

FULL-LENGTH REPORT



Sex differences in the longitudinal association between high risk of internet gaming disorder and subsequent suicidality among adolescents: A cohort study

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ABSTRACT

Objectives: Internet Gaming Disorder (IGD) has become a growing public health concern among adolescents. Although previous cross-sectional studies have linked problematic gaming with suicidality, longitudinal evidence remains limited. This study examined sex-specific associations between IGD risk and subsequent suicidal behaviors among adolescents who were not suicidal at baseline. **Methods:** Data were derived from the iCURE study, a prospective cohort involving 1,874 students (1,082 boys and 792 girls) aged 9–14 years. Participants with baseline suicidality were excluded. The Internet Game Use-Elicited Symptom Screen was used to identify adolescents at high risk of IGD (HRIGD). Suicidality was assessed at two-year follow-up using items adapted from the SCID-I. Relative risks (RRs) and 95% Confidence Intervals (CIs) were estimated using generalized linear models stratified by sex and adjusted for potential confounders. **Results:** At baseline, 8.0% of boys and 3.4% of girls were classified as HRIGD. At the two-year follow-up, boys in the HRIGD group showed significantly higher incidences of suicidality (17.4% vs. 5.0%), suicidal ideation (16.3% vs. 4.7%), and suicide plans or attempts (5.8% vs. 1.0%) than those at lower risk. In fully adjusted models, HRIGD remained associated with suicidality (RR = 3.05, 95% CI = 1.53–6.07), suicide ideation (RR = 2.99, 95% CI = 1.48–6.05), and suicide plans and/or attempts (RR = 4.03, 95% CI = 1.08–15.07) among boys, but not among girls. **Conclusions:** This longitudinal cohort study among adolescents without baseline suicidality indicates that IGD risk is related to subsequent suicidality in boys. Early identification and sex-specific preventive strategies targeting excessive gaming may help mitigate future suicide risk in adolescents.

KEYWORDS

internet gaming disorder, cohort, suicidality, suicidal ideation, suicide plan, attempt, adolescents

INTRODUCTION

In recent years, videogaming has emerged as a prominent form of leisure among children and adolescents. Although most individuals play games for enjoyment and relaxation and videogaming can serve as an educational and skills training activity (Kahila et al., 2021),

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a minority may experience harmful consequences, including physical or psychological impairment, as a result of excessive videogaming (Delfabbro, King, & Carey, 2021; Sangeeth et al., 2025). Given these concerns, psychiatric classification systems have introduced diagnostic terms including Internet Gaming Disorder (IGD) in the Diagnostic and Statistical Manual of Mental Disorders, Fifth and Gaming Disorder (GD) in the International Classification of Diseases, Eleventh Revision (Saunders, Rumpf, Carragher, & Poznyak, 2025). Both IGD and GD have been considered as addictive disorders. Given the increasing prevalence, an improved understanding of how IGD/GD may impact health and functioning has become increasingly important (Mylona, Deres, Dere, Tsinopoulos, & Glynnatsis, 2020; Pontes, Rumpf, Selak, & Montag, 2024).

The prevalence of IGD has been increasing, especially among adolescents (Gao, Wang, & Dong, 2022; Satapathy et al., 2025), and there are concerns about the negative consequences of videogaming. Emotional distress, negative emotions, and poor emotion recognition may contribute to addictive behaviors. Problematic videogaming has been associated with measures of poor mental health, including anxiety, depression, sleep disturbances, loneliness, social withdrawal, and bullying victimization (Chang et al., 2023; Kaya, Türk, Batmaz, & Griffiths, 2023; Sun & Diez, 2025). These mental health concerns have been repeatedly identified as potential risk factors for suicidality, especially in adolescents (Sivertsen et al., 2024).

According to the Escape Coping Model, individuals may engage in excessive videogaming as a means of escaping from negative self-perceptions, stress, and aversive emotional states, thereby obtaining temporary relief through attentional narrowing and mood modification; however, such relief is short-lived and ultimately reinforces avoidance-oriented coping while exacerbating underlying distress (Melodia, Canale, & Griffiths, 2022). In line with Self-Determination Theory, adolescents whose basic psychological needs are unmet may rely on videogaming for satisfaction. However, if IGD develops, the accompanying functional impairment further aggravates the constructs of thwarted belongingness and perceived burdensomeness, thereby heightening the risk of suicidal desire (Kaya et al., 2023).

Suicidal behaviors currently rank among the leading contributors to disability-adjusted life years (DALYs) among adolescents globally (GBD 2021 Suicide Collaborators, 2025). For example, suicide has become the second leading cause of death among young people in the United States and the fourth leading cause worldwide (Hua, Lee, Rahmandar, & Sigel, 2024). In Korea, suicide is the leading cause of death among individuals in their teens to thirties, highlighting its significance as a major public health concern (Lee et al., 2025).

Both suicidal behavior and online gaming have emerged as critical concerns in adolescent mental health. A previous systematic literature review of 12 studies involving 88,732 participants found that 11 of the 12 studies reported a positive correlation between problematic gaming and suicidal ideation, with excessive gaming also associated with

suicide attempts in some studies (Erevik et al., 2022). Recent studies have begun to document a significant association between problematic gaming and suicidality. For example, Yu et al. (2024) reported that higher levels of gaming-related addiction were associated with increased suicidal ideation and attempts even after adjusting for depressive symptoms and impulsivity (Yu et al., 2024). Similarly, Canale et al. (2025) found that problematic gaming severity was significantly linked to suicidal ideation, partly mediated by psychosocial distress (Canale et al., 2025).

While a limited number of prior studies have explored the link between IGD and suicidality, the majority have relied on cross-sectional designs. Although these studies provide important foundational evidence, it remains unclear whether IGD risk prospectively increases the likelihood of subsequent suicidality among adolescents who initially presented with low suicidal risk. We utilized a 2-year longitudinal cohort and strictly excluding participants with baseline suicidality, we provide robust evidence that IGD risk precedes the onset of suicidal behavior rather than merely co-occurring with it.

Given the documented sex differences in IGD prevalence (Dong & Potenza, 2022), it is crucial to examine whether the association between IGD risk and suicidality varies by sex, especially considering the gender-specific patterns of emotion regulation and the higher prevalence of competitive, immersive gaming behaviors typically observed in male adolescents (Chen, Olliffe, & Kelly, 2018). Therefore, we used a prospective cohort design to investigate sex-specific associations between IGD risk and the subsequent emergence of suicidal thoughts and behaviors, hypothesizing that IGD risk would associate with prospective suicidality.

In light of the theoretical frameworks and existing literature, we hypothesized that baseline IGD risk would be significantly associated with the incidence of prospective suicidality at the 2-year follow-up. Furthermore, we specifically hypothesized that this association would be more robust among male adolescents.

METHODS

Study population

The current study was derived from the internet user Cohort for Unbiased Recognition of gaming disorder in Early adolescence (iCURE) study, which has been described in detail elsewhere (Jeong et al., 2017). In brief, recruitment was conducted at the school level between March 2015 and August 2017 across three major educational districts in Seoul and Gyeonggi-do Province. These areas represent the most populous and socioeconomically diverse metropolitan regions in South Korea. The iCURE study is a prospective longitudinal study. A total of 2,319 (third-grade, fourth-grade, and seventh-grade students) were enrolled at baseline. Among them, 1,874 were included in the current study after excluding 445 subjects (251 subjects with the presence of suicidality at baseline; 192 subjects who did not participated

in 2-year follow-up assessments; and 2 subjects who did not complete suicide assessment at follow-up) (Fig. 1).

Written informed consent was obtained from all participants' parents or legal guardians, and assent was obtained from all child and adolescent participants after providing an explanation of the study's purpose, procedures, confidentiality, and voluntary participation. The study adhered to the principles of the Declaration of Helsinki. This study was fully reviewed and approved by the Institutional Review Board of The Catholic University of Korea (MC20EISE0019). De-identified data were released by the data management board for analysis. The study complies with Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline for cohort studies (Supplement 1 in Supplementary materials).

Measurements

Data collection was performed at participants' schools during school hours at both baseline and 2-year follow-up. All participants completed questionnaires using self-administered web-based surveys during school hours, with a supervising research assistant available to answer questions.

Main exposure variable: high risk of IGD (HRIGD) at baseline

We assessed HRIGD at baseline using the Internet Game Use-Elicited Symptom Screen (IGUESS), a brief self-report scale developed based on the DSM-5 diagnostic criteria for IGD. The IGUESS consists of items assessing nine IGD symptoms experienced during the past 12 months (e.g., Have you felt irritable, anxious, or sad when trying to cut down or stop gaming?), with each item rated on a four-point Likert scale. In prior validation research, the IGUESS demonstrated good diagnostic performance compared with clinician-based DSM-5 IGD diagnoses, with sensitivity of 86.7%, specificity of 80.0%, and diagnostic accuracy of 86.8% at a cutoff score of ≥ 10 to identify respondents at high risk for IGD (HRIGD) (Jo et al., 2018). In the present study, the scale showed good internal consistency (Cronbach's $\alpha = 0.85$). In this study, an IGUESS score of 10 or higher

was defined as HRIGD, whereas a score below 10 was defined as low risk of Internet Gaming Disorder (LRIGD).

Main outcome variable: suicidality at the two-year follow-up

The presence of suicidal ideation, suicide plan, and suicide attempt was assessed at the two-year follow-up using self-reported items adapted from the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I) suicide module (First & Gibbon, 2004). Participants were asked: 'Have you seriously thought about committing suicide during the past year?' 'Have you made a plan for committing suicide during the past year?', and 'Have you attempted suicide during the past year?' Responses were recorded as 'yes' or 'no'. Suicidality was defined as endorsement 'yes' of any of the three items (i.e., suicidal ideation, plan, or attempt) during the past year at the two-year follow-up.

Confounding variables: socio-demographic, online gaming activity, and psychosocial characteristics measured at baseline

General characteristics of participants, including age, family structure, and socioeconomic status (SES), were obtained from baseline data. Family structure was categorized as intact or non-intact. An intact family was defined as living with both parents, whereas a non-intact family was defined as living with only one parent or neither parent due to divorce, death, or parental separation. SES was assessed based on parents' responses to the question, "Which of the following best represents your family's socioeconomic status?" (Rated on a scale from 1 = lowest to 7 = highest). SES scores of 1–4 was classified as low to moderate, and scores of 5–7 were classified as high.

Gaming time was assessed at baseline by asking participants how many minutes they spent playing online games on an average weekday. Based on the distribution of the data, average gaming time was categorized as <60 min, 60–119 min, or ≥ 120 min per day.

Depressive symptoms were assessed using the 27-item Children's Depression Inventory (CDI) (Kovacs, 1985).

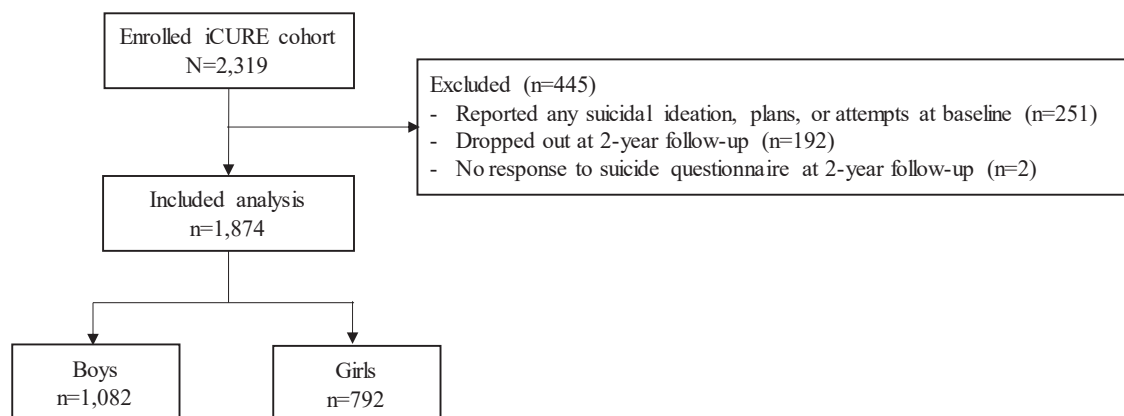


Fig. 1. Process of selecting participants included in the analysis

Items include statements such as ‘I am sad all of the time’, with each item rated on a 3-point scale (0–2) reflecting symptom severity over the past two weeks. Total scores ranged from 0 to 54, and scores ≥ 20 indicated significant depressive symptoms (Bang, Park, & Kim, 2015). Cronbach’s α was 0.89 in this study.

Self-esteem was measured with the 10-item Rosenberg Self-Esteem Scale (Rosenberg, 1965). The instrument includes items such as ‘On the whole, I am satisfied with myself, with each item rated on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree; total range 10–50), reflecting self-acceptance, self-respect, and positive self-evaluation. A validated Korean version was used (Bae, Yu, Lee, & Choi, 2014). Higher scores indicated higher self-esteem. Cronbach’s α was 0.85 in this study.

Attachment to parents was evaluated using the 25-item Inventory of Parent and Peer Attachment—Revised (Armsden & Greenberg, 1987). Sample items include ‘My parents respect my feelings’, rated on a 5-point Likert scale (score range 25–125), assessing mutual trust, communication quality, and alienation. Higher scores indicated stronger attachment to parents. Median splits defined higher vs. lower attachment for descriptive purposes. A validated Korean version was used (Yoo, Park, & Hwang, 2010). Cronbach’s α was 0.94 in this study.

Openness of communication with parents was measured using the 20-item subscale of the Parent–Adolescent Communication Inventory (score range 0–60) (Barnes & Olson, 1982). Examples of items include ‘I find it easy to discuss problems with my parents’, with higher scores indicating more open communication. The degree of openness of communication between adolescents and their parents was assessed at baseline. For descriptive purposes, we used median splits to define higher and lower levels of openness of communication between parents and adolescents. A validated Korean version was used (Min, 1991). The Cronbach’s alpha value was 0.71 in this study.

Perceived social support was assessed using the 24-item Social Support Appraisals Scale, rated on a 5-point Likert scale (Vaux et al., 1986). It includes items such as ‘My friends really care about me’, with higher scores indicating stronger social support. Although used as a continuous predictor, median splits defined higher vs. lower support for descriptive purposes. A validated Korean version was used (Min, 1991). Cronbach’s α was 0.94 in this study.

Statistical analysis

Baseline characteristics were compared between the group with HRIGD and that with lower risk (LRIGD), stratified by sex. Continuous variables were summarized as means and standard deviations, while categorical variables were presented as frequencies and percentages. Incidence rates of suicidality over the two-year follow-up were calculated separately for the HRIGD and LRIGD groups by sex. In addition, incidence rates were estimated for specific suicidal outcomes, including suicidal ideation and suicide plans or attempts.

To estimate the effect of baseline HRIGD on subsequent suicidal outcomes, the GENMOD procedure was used to calculate the relative risks (RRs) and the corresponding 95% Confidence Intervals (CIs) of incident suicidality, suicidal ideation, and suicide plan or attempt, comparing adolescents with HRIGD at baseline to those with LRIGD. Directed Acyclic Graphs (DAGs) were employed to identify a minimal sufficient adjustment set for confounding control in the multivariable models (Supplement 2 in Supplementary materials). Three models were constructed. Model I reported unadjusted (crude) relative risks. Model II adjusted for age and baseline daily time spent playing online games to account for age-related and cumulative gaming exposure. Model III further adjusted for additional covariates identified through the DAG-based minimal sufficient adjustment set, including age, baseline average time spent to playing game, family structure, and baseline depression allowing estimation of the independent effect of HRIGD on suicidal outcomes. To assess the robustness of the observed associations to potential unmeasured confounding, E-values were calculated for the fully adjusted RRs and their lower 95% CIs. The E-value quantifies the minimum strength of association that an unmeasured confounder would need to have with both the exposure HRIGD and suicidal behavior to fully explain away the observed association, conditional on the measured covariates. Larger E-values indicate greater robustness to unmeasured confounding (VanderWeele & Ding, 2017). All analyses were stratified by sex and conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). All statistical tests were two-tailed, and statistical significance was set at $\alpha = 0.05$.

Ethics

Written informed consent was obtained from all participants’ parents or legal guardians, and assent was obtained from all child and adolescent participants after providing an explanation of the study’s purpose, procedures, confidentiality, and voluntary participation. The study adhered to the principles of the Declaration of Helsinki. This study was fully reviewed and approved by the Institutional Review Board of The Catholic University of Korea (MC20E-ISE0019). De-identified data were released by the data management board for analysis.

RESULTS

Of the 1,874 participants, 1,082 were boys and 792 were girls. At baseline, 8.0% of boys and 3.4% of girls were classified as having HRIGD. In both boys and girls, the HRIGD group had a higher proportion of individuals who played games for more than 120 min per day and a higher prevalence of depressive symptoms compared to the LRIGD group. In addition, the HRIGD group showed lower proportions of individuals reporting high self-esteem, secure attachment, open communication with parents, and perceived social support in both boys and girls. However,

there were no significant differences between the HRIGD and LRIGD groups in terms of age, family structure, or SES (Table 1).

Among boys, the incidence of suicidality, suicidal ideation, and suicide plan or attempt at the two-year follow-up was significantly higher in the HRIGD group compared to the LRIGD group. Specifically, 17.4% of boys in the HRIGD group experienced suicidality, 16.3% reported suicidal ideation, and 5.8% reported suicide plan or attempt, whereas the corresponding percentages in the LRIGD group were 5.0, 4.7, and 1.0%, respectively ($p < 0.001$ for all comparisons). Among girls, the incidence of suicidality was 11.1% in the HRIGD group and 8.5% in the LRIGD group ($p = 0.634$). For suicidal ideation, the percentages were 7.4% in the

HRIGD group and 8.2% in the LRIGD group ($p = 0.878$). For suicide plan or attempt, 3.7% of girls in the HRIGD group and 2.9% in the LRIGD group reported these behaviors ($p = 0.801$) (Fig. 2).

Among boys, those in the HRIGD group showed significantly higher subsequent incidence risks for all suicidal outcomes—including suicidality, suicidal ideation, and suicide plans and/or attempts—compared with the LRIGD group at the two-year follow-up. In the crude model, the RR was 4.00 (95% CI: 2.14–7.47) for suicidality, 3.93 (95% CI: 2.06–7.47) for suicidal ideation, and 6.09 (95% CI: 2.03–18.23) for suicide plan and/or attempt. These associations remained statistically significant in the fully adjusted model, with RRs of 3.05 (95% CI: 1.53–6.07), 2.99

Table 1. Baseline characteristics of the study participants stratified by sex ($N = 1,874$)

Variables	Boys ($n = 1,082$)			Girls ($n = 792$)		
	High risk of IGD ($n = 86, 8.0\%$)	Lower risk of IGD ($n = 996, 92.0\%$)	p value	High risk of IGD ($n = 27, 3.4\%$)	Lower risk of IGD ($n = 765, 96.6\%$)	p value
Age, years (Mean $\pm$ SD)	12.5 $\pm$ 1.2	12.4 $\pm$ 1.4	0.359	12.7 $\pm$ 1.1	12.3 $\pm$ 1.5	0.086
Family structure			0.683			0.614
Intact family	80 (93.0)	914 (91.8)		24 (88.9)	701 (91.6)	
Non-intact family	6 (7.0)	82 (8.2)		3 (11.1)	64 (8.4)	
Socioeconomic status (high)	32 (37.2)	316 (31.7)	0.296	9 (33.3)	249 (32.6)	0.932
Game time per day (min/day)			<.001			<.001
<60	6 (7.0)	269 (27.0)		8 (29.6)	529 (69.2)	
60–119	14 (16.3)	301 (30.2)		5 (18.5)	122 (15.9)	
≥ 120	66 (76.7)	426 (42.8)		14 (51.9)	114 (14.9)	
Depression (CDI ≥ 20)	9 (10.5)	20 (2.0)	<.001	3 (11.1)	17 (2.2)	0.004
Self-esteem (higher level)	19 (22.1)	582 (58.4)	<.001	5 (18.5)	408 (53.3)	0.001
Attachment to parents (higher level)	20 (23.3)	493 (48.5)	<.001	13 (48.2)	454 (59.4)	0.245
Openness of communication with parents (higher level)	20 (23.3)	472 (47.4)	<.001	12 (44.4)	451 (58.9)	0.133
Social support (higher level)	19 (22.1)	508 (51.0)	<.001	7 (25.9)	424 (55.4)	0.003

CDI: Child depression inventory; IGD: Internet gaming disorder.

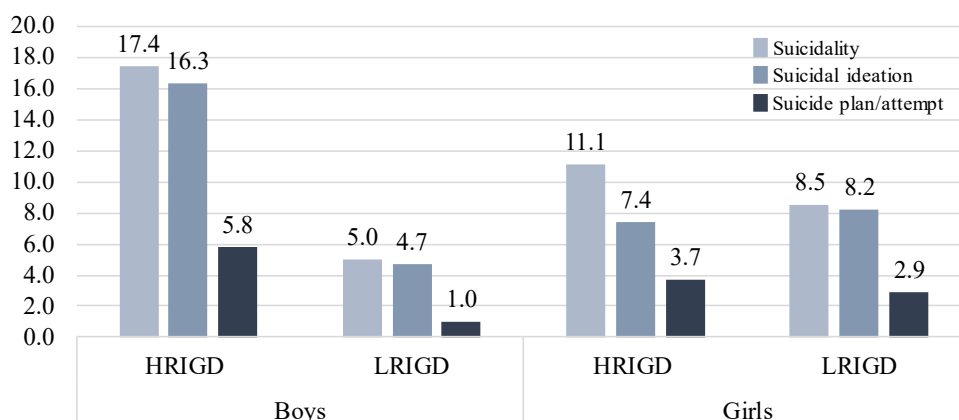


Fig. 2. Incidence rates of suicidality, suicidal ideation, and suicide plan and/or attempt between baseline HRIGD and LRIGD groups stratified by sex ($N = 1,874$)

In boys, the differences in the 2-year incidence of suicidality, suicidal ideation, and suicide plan and/or attempt between the HRIGD and LRIGD groups were significant ($p < .001$, $p < .001$, $p = .001$). In girls, the differences in the 2-year incidence of suicidality, suicidal ideation, and suicide plan and/or attempt between the HRIGD and LRIGD groups were not significant ($p = .634$, $p = .878$, $p = .801$)

Data were indicated percentages

HRIGD: high risk of internet gaming disorder; LRIGD: lower risk of internet gaming disorder

(95% CI: 1.48–6.05), and 4.03 (95% CI: 1.08–15.07), respectively. Among girls, baseline HRIGD was not associated with the subsequent incidence of suicidality, suicide ideation, or suicide plan and/or attempt. Among boys, the E-values corresponding to the fully adjusted models were 5.55 for suicidality, 5.43 for suicidal ideation, and 7.52 for suicide plan and/or attempt, suggesting that an unmeasured confounder would need to be associated with both HRIGD and suicidality by a relative risk of at least 5.43–7.52, above and beyond the measured covariates, to fully account for these associations. These findings indicate substantial robustness to unmeasured confounding. In contrast, the E-values for girls ranged from 1.49 to 2.43, indicating that the observed null associations in girls could be explained by even modest unmeasured confounding (Table 2).

DISCUSSION

The present longitudinal cohort study among adolescents who were not suicidal at baseline demonstrated that a HRIGD at baseline statistically predicted a significantly increased incidence of suicidality—including suicidal ideation and suicide plans and attempts—at the two-year follow-up among boys. This suggests that IGD contributes to suicidal risk through mechanisms that are, at least in part, independent of these established risk factors.

This association remained robust even after adjusting for depressive symptoms, self-esteem, parental attachment, and perceived social support. In contrast, no such association was observed among girls. These findings suggest that IGD risk may act as a sex-specific predictor of later suicidality, particularly in boys (Macur & Pontes, 2021; Peng et al., 2026).

Our results are consistent with previous cross-sectional studies reporting a positive relationship between problematic gaming and suicidality (Erevik, 2022). However, the present study extends this literature by providing longitudinal evidence in the association between HRIGD and subsequent suicidal thoughts and behavior, addressing the

temporal limitation of earlier work (Bolat, Çelik, Özgül, & Ercan, 2021; Soares et al., 2020). The prospective design of this study, along with the exclusion of participants who exhibited suicidality at baseline, supports the interpretation that HRIGD status may serve as an antecedent risk factor for subsequent suicide-related outcomes rather than represent a covariate of concurrent emotional distress.

Our findings also highlight the importance of the broader psychosocial context. For instance, the significant role of depressive symptoms and parental communication as covariates aligns with the biopsychosocial model, where IGD may act as both a consequence of existing distress and a catalyst that further depletes social and psychological resources. By controlling for these variables, we were able to demonstrate the robust nature of IGD as a prospective risk factor while acknowledging that clinical interventions must simultaneously address these co-occurring psychosocial vulnerabilities to be effective.

From a neurobiological perspective, accumulating evidence indicates that chronic IGD is associated with functional and structural alterations in prefrontal and reward-related circuitry, which may compromise executive control and increase impulsivity—factors strongly implicated in the transition from suicidal ideation to suicidal behavior (Brand et al., 2019; Weinstein & Lejoyeux, 2020). These biological vulnerabilities are unlikely to operate in isolation; rather, they interact with psychological processes such as escape-oriented coping, whereby gaming is used to regulate negative affect and avoid distressing self-states (Blasi et al., 2019). Within this integrated model, IGD may simultaneously reflect underlying distress and function as a chronic stressor that further weakens cognitive and interpersonal resources. Over time, this convergence of vulnerabilities may lower the threshold at which suicidal ideation emerges and increase the likelihood that such ideation develops into prospective suicidal risk.

Adolescents may exhibit heightened vulnerability to suicidality associated with excessive gaming, driven by a complex interplay of neurodevelopmental, affective, and sociocultural

Table 2. Univariable and multivariable models to estimate relative risks of incident suicidal behavior in the HRIGD and LRIGD (comparison) groups stratified by sex (N = 1,874)

Suicide behavior incidence (ref = LRIGD)	Model I cRR (95%CI)	Model II aRR (95%CI)	Model III aRR (95%CI)	E-value
Boys (n = 1,082)				
Suicidality	4.00 (2.14–7.47)	3.79 (1.98–7.26)	3.05 (1.53–6.07)	5.55
Suicidal ideation	3.93 (2.06–7.47)	3.67 (1.88–7.16)	2.99 (1.48–6.05)	5.43
Suicide plan/attempt	6.09 (2.03–18.23)	6.61 (2.03–21.56)	4.03 (1.08–15.07)	7.52
Girls (n = 792)				
Suicidality	1.35 (0.39–4.59)	1.28 (0.37–4.49)	1.12 (0.31–4.02)	1.49
Suicidal ideation	0.89 (0.21–3.85)	0.82 (0.19–3.63)	0.68 (0.15–3.10)	2.30
Suicide plan/attempt	1.30 (0.17–10.01)	1.60 (0.20–12.94)	1.53 (0.19–12.72)	2.43

Model I: Crude.

Model II: adjusted for age and baseline average time spend to playing game.

Model III: adjusted for age, baseline average time spend to playing game, family structure, and depression score based on DAG minimal sufficient adjustment set.

HRIGD: high risk of internet gaming disorder; LRIGD: lower risk of internet gaming disorder; cRR: crude relative risk; aRR: adjusted relative risk.

factors. This developmental stage is characterized by ongoing maturation of neural circuits implicated in impulse control, emotional regulation, and executive functioning, which may increase susceptibility to maladaptive coping behaviors. Although gaming may initially serve as a temporary means of psychological escape, prolonged engagement may exacerbate emotional isolation and intensify feelings of hopelessness, thereby increasing the risk of suicidal ideation (Koçak et al., 2025).

Beyond biological and internalizing factors, the environmental context of digital immersion must be considered. Adolescents at high risk for IGD spend a disproportionate amount of time in online environments where they may encounter suicide-related informational content. Exposure to websites or communities that discuss self-harm or provide detailed information on suicide methods can significantly lower the threshold for suicidal behavior (Brennan et al., 2022; Kirtley, Hussey, & Marzano, 2021). For male adolescents, who showed a 4-fold increase in suicide plans and attempts in our study, the internet may serve not only as a platform for gaming but also as a source of harmful information that facilitates the transition from suicidal ideation to concrete planning.

A deeper understanding of the biological mechanisms linking HRIGD status and suicidality may help design targeted interventions that address both concerns.

The absence of a significant link between HRIGD and suicidality in girls highlights the importance of examining potential sex-specific mechanisms. Previous research has suggested that boys are more likely to engage in competitive or violent gaming, which may exacerbate impulsivity and risk-taking behaviors associated with suicidality (Gan, Chen, Wu, Huang, & Wang, 2024; Liao et al., 2025). Engagement in these genres is often characterized by high levels of immersion, time investment, and social involvement, which may increase vulnerability to functional impairment when gaming becomes pathological (Brand et al., 2019).

In contrast, the non-significant association observed among girls may partly reflect gender-distinct gaming patterns and psychosocial characteristics. Female adolescents tend to engage more frequently in socially oriented or casual gaming, which may foster greater opportunities for meaningful social interaction and perceived social support (Hartmann & Klimmt, 2006). Additionally, girls are generally more inclined to employ a broader repertoire of coping strategies and to utilize social support networks outside the gaming context, potentially buffering the pathway from IGD to suicidal risk (Rose & Rudolph, 2006). Another plausible explanation is the limited statistical power within the female subgroup; the prevalence of high-risk IGD among girls in our sample was substantially lower (3.4%) than among boys (8.0%). This lower prevalence may have hindered our ability to detect a significant association, particularly for infrequent outcomes such as incident suicidality.

The pronounced association between IGD and suicidality among male adolescents can be further understood through the lens of gender socialization and help-seeking norms. Traditional masculine norms often emphasize emotional stoicism and self-reliance, which may discourage

adolescent boys from seeking professional or social support when experiencing psychological distress (Addis & Mahalik, 2003). Consequently, boys may be more likely to rely on immersive and competitive gaming as a form of avoidance or escape-oriented coping to manage internalized negative affect (Blasi et al., 2019). Although such gaming may provide short-term relief, limited emotional expression and reduced help-seeking can contribute to an accumulation of distress, which—when combined with functional impairments associated with IGD—may heighten the risk of prospective suicidality (Brand et al., 2019).

This study has several limitations. First, all measures were based on self-reports, which may be subject to recall, social-desirability, or common method bias, although the longitudinal nature of our design and the exclusion of baseline suicidality mitigate this concern to some extent. Second, despite the longitudinal design, the two-year follow-up period may not fully capture long-term trajectories of suicidality and gaming behavior. Nevertheless, the study's strength lies in providing prospective evidence that HRIGD increases subsequent suicidal risk among adolescents who were free of suicidality at baseline. Third, although the robustness of our findings is supported by the high E-value (ranging from 5.43 to 7.52), some potential confounding factors, such as academic stress, experiences of bullying victimization, and time spent on non-gaming screen activities, were not explicitly measured. Future research should integrate a more comprehensive set of social and environmental stressors to further refine the risk profile. Fourth, this study examined the association between HRIGD and suicidality rather than between clinically diagnosed IGD and suicidality. Although we utilized the validated IGUESS to identify IGD risk, measurement invariance across sex and age subgroups was not formally tested in this study. Therefore, we cannot entirely rule out the possibility that certain items might be interpreted differently by boys and girls, which could potentially influence the observed sex differences in the association between IGD and suicidality. Future research should employ multi-group confirmatory factor analysis to establish robust measurement invariance for IGD screening tools across diverse demographic groups. As HRIGD reflects individuals at elevated risk rather than those meeting full diagnostic criteria, the observed association may be conservative, and the true association between clinically diagnosed IGD and suicidality may be even stronger. Fifth, suicidality was assessed using three brief self-report items (focusing on ideation, plan, and attempt) adapted from the SCID-I, rather than a full clinician-administered diagnostic interview. Although we did not directly examine the concordance between these items and a comprehensive clinical assessment within our sample, according to a recent meta-analysis by Campos et al. (2023) of 27 international cohorts, various suicide risk assessment instruments demonstrate high concurrent validity, with Pearson's r reaching 0.94 and Cohen's kappa reaching 0.97, supporting the validity of this approach (Campos et al., 2023). This suggests that brief screening items derived from standardized frameworks are statistically reliable and

effectively capture the core construct of suicidality. Future research should incorporate multi-informant or clinician-based assessments to further validate these longitudinal associations. Seventh, although the recruitment process aimed to encompass a socioeconomically diverse population by sampling major metropolitan districts, the exclusion of small-scale schools in rural and provincial areas may limit the generalizability of our findings to the entire adolescent population in South Korea. Finally, our study focused on a relatively narrow age range (9–14 years). While this captures the critical onset period for IGD, it may not fully represent the peak risk period for suicidality in late adolescence, necessitating caution when generalizing these results to older age groups.

To enhance the translational utility of our findings, we propose specific strategies for early identification and intervention. First, for effective screening, practitioners should utilize validated instruments such as the IGUESS, which provides a brief yet robust assessment suitable for school-based mental health check-ups. Regarding family-based interventions, evidence-informed approaches such as parent psychoeducation, family communication skills training, and structured family therapy models (e.g., multidimensional family therapy and family-based cognitive-behavioral approaches) that target parenting practices, monitoring of gaming behaviors, and emotional support. On a policy level, establishing structured referral pathways between educational institutions and specialized mental health centers is essential for providing timely psychiatric care to high-risk adolescents.

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SUPPLEMENTARY MATERIAL

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