphone-dependent.

[a] Single: never married, divorced, separated or widowed; Couple: married or living with a partner.

[b] Office worker etc.: office worker, administrative position, service industry position, professional technician and production employee.

as presented in Appendix Table 2. The QUEST and CART have higher accuracy and specificity. However, their sensitivity is optimal for developing a new model. The IBM SPSS Modeler 16.0 cannot be used to develop the CHAID model or assess its fit. CHAID is useful when data cannot be subjected to a regression analysis because the normality assumption is violated. In the present study, we used 15 input variables; 7 numeric and 8 nominal type, as presented in Table 1. Therefore, our variables were not appropriate for using CHAID. Accordingly, we applied the C5.0 algorithm to identify types of problematic smartphone use.

We used the partition node to divide the data into two sets, the training and test dataset. We matched six training datasets to four test datasets. Fig. 1 explains the research process.
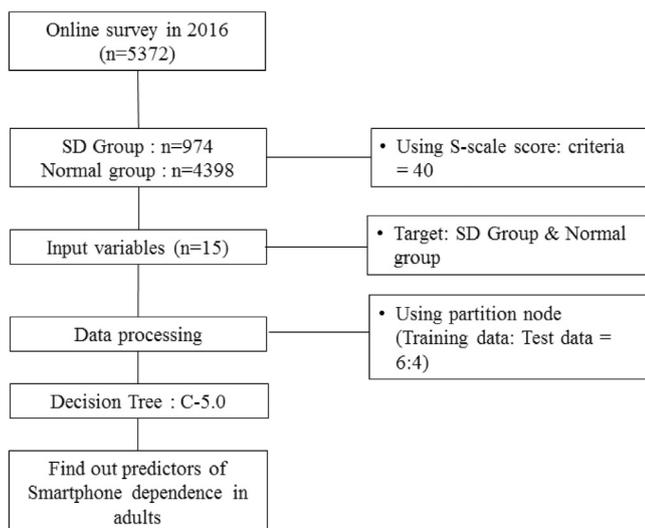

Fig. 1. The research process.

2.3. Statistical analysis

Data collected from 5372 smartphone users were analyzed using IBM SPSS Modeler 16.0 for the decision tree analysis. We applied the C5.0 algorithm. Additionally, descriptive analyses and *t*-tests for two independent samples were conducted using IBM SPSS Statistics version 18.0.

3. Results

3.1. Participants' characteristics

As shown in Table 1, respondents' age ranged from 19 to 39 years, and most participants were in the 20–29-year-old age group (62.6%). Further, 54.5% of the respondents were female, 48.2% lived in the capital area, and 82.3% were single. In terms of employment, 47.0% of the respondents belonged to the group of office workers, administrative positions, service industry positions, professional technicians, and production employees, while 39.5% were students. Further, 47.8% of the respondents had an undergraduate level of education or less, 45.9% reported having a fair income level, and 69.8% usually engaged in playing games. Finally, 18.1% of the participants were in the problematic smartphone use group.

3.2. Smartphone usage and psychological characteristics

The results indicated significant differences between the normal and smartphone-dependent groups in terms of scores on dysfunctional impulsivities ($t = -17.798$, $p < 0.001$), self-control ($t = -26.634$, $p < 0.001$), depression ($t = -29.361$, $p < 0.001$), and anxiety ($t = -28.236$, $p < 0.001$). With reference to smartphone usage duration, the smartphone-dependent group spent an average of 5.88 h on weekdays and 5.80 h on weekends and holidays. However, there was no significant difference between the normal and smartphone-dependent groups' smartphone usage duration, as presented in Table 3 (smartphone usage duration on weekdays: $t = -1.503$, smartphone usage duration on weekends: $t = -1.813$).

3.3. Decision tree: rule induction method

We extracted meaningful problematic smartphone use types from the C5.0 algorithm. The total prediction rate was 83%, as presented in Table 4, which is considered reasonably accurate. The specificity and sensitivity were 85% and 60%, respectively. Therefore, the present results were acceptable. We set the parent node value to 50 and the child node to 20 samples.

Four variables emerged as important predictors of being identified as having problematic smartphone use, self-control (66%), anxiety (25%), depression (7%), and dysfunctional impulsivities (3%). The percentages signify the relative importance of variables. Accordingly, self-control and anxiety predicted 81% of the possibility of group membership. According to the C5.0 algorithm, we found the following types of problematic smartphone use. The initial risk ratio of problematic smartphone use was 18.43% (Node 0). Fig. 2 presents the results of the decision tree.

According to the C5.0 algorithm, we found the following 8 rules. In Rule # 1, participants' BSCS score was less than 38 (Risk ratio: 8.07%, Node 1). In Rule # 2, their BSCS score was more than 51 (69.23%, Node 12). In Rule # 3, their BSCS score ranged from 39 to 51, and they had no or mild anxiety (24.41%, Node 4). In Rule # 4, their BSCS score ranged from 39 to 51; they had moderate anxiety; and they had no, mild, or moderate depression (39.25%, Node 6). In Rule # 5, their BSCS score ranged from 39 to 51 and they had severe anxiety (56.04%, Node 11). In Rule # 6, their BSCS score ranged from 39 to 51, they had moderate or moderately severe depression, and their dysfunctional DII score was less than 4 (32.26%, Node 8). In Rule # 7, their BSCS score

Table 3

Participants' smartphone and psychological characteristics.

Characteristic	Normal group (n = 4398)		SD group (n = 974)		t-Test	
	Mean	SD	Mean	SD	t-Value	Sig.
Total sleeping time	422.26	91.670	423.15	111.554	−0.263	.792
Smartphone usage time (weekdays)	5.25	11.672	5.88	12.116	−1.503	.133
Smartphone usage time (weekends)	5.05	11.564	5.80	12.157	−1.813	.070
Functional impulsivities	4.84	2.460	4.92	2.297	−0.915	.360
Dysfunctional impulsivities	3.78	2.688	5.46	2.568	−17.798***	P < 0.001
Self-control	35.13	6.758	41.36	5.806	−26.634***	P < 0.001
Depression	5.77	4.968	11.16	6.053	−29.361***	P < 0.001
Anxiety	4.09	4.246	8.54	5.318	−28.236***	P < 0.001

Note:

*** t.0.001 = 3.291, Time unit: minutes, Usage unit: hours, SD: smartphone dependence, Sig.: significance.

Table 4

Misclassification table (prediction rate) according to the decision tree analysis.

Observation	Expected rate			Prediction rate
	Normal group	SD group	Total	
Normal group	4240	737	4977	85% (Specificity)
SD group	158	237	395	60% (Sensitivity)
Total	4398	974	5372	83% (Accuracy)

Note: SD: Smartphone-dependent.

ranged from 39 to 51, and they had moderate anxiety and severe depression (58.33%, Node 10). In Rule # 8, their BSCS score ranged from 39 to 51, they had moderate anxiety and moderately severe depression, and their dysfunctional DII score was more than 4 (68.24%, Node 9).

As shown in Fig. 2, we identified five types of problematic smartphone use based on psychiatric symptoms. This five types were defined as follows: users fulfilling Rule # 1 were classified as non-comorbid type (Node 1); those fulfilling Rule # 2 and 3 were classified as self-control type (Node 4 and 12), those fulfilling Rule # 4 and 5 were classified as Sc + Anx type (Node 6 and 11), those fulfilling Rule # 6 and 7 were classified as Sc + Anx + Dep type (Node 8 and 10), and those fulfilling Rule # 8 were classified as Sc + Anx + Dep + Imp type (Node 9).

As shown in Table 5, the dominant phenotype was the low self-control type (*n* = 222, 38%, Rule 2 and 3). In this type, smartphone-dependent users only had problems pertaining to self-control. Specifically, they had low self-control with a mild level of anxiety. Further, 26%, 23%, 10%, and 3% of the smartphone-dependent users belonged to the non-comorbid, Sc + Anx, Sc + Anx + Dep + Imp, and Sc + Anx + Dep types, respectively.

4. Discussion

We identified types of problematic smartphone use based on psychiatric symptoms, using the decision tree method. Based on the results of this study, we drew the following conclusions.

We found that the following mental health problems were related to problematic smartphone use: (1) self-control (66%), (2) anxiety (25%), (3) depression (7%), and (4) dysfunctional impulsivities (3%). Additionally, the normal and smartphone-dependent groups exhibited significant differences in scores on these four variables. Among the predictors, self-control and anxiety predicted 81% of the possibility of group membership. We identified poor self-control as a dispositional factor for problematic smartphone use. Previous studies have reported that poor self-control was an important feature of problematic smartphone use (Chotpitayasunondh and Douglas, 2016; Kim et al., 2016). In addition, anxiety, depression, and impulsivity are core features of addiction (Demirci et al., 2015; Kim et al., 2015; Lee et al., 2014; Roberts et al., 2015). Elhai et al., (2017) reported that depression was consistently related to problematic smartphone use (Elhai et al., 2017).

Anxiety is also consistently related to problematic smartphone use, but with small effect sizes. However, we found that anxiety (25%) was a stronger predictor of problematic smartphone use than was depression (7%).

In addition, according to the research conducted by Billieux et al. (2015), there is a three pathway model of problematic mobile phone use: (1) an excessive reassurance pathway, (2) an impulsive-antisocial pathway, and (3) an extraversion pathway (Billieux et al., 2015). They explained the risk factors depending on the pathway. In the excessive reassurance pathway, users have an addictive pattern of use. They use smartphones for reassurance from others and to maintain relationships. In the impulsive pathway, users have an antisocial pattern of use. In their study, anxiety was identified as one of the risk factors in the excessive reassurance pathway, with participants exhibiting low self-esteem, neuroticism, attachment, emotional instability, social anxiety, and general anxiety. Low self-control and impulsiveness are risk factors in the impulsive pathway, with participants exhibiting impulsivity, low self-control, aggressive traits, antisocial personality, and ADHD. Therefore, the four comorbid symptoms examined in the present study are meaningful factors in developing a model on risk of problematic smartphone use.

We identified the following five types of problematic smartphone use: (1) non-comorbid, (2) self-control, (3) Sc + Anx, (4) Sc + Anx + Dep, and (5) Sc + Anx + Dep + Imp. The first interesting result was the non-comorbid type. Although 26% of smartphone-dependent users had no mental health problems and no problems with self-control, they continued to exhibit problematic smartphone use. In this regard, the non-comorbid type is an interesting group because its participants merely need to control their smartphone usage duration to overcome problematic smartphone use. It may be feasible for them to manage their smartphone usage duration using a mobile application.

Second, 74% of smartphone-dependent users had psychiatric symptoms, including the self-control, Sc + Anx, Sc + Anx + Dep, and Sc + Anx + Dep + Imp types. In other words, the rest of the types exhibited mixed psychiatric symptoms along with problematic smartphone use, excluding Rule # 2 (Node 12), which included participants with low self-control. Previous research has not clarified the directionality of the comorbidity between problematic smartphone use and mental health problems. Thus, problematic smartphone use could co-exist with mental health problems and the latter could lead problematic smartphone use (Kim, 2017; Van Deursen et al., 2015). Evidently, users with mixed psychiatric symptoms need multiple treatments to address problematic smartphone use. Therefore, they may not only need interventions for smartphone use management but also psychiatric treatments, including medications.

The mixed types are explained below.

The dominant type focused on self-control (*n* = 222, 38%). In cases where smartphone-dependent users had higher BSCS scores, the risk ratio of this type was the highest among problematic smartphone use types (69.23%). It means that poor self-control is the highest risk factor
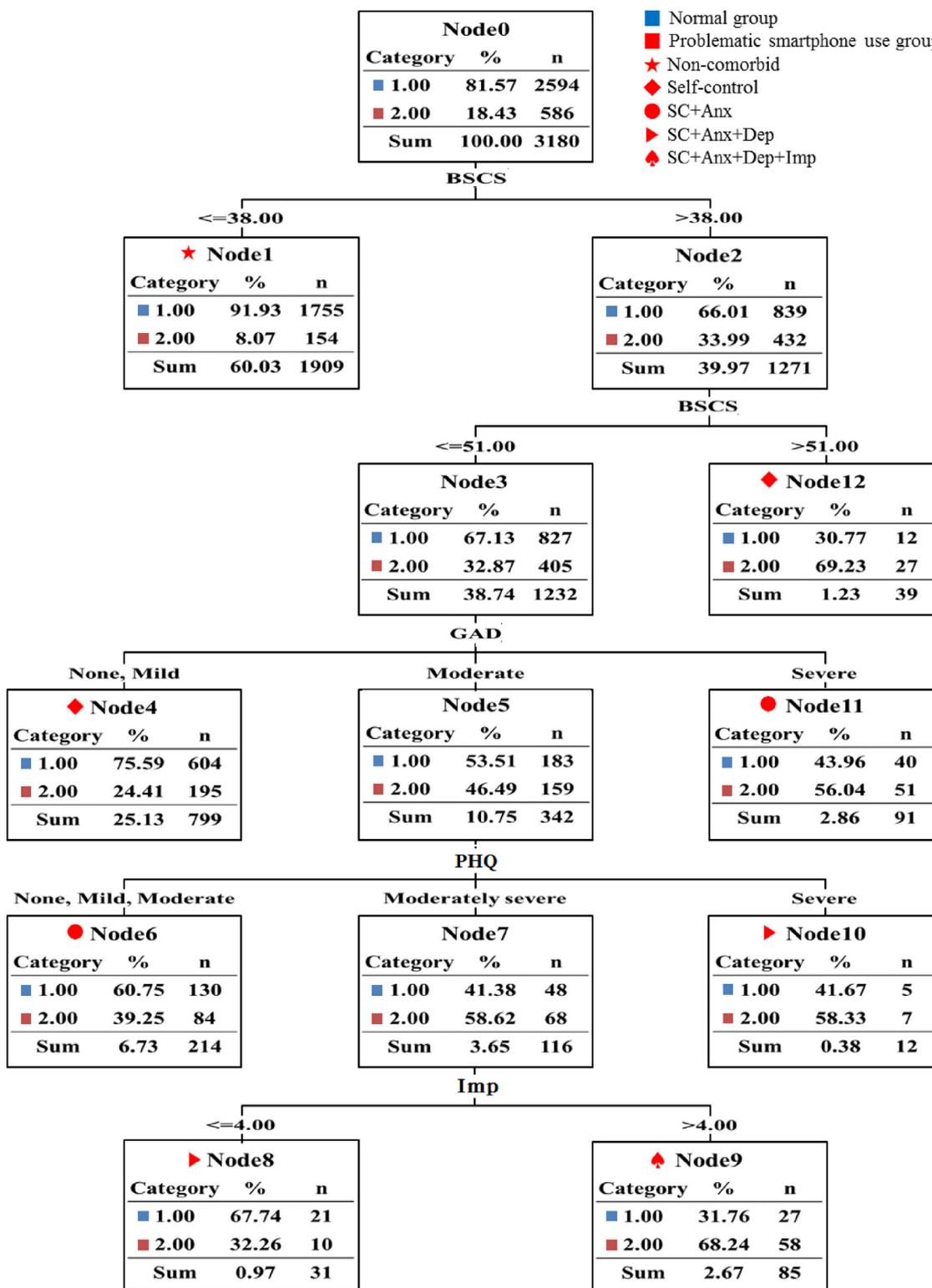
Fig. 2. Results of the decision tree. * SC: Self-control, Anx: Anxiety, Dep: Depression, Imp: Dysfunctional impulsivities.

for problematic smartphone use. Therefore, users with this type need clinical treatment for low self-control.

Further, 23% of smartphone-dependent users belonged to the Sc + Anx type. In this case, smartphone-dependent users have low self-control and anxiety problems. In other words, they have characteristics of an excessive reassurance pathway and an impulsive-antisocial

pathway pertaining to problematic smartphone use (Billieux et al., 2015). Therefore, they need multilateral treatment for problematic smartphone use. However, above all, they need appropriate treatment to address their relatively severe anxiety problem.

The percentages of participants in the Sc + Anx + Dep and Sc + Anx + Dep + Imp types were lower than those in other types.

Table 5
Problematic smartphone use types.

Rule #	Problematic smartphone use Classifier				Type
1	BSCS ≤ 38 (n = 154, 8.07%)				Non-comorbid (n = 154, 26%)
2	BSCS > 51 (n = 27, 69.23%)				Self-control (n = 222, 38%)
3	BSCS 38–51 (n = 405, 32.87%)	GAD (none, mild) (n = 195, 24.41%)			
4	BSCS 38–51 (n = 405, 32.87%)	GAD (moderate) (n = 159, 46.49%)			
5	BSCS 38–51 (n = 405, 32.87%)	GAD (severe) (n = 51, 56.04%)			SC+Anx (n = 135, 23%)
6	BSCS 38–51 (n = 405, 32.87%)	GAD (moderate) (n = 159, 46.49%)	PHQ (moderately severe) (n = 68, 58.62%)		SC + Anx + Dep (n = 17, 3%)
7	BSCS 38–51 (n = 405, 32.87%)	GAD (moderate) (n = 159, 46.49%)	PHQ (severe) (n = 7, 58.33%)		
8	BSCS 38–51 (n = 405, 32.87%)	GAD (moderate) (n = 159, 46.49%)	PHQ (moderately severe) (n = 68, 58.62%)	Dysfunctional DII > 4 (n = 58, 68.24%)	SC + Anx + Dep + Imp (n = 58, 10%)

Note: SC: Self-control, Anx: Anxiety, Dep: Depression, Imp: Dysfunctional impulsivities.

However, these two types involve three or more psychiatric symptoms along with problematic smartphone use. We can consider this type as a mixed-symptom type. Therefore, they also need multilateral treatment for problematic smartphone use. Those belonging to the Sc + Anx + Dep type have severe depression. Therefore, the primary intervention needs to focus on depression. The risk ratio of Sc + Anx + Dep + Imp was 68.24%; therefore, this type is also serious. It has characteristics of an excessive reassurance pathway and an impulsive-antisocial pathway (Billieux et al., 2015). This type of user has multiple psychiatric symptoms such as low self-control, moderate anxiety, moderate depression, and dysfunctional impulsivities. Therefore, they need comprehensive treatment for problematic smartphone use. Dysfunctional impulsivities had a relative importance of 3% among the variables included in our study. However, we considered dysfunctional impulsivities as a risk factor in the impulsive group. Therefore, users from these two types may not only need interventions for smartphone use management but also psychiatric treatments, including medications.

There were a few limitations in this study. First, we used the S-scale to identify the problematic smartphone use group. Specifically, smartphone users with S-scores above 40 were assigned to the smartphone-dependent group. However, none of the respondents underwent face-to-face interviews. Future studies should include face-to-face interview to identify the problematic smartphone use group. Second, we found the following four variables to be important psychological predictors: (1) self-control, (2) anxiety, (3) depression, and (4) dysfunctional impulsivities. However, some studies have proposed self-esteem, aggression, and ADHD as psychological symptoms of problematic smartphone use (Billieux et al., 2015). We chose the four mental health problems based on recommendations of psychiatrists and psychology consultants. However, we did not consider self-esteem and ADHD as psychological symptoms of problematic smartphone use. Thus, future research should examine the role of self-esteem, aggression, and ADHD as psychological symptoms of problematic smartphone use. Third, we identified five problematic smartphone use types using the C 5.0 decision tree, using the data mining method. The C 5.0 decision tree was appropriate for identifying types of problematic smartphone use. It is appropriate for use when the target variable is binary, and it can be used to generate rules when the input variables contain numeric and nominal data. In this study, the outcome variable was binary and the 15 input variables included both nominal and numeric types. Decision tree models exhibit different accuracies depending on variables' characteristics. The C5.0 has more balanced performance as compared to other methods. However, future research could use diverse analysis methods depending on collected variables' characteristics. Fourth, we did not observe a significant differences in the smartphone usage duration of the normal and problematic smartphone use groups. This study collected information on smartphone usage duration using self-report questions. Therefore, there may be a difference between real and self-reported usage duration. Accordingly, future research should collect real usage data to determine the role of usage duration in problematic smartphone use.

Despite these limitations, this study has several valuable implications. First, we identified the ratio of non-comorbid and comorbid types of problematic smartphone use (26% vs. 74%). These results are important for developing services for managing problematic smartphone use. Second, this study proposed five types of problematic smartphone use, which are valuable for classifying smartphone-dependent users. Based on our types, we developed a mobile application to manage smartphone usage and provide services for customized treatments. Third, we focused on adults with problematic smartphone use, because problematic smartphone use is not restricted to children and adolescents. Accordingly, this study would help develop effective treatments for adults. Fourth, internalizing and externalizing concepts have been used for grouping behavioral or emotional problems (Achenbach et al., 2016). As stated previously, problematic smartphone use could be explain based on a three-pathway model (Billieux et al., 2015). However,

we found that some smartphone-dependent users have multiple psychiatric symptoms that coexist with problematic smartphone use. We identified that these psychiatric symptoms did not appear separately ad that there were mixed problem patterns. Some research has proposed the need to analyze internalizing and externalizing problems together, hypothesizing that externalizing behaviors have an association with internalizing behaviors (Achenbach et al., 2016; Groh et al., 2012; Madigan et al., 2013). These findings are corroborated by the results of our study. Fifth, the ratio of participants in non-comorbid and self-control types was 64%. Users falling under these two types need to manage their smartphone usage duration. Additionally, mixed types (Sc + Anx, Sc + Anx + Dep, and Sc + Anx + Dep + Imp) accounted for 36% of the participants. These users need multiple treatments for problematic smartphone use, not only to manage their smartphone usage but also to address their psychiatric symptoms, through different treatments, including medications. Accordingly our problematic smartphone use types can be helpful for making clinical decisions about the treatment of problematic smartphone use in adults. Sixth, our results were derived from a decision tree analysis model. Many analysis models classify patterns in the data. Therefore, future research could use a different analysis method, such as CART, CHAID, and QUEST, depending on variables' characteristics. Finally, as mentioned previously, the present results do not clarify the directionality of the relationship between problematic smartphone use and mental health problems. Additionally, we could not propose a theory on their relationship. Therefore, future research could develop the related theory and explain the directionality of this relationship.

Despite its limitations, the present study identified five types of problematic smartphone use based on psychiatric symptoms. The five types could be useful for developing services to manage problematic smartphone use.

Declaration of competing interest

No competing financial interests exist.

Ethics

The study procedures were carried out in accordance with the Declaration of Helsinki. The Institutional Review Board of Catholic University (IRB number: KC15EISI0103) approved the study.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2019.02.071.

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