Joint effects of children's emotional problems and parental depressive symptoms on the occurrence of internet gaming disorder among children and adolescents: A longitudinal study

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ABSTRACT

Background and aims: Parental depressive symptoms may aggravate the effects of children's emotional problems on risks for Internet gaming disorder (IGD). Here we examined the joint effects of children's emotional problems and parents' depressive symptoms on the incidence of IGD. *Methods:* A large prospective, population-based cohort tested potential interactions between children's emotional problems, parents' depressive symptoms, and incidence of high risk of IGD (HRIGD). Family dyads ($n=2,031$) that included children who were non-HRIGD at baseline completed assessments of childhood and parental affective symptomatology. HRIGD was assessed at baseline and 12 months. Relative excess risk due to interaction (RERI) estimated the magnitudes of interactions. *Results:* In terms of risk for the development of IGD, parental depression was 1.8 times greater, children's emotional problems were 2.9 times greater, and both risk factors together were 6.1 times greater than the background risk, with the last two findings reaching statistical significance. The expected risk for the development of HRIGD was RR=3.7. *Discussion and conclusions:* Children's emotional problems demonstrated a particularly strong relationship with HRIGD. Joint effects of children's emotional problems and depressive symptoms in parents on the incidence of HRIGD were stronger than the sum of the independent effects of each factor. The findings suggest that combining interventions for the treatment of children's emotional problems and parents' depressive symptoms may have extra risk reduction effects on preventing IGD in children and adolescents.

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INTRODUCTION

The use of online games is a growing phenomenon worldwide. Due to increases in time spent on online gaming activities, there are concerns about the possibility of certain populations

developing disorders around Internet gaming (Petry & O'Brien, 2013). In particular, adolescents may be particularly vulnerable to Internet gaming disorder (IGD) risks as they may have more difficulties controlling their engagement in entertainment that sparks their interest, such as online games. Adolescent brain development is not fully mature and thus adolescents are often more impulsive than adults. Compulsively escaping into gaming can be associated with serious problems for adolescents (King, Delfabbro, Zwaans, & Kaptsis, 2013; Kuss & Griffiths, 2012).

Emotional problems such as depression and anxiety are the most reported comorbidities in IGD and are discriminative factors for IGD among adolescents (Liu et al., 2018). Emotional problems in adolescents may be markers of or risk factors for addictive disorders, and they may also result from addictive disorders (Burleigh, Griffiths, Sumich, Stavropoulos, & Kuss, 2019). In longitudinal studies, problematic video gaming has been statistically predicted by anxiety and depressive symptoms (Brunborg, Mentzoni, & Froyland, 2014; Gentile et al., 2011).

Important risk factors for IGD among adolescents may involve familial and parental factors (Lam, 2015; Psychogiou et al., 2017). There are several empirical evidences on the problematic behavior in children and adolescents that have been associated with mental health problems in their parents (Burleigh, Stavropoulos, Liew, Adams, & Griffiths, 2018; Erceg et al., 2018; Loechner et al., 2020; Paquin et al., 2020). Especially parental depression plays a significant role in the development of IGD among children and adolescents (Choi, Chun, Lee, Han, & Park, 2018; Lam, 2015).

Although both children's emotional problems and parent's depressive symptoms were reported as an independent risk factor for IGD in children and adolescents, the magnitude of joint effect of the two risk factor on the subsequent development of high risk of IGD in children and adolescents remains unclear. Therefore, we evaluated the interactions between children's emotional problems and parent's depressive symptoms to see if there was relative excess risk (RERI) in absolute risk of the occurrence of HRIGD due to the interaction by the coexistence of both risk factors using a population-based, prospective cohort study. The RERI may be the most useful in terms of assessing synergism between 2 binary risk factors (VanderWeele, 2011; VanderWeele & Robins, 2007). We hypothesized that the joint effect of children's emotional problems and a parent's depressive symptoms on development of IGD might be larger than the sum of their independent effects in children and adolescents without a high risk of IGD at baseline.

METHOD

Study population

The current study was derived from the iCURE study, which was described in detail elsewhere (Jeong et al., 2017). In brief, the iCURE study was a prospective longitudinal study. A total of 2,319 family dyads (third-grade, fourth-grade, and

seventh-grade students and a parent or related caregiver each) were enrolled at baseline. Among them, 288 subjects were excluded from the current study including 167 subjects with the presence of IGD features (IGUESS total score ≥10) at baseline, 19 subjects with missing information in parents' depressive symptom scores, and 102 subjects who did not complete 12-month follow-up assessments. A total of 2,031 family dyads were thus examined. Most primary caregivers who participated in assessments were mothers (93.4%), with fathers (5.7%) and legal guardians (0.9%) also participating.

Measurements

Procedure. The collection of children's data was conducted at participants' schools during school hours at both baseline and 12-month follow-up. Participants completed questionnaires independently, using a web-based self-administration method in a class setting. One parent or guardian per each participating child completed self-administered questionnaires at participants' homes or in a private space in their child's school based on the participant's preference at baseline.

Presence of high risk of IGD (HRIGD). To assess the presence of HRIGD within the preceding 12 months, we applied the Internet Game Use-Elicited Symptom Screen (IGUESS) at both baseline and 12-month follow-up assessments. Originally, the IGUESS incorporated DMS-5 IGD diagnostic criteria into a brief self-reported assessment tool. It was comprised of nine IGD symptoms experienced during the past 12-months and each item rated on a four-point Likert scale (0 = not at all, 1 = occasionally, 2 = frequently, and 3 = always). When compared the clinician's diagnosis based on the DSM-5 IGD criteria, the sensitivity, specificity, and diagnostic accuracy of IGUESS were 86.7%, 80.0%, and 86.8%, respectively at a cut-off score of 10 for designation of presence of IGD feature (Jo et al., 2018). This scale was reliable, with a Cronbach's alpha value of 0.87.

Children's emotional problems. In children and adolescents, emotional problems were operationally defined as the presence of depressive and/or anxiety symptoms. Self-reported depressive symptoms were assessed by the Korean version of Children's Depression Inventory (CDI) at baseline (Cho & Lee, 1990). There were 27 items quantifying symptoms such as depressed mood, hedonic capacity, vegetative functions, self-evaluation, and interpersonal behaviors. Each item consisted of three statements graded in order of increasing severity from 0 to 2; children and adolescents were asked to select the one statement that best characterized their symptoms during the preceding two weeks. The item scores were combined into a total depression score, ranging from 0 to 54. Higher CDI scores reflect more severe depressive states, with a score of 22 or more considered indicative of significant depressive symptoms (Cho & Lee, 1990). A Cronbach's alpha value of 0.89 was observed in this study.

Children and adolescents' anxiety symptoms were assessed by the Korean version of the Trait Anxiety

Inventory for Children (TAIC) at baseline (Cho, 1989). The TAIC is a 20-item inventory that asks respondents to indicate how frequently they feel worried, bothered, or nervous on a three-point scale (with scores ranging from 1 = *almost never* to 3 = *almost always*) (Spielberger, 1972). Total scores range from 20 to 60. A score of 41 or more has been considered indicative of subjects having anxiety symptoms (Cho, 1989). Herein, the Cronbach's alpha value was 0.91.

In this study, having a CDI score of 22 or higher and/or a TAIC score of 41 or higher defined the presence of emotional problems.

Parents' depressive symptoms. Parents' depressive symptoms were evaluated by the Patient Health Questionnaire-9 (PHQ-9). The PHQ-9 is a nine-item self-reported scale, developed to evaluate symptoms of major depressive disorder according to the major depressive disorder criteria of the DSM-IV. Each question has four possible response choices including 0 = "not at all", 1 = "several days", 2 = "more than half of the days", and 3 = "nearly every day" during the previous two weeks. Each item was rated on a scale of zero to three, with total scores ranging from 0 to 27. Higher scores reflect more severe depressive symptoms (Han et al., 2008), with a score of 5 or more considered indicative of significant depressive symptoms (Chung et al., 2018). A Cronbach's alpha value of 0.82 was observed in this study.

Baseline characteristics as covariates. Potential confounding factors, including sex, age, family structure, socioeconomic status, and average daily time spent on Internet gaming during weekdays were obtained from children and adolescents' self-reports at baseline. Regarding family structure, an intact family was defined as children and adolescents living with both parents and a non-intact family was defined as children and adolescents living with only a mother or father, or with neither parent, because of parental divorce, death, or separation. Socioeconomic status was surveyed in seven stages from 1 = lowest to 7 = highest; scores of 1–4 were categorized as low to middle and scores of 5–7 were categorized as high in the analysis.

Statistical analysis

The four groups were stratified by the existence of children's emotional problems and/or parents' depressive symptoms. The groups were denoted as C-P- dyads for children having neither emotional problems nor a parent with depressive symptoms, C-P+ dyads for children having no emotional problems but having a parent with depressive symptoms, C+P- dyads for children having emotional problems but having parents without depressive symptoms, and C+P+ dyads for children having both emotional problems and a parent with depressive symptoms.

Chi-square, Fisher's exact test, and analysis of variance (ANOVA) tests were used to compare baseline characteristics among the four groups. To examine whether effects of children and adolescents' emotional problems on subsequent features of IGD were modified by parents' depressive symptoms, we used the GENMOD procedure to estimate relative risks (RRs) and 95% confidence intervals (CIs) in which the reference group was the C-P- dyad.

To investigate the additive interaction of children's emotional problems and a parent's depressive symptoms, the relative excess risk due to interaction (RERI) was calculated using the following formula, which has been recommended in previous research (Knol et al., 2011).

$$RERI = RR_{11} - RR_{10} - RR_{01} + 1$$

Here, RR_{11} is the relative risk for both risk factors present, RR_{10} is the relative risk for children's emotional problems without a parent's depressive symptoms, and RR_{01} is the relative risk for children without emotional problems but with a parent's depressive symptoms. In terms of values, RERI = 0 means no interaction or equal additivity, RERI > 0 means positive interaction or greater additivity, and RERI < 0 means negative interaction or lesser additivity. The RERI quantifies the portion of the RR that is attributable to the interaction of both exposures—or in other words, how much larger or smaller in magnitude the RR is than expected.

To adjust for potential confounders, all interaction models included subject factors of age, gender, family structure, socioeconomic status (SES), and time spent gaming online during weekdays. Analyses were performed using statistical analysis system (SAS) software version 9.4 (SAS Institute, Cary, NC). All p-values were two-sided.

Ethics

Written informed consent was acquired from all participants (both younger participants and their parents or legal guardians) following explanation of the nature of the principles of research, including confidentiality and the voluntary participation. This analytic study was fully reviewed and approved by the Institutional Review Board of The Catholic University of Korea (MC20EISI0129). The iCURE data management board released de-identified data for analyses. All procedures were performed in accordance with the Helsinki Declaration of 1975, as revised in 2013.

RESULTS

Study population

Of 2,031 family dyads, 41 (2.0%) were classified as C+P+ dyads, 155 (7.6%) as C+P- dyads, 300 (14.8%) as C-P+ dyads, and 1,535 (75.6%) as C-P- dyads. In the comparisons of baseline demographic characteristics of C-P- dyad, C-P+ dyad, C+P- dyad, and C+P+ dyad, the proportion of female gender were 43.2%, 42.3%, 57.4%, and 61.0%, respectively (P < 0.001), the proportion of individuals with non-intact family were 7.7%, 10.0%, 9.0%, and 19.5%, respectively (P = 0.033), and the proportion of middle to high SES were 66.5%, 75.0%, 63.2%, and 75.6%, respectively (P = 0.012). The C+P+ dyads had higher proportions of girls and non-intact families than the other three groups. Average online gaming time proportions of 240 minutes or

more during weekdays were highest in C+P+ dyads. There were no differences between groups in proportions of average time spent on online gaming during weekdays and relationship of caregiver to child (Table 1).

The background risk of occurrence of HRIGD was 34/1,000 persons (RR = 1) among C-P- dyads. The rate among C-P+ dyads was 1.8 times greater (60/1,000 persons), among C+P- dyads was 2.9 times greater (90/1,000 persons), and among C+P+ dyads was 6.1 times greater (206/1,000 persons) than the background rate in the occurrence of HRIGD. The RERI was 2.40, suggesting that estimated joint effects on the additive scale of children's emotional problems and parental depressive symptoms together were greater than the sum of the estimated effects of children's emotional problems and parental depressive symptoms alone. Thus, the results suggest a positive additive effect. The expected risk for the development of HRIGD was RR = 3.7, which was derived from sum of the background risk is RR = 1, the individual effects of a parent's depressive symptoms is RR = 0.8, and children's emotional problems is RR = 1.9 (Fig. 1).

Table 2 shows associations between children's emotional problems and parents' depressive symptoms on the occurrence of HRIGD after adjusting for age, sex, family structure, SES and time spent playing online game during weekdays. Compared with the C-P- dyads group, the risk of developing HRIGD was 5.07 times (aRR=5.07; 95% CI: 2.53–10.18) higher in the C+P+ dyads group, 2.84 times (aRR=2.84; 95% CI: 1.64–4.92) higher in the C+P- dyads group, and slightly higher but not statistically significant in the C-P+ dyads (aRR = 1.49; 95% CI: 0.88–2.50). The relative risk was elevated at 3.45 (95% CI: 1.56–7.64) in the association
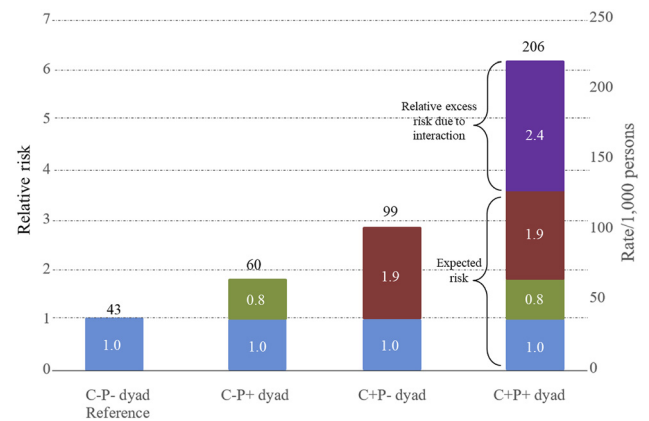

Fig. 1. Unadjusted rates of subsequent features of IGD per 1,000 persons (right y axis) on a relative risk scale (left y axis) during 12-month follow-up among four groups, with C-P- dyad as a reference. The background risk is IR = 34/1,000 persons; RR = 1. The individual effect of a parent's depressive symptoms is RR = 0.8, the individual effect of children's emotional problems is RR=1.9, the expected risk for the development of HRIGD was RR=3.7 (3.7=1.0+0.8+1.9), and the relative excess risk due to interaction (RERI) is RR = 2.4 on subsequent features of IGD among children and adolescents without a high risk of IGD at baseline

C-P- dyad: children having neither emotional problems nor a parent with depressive symptoms

C-P+ dyad: children having no emotional problems but having a parent with depressive symptoms

C+P- dyad: children having emotional problems but not having a parent with depressive symptoms

C+P+ dyad: children having both emotional problems and a parent with depressive symptoms

Table 1. Baseline characteristics of 2,031 participants stratified by adolescents' emotional problems and parents' depressive symptoms

	C-P- dyad (n=1,535, 75.6%)	C-P+ dyad (n=300, 14.8%)	C+P- dyad (n=155, 7.6%)	C+P+ dyad (n=41, 2.0%)	P value
Age (years)	12.39 ± 1.37	12.16 ± 1.59	12.65 ± 1.10	12.20 ± 1.62	0.003
Gender					<0.001
Male	872 (56.8)	173 (57.7)	66 (42.6)	16 (39.0)	
Female	663 (43.2)	127 (42.3)	89 (57.4)	25 (61.0)	
Family structure					0.033
Intact	1,417 (92.3)	270 (90.0)	141 (91.0)	33 (80.5)	
Non-intact	118 (7.7)	30 (10.0)	14 (9.0)	8 (19.5)	
SES (middle to high)	1,021 (66.5)	225 (75.0)	98 (63.2)	31 (75.6)	0.012
Gaming time (weekday)					0.011
<60	823 (53.6)	137 (45.7)	90 (58.0)	29 (70.7)	
60–239	642 (41.8)	146 (48.7)	59 (38.1)	9 (22.0)	
≥240	70 (4.6)	17 (5.7)	6 (3.9)	3 (7.3)	
Relationship of caregiver to child					0.703
Mother	1,434 (93.4)	147 (94.8)	279 (93.0)	37 (90.2)	
Father	88 (5.7)	7 (4.5)	17 (5.7)	3 (7.3)	
Other	13 (1.0)	1 (0.6)	4 (1.3)	1 (2.4)	

C-P- dyad: children having neither emotional problems nor a parent with depressive symptoms
C-P+ dyad: children having no emotional problems but having a parent with depressive symptoms
C+P- dyad: children having emotional problems but not having a parent with depressive symptoms
C+P+ dyad: children having both emotional problems and a parent with depressive symptoms
SES: socioeconomic status
P values of Gaming time and relationship of caregiver to child variables are calculated by fisher's exact tests due to the presence of the expected cell count less than 5
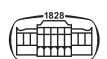
Table 2. Interaction between adolescents' emotional problems and parents' depressive symptoms at 12-month follow-up

	No depressive symptoms (parent)		Depressive symptoms (parent)		RR (95% CI) for parents' depression within strata of adolescents' emotional status
	N with/without IGD	RR (95% CI)	N with/without IGD	RR (95% CI)	
No emotional problems (child/adolescent)	59/1,476	1 (reference)	17/283	1.49 (0.88–2.50) $P = 0.135$	1.49 (0.88–2.50) $P = 0.135$
Emotional problems (child/ adolescent)	14/141	2.84 (1.64–4.92) $P < 0.001$	7/34	5.07 (2.53–10.18) $P < 0.001$	1.80 (0.78–4.14) $P = 0.169$
RR (95% CI) for adolescents' emotional status within strata of parents' depressive symptoms		2.84 (1.64–4.92) $P < 0.001$		3.45 (1.56–7.64) $P = 0.002$	

RRs are adjusted for age, gender, socioeconomic status, and family type, and time spent playing online game during weekdays
Multiplicative interaction RR: 1.23 (95% CI: 0.45–3.33) $P = 0.68$

between children's emotional problems and subsequent features of IGD in the group with parental depressive symptoms. The relative risk was not elevated (1.80; 95% CI: 0.78–4.14) in the relationship between a parent's depressive symptoms and subsequent features of IGD in the group of children with emotional problems. A multiplicative interaction was not significant (Table 2).

DISCUSSION

The study results suggest that children's emotional problems and parents' depressive symptoms may represent independent risk factors for the occurrence of HRIGD, with children's emotional problems more consistently linked to emergent HRIGD than parents' depressive symptoms. Additionally, synergic effects of children's emotional problems and parents' depressive symptoms on the occurrence of HRIGD were observed. Considerable evidence implicates emotional problems in the development of IGD. Emotional problems in children have been linked longitudinally to incident IGD in adolescents in Singapore (Gentile et al., 2011) and Taiwan (Ko, Yen, Chen, Yeh, & Yen, 2009) within two-year follow-up periods, and in adolescents in Germany within a one-year follow-up period (Wartberg, Kriston, Zieglmeier, Lincoln, & Kammerl, 2019). Our findings show that adolescents with emotional problems were 2.8 times more likely to develop HRIGD within a 12-month period in comparison to adolescents with no emotional problems at baseline.

IGD may emerge from attempts to self-regulate, escape, or relieve negative moods and/or emotions through the use of online games (Petry & O'Brien, 2013). Online addictive behaviors may influence emotion regulation via reinforcement of feelings of control, obtaining of online social acknowledgement, and compensation for real-life disadvantages (Yen et al., 2017). Excessive online behaviors have been hypothesized as possibly representing conditions arising from various other disorders, such as depression (Dong & Potenza, 2014; Ko et al., 2014). Within this hypothetical frame, playing online games excessively may serve as a strategy for relieving pre-existing depression psychopathology, which could, in

turn, reinforce further symptomatology (Brand et al., 2019; von der Heiden, Braun, Müller, & Egloff, 2019).

In the current study, 8 (19.5%) out of 41 C+P+ dyad were non-intact families. Of these, there were 6 mothers, 1 father, and 1 grandmother, and as for children, 4 boys and 4 girls. Even though absolute comparison might be impossible due to the small number of samples, among C+P+ dyads, the frequency of mother was higher than that of father, but the gender ratio of children was the same. According to previous finding, single parents, especially single mothers have experienced significantly higher rates of psychiatric disorder, compared with their married counterparts (Liang, Berger, & Brand, 2019). When it comes to family environment, family structure played an important role as risk factors for depression regardless of gender (Yu, Li, & Zhang, 2015).

Parental depression has been related to children's IGD in a population sample in Hong Kong (Lam, 2015), and has been associated with negative impacts relating to IGD in Korean adolescents (Choi et al., 2018). However, these findings were derived from cross-sectional surveys in which temporal relationships could not be determined between parental depression and IGD in children (Lam, 2015). Our longitudinal findings did not observe a statistically significant independent effect on HRIGD in and of itself. That is, although parental depressive symptoms were associated with a numerically higher risk of HRIGD in children (as much as 1.49 times for the development of IGD at 12-month assessment), it was not a statistically significant difference. The possibility of whether this may represent an absence of the effect or a limited power in the current study warrants additional investigation. Nonetheless, given the positive RERI, findings suggest possible increased risk of HRIGD in both children's emotional problem and parent's depressive symptom dyads.

Parents with depressive symptoms may have more difficulty caring for their children and monitoring their behaviors; they may also communicate less effectively and have fewer interactions with their children (Loechner et al., 2020). Consequently, parental depression may increase the likelihood of their children developing IGD.

This study estimates the RERI, a measure of additive-scale interaction that estimates excess risk due to the interaction of two exposures relative to the risk without either

exposure. Herein, the magnitude of the excess risk due to interaction was 2.4. This means that the risk of development of HRIGD was 2.4-fold higher than the background risk due to the interaction of the two risk factors of children's emotional problems and parents' depressive symptoms. Speculatively, such a synergic effect may be explained by complex interactions of genetic/biological vulnerabilities (Aktar & Bögels, 2017). Children of parents with depressive symptoms may be at increased risk of emotional problems due to a genetic predisposition for their expression that may confer risk for these symptoms (Aktar & Bögels, 2017; Roos et al., 2016). According to the cumulative risk hypothesis, the greater the amount of adversity or risk to which a child is exposed, the greater the likelihood for poorer outcomes. The cumulative risk hypothesis posits that the effects of risk on child outcomes may operate in an additive fashion (Solomon, Åsberg, Peer, & Prince, 2016).

It has been well established that depressed parents poorly interact with their children displaying more negative parenting behaviors compared to those with no depression. In addition, depressed children may require additional parental support and caring to manage their emotional problems than non-depressed children. Since the joint effect of the two factors is greater than the sum of each independent effect, it could be assumed that both children's emotional problems and parents' depressive synergistically cause the occurrence of HRIGD. Considering additive interaction is more closely relevant to risk prediction and prevention of diseases, this result can be helped to identify subgroups of individuals for whom a targeted intervention designed to reduce a modifiable exposure could have the highest impact. Family-based intervention for adolescents with IGD has been reported to be effective in improving IGD symptoms (Bonnaire, Liddle, Har, Nielsen, & Phan, 2019; Han, Kim, Lee, & Renshaw, 2012). Considering that both children and parents' emotional and psychological problems are influenced by how the children have been raised in that family, a family therapy approach may be an effective way of preventing HRIGD development for C+P+ dyads. Family therapies may enhance the engagement, resolve parent-child conflict, increase family support, and reduce exposure to stressors within the family (Dardas, van de Water, & Simmons, 2018).

Among this study's participants, 99.1% of caregivers were biological parents (1,897 mothers at 93.4% and 115 fathers at 5.7%), 17 were grandparents, and two were aunts. There were no differences in associations between the two potential risk factors and IGD and the magnitude of relative risk due to interaction when sensitivity analysis was performed, including when the primary caregiver was a parent.

We investigated the effects of emotional problems of children and depressive symptoms of parents which were evaluated by self-reported assessments during the past 2 weeks at baseline on the occurrence of HRIGD after 1 year. When it comes to the stability of the depressive symptoms, the Pearson's correlation of the CDI total scores between baseline and 1-year follow-up was 0.63. Unfortunately, the parental survey was conducted only at baseline, we could not

evaluate the stability of the parent's depressive symptoms directly. However, the distribution of PHQ-9 total scores revealed generally stable throughout all periods of adulthood (Tomitaka et al., 2018).

The major strength of this study is that it was conducted using data from a large, well-characterized community-based cohort with a follow-up rate of 95%. Second, our results can be readily compared with other studies that utilize DSM-5 IGD diagnostic criteria because IGD was measured using a validated instrument. Third, because our study was longitudinal, only random misclassifications of exposure would have occurred insofar as exposure was measured before outcomes.

The study also has limitations. First, because a limited number of participants experienced the presence of both children's emotional problems and parental depressive symptoms, we could not investigate whether the joint effects differed in young subjects by gender. Previous research reports that psychosocial mechanisms may account for gender-related differences in internalizing symptoms of depression and anxiety during adolescence, and girls have typically shown higher initial levels of emotional problems than boys (Hankin, 2009). Second, because information was collected through self-administered questionnaires, we were not able to exclude possible over- or under-reporting by participants in response to gaming-related questions (Jeong et al., 2018), as well as those about depression and anxiety. Third, we did not include out-of-school children and adolescents because the iCURE study was a school-based cohort. The prevalence rate of the risk of IGD is likely to have been underestimated. In fact, IGD prevalence is likely to be higher among out-of-school children and adolescents than in those attending school because the use of games or cell phones is prohibited during school hours in Korea. Prevalence of IGD of out-of-school students has been reported as high as 35% in South Korea (Lee, 2018). Therefore, our findings should be interpreted with caution with respect to generalizing the results to other populations. Finally, the IGUESS scale was adapted polythetic formats to determine whether someone is addicted to games. However, the polythetic format is likely to lead to over-estimation of the frequency of individuals with IGD compared to a monothetic approach. Previous studies have reported a higher number of addicted gamers when a polythetic format of game addiction scale was used than monothetic ones (Esposito et al., 2020; Khazaal et al., 2016). It would be better to interpret the outcome variable as HRIGD rather than the IGD in the current study. Since this study was a cohort study, in which the magnitude of the effect was measured in terms of relative risks, using a polythetic format for the outcome measurement would not have had a significant impact on relative risks.

CONCLUSION

In conclusion, the joint effects of children's emotional problems and parents' depressive symptoms on the incidence of HRIGD appear stronger than the sum of the independent effects of each factor, with children's emotional problems

being most consistently associated with incident HRIGD. Adolescents with a combination of children's emotional problems and a parent or caregiver with depressive symptoms should be warned of a possibly increased risk of HRIGD. This finding suggests that combining interventions for the treatment of children's emotional problems and their parents' depressive symptoms may have extra risk reduction effects in preventing IGD in children and adolescents.

Authors' contributions: HJ and HWY conceptualized the manuscript. HJ, HWY, SYL, and HKL collected data. All authors assisted with the design of the study and the development of the analysis plan. HJ, HWY, and MP analyzed the data. All authors interpreted the results. HJ drafted the manuscript. HWY guided and supervised the writing of the manuscript. SYL, HKL, and MNP reviewed scientific content and edited the manuscript. All authors read, edited, and approved the final manuscript.

Conflict of interest: All authors declare that they have no competing interests except for Dr. Potenza. Dr. Potenza has consulted for and advised Game Day Data, the Addiction Policy Forum, RiverMend Health, Lakelight Therapeutics/Opiant and Jazz Pharmaceuticals. He has received research support from the Mohegan Sun Casino and the National Center for Responsible Gaming (now the International Center for Responsible Gaming). He has participated in surveys, mailings, and telephone consultations related to drug addiction, impulse control disorders, and other health topics, and has consulted for law offices and gambling entities on issues related to impulse control and addictive disorders.

Data availability: The datasets generated and/or analyzed during the current study are available from the corresponding author.

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