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Symptoms of internet gaming disorder and depression in Chinese adolescents: A network analysis

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ABSTRACT

The current study aimed to investigate comorbidity among symptoms of depression and internet gaming disorder (IGD) utilizing symptom network analysis in a sample of Chinese adolescents. A total of 1,362 Chinese adolescents (Mean age = 15.19 ± 1.67; range 13–21; 39.79% female, 56.02% male, 4.19% not disclosed) were recruited from 11 local secondary schools between June and July 2020. Symptoms of depression and IGD were assessed by the 7-item DASS-21 depression subscale and the 9-item Internet Gaming Disorder Scale. We conducted network analysis to estimate network models and the most central symptoms of depression and IGD and computed a combined network model of both depression and IGD symptoms to find bridge symptoms and illustrate the comorbidity between depression and IGD. We found that feeling '*Worthless*', '*Meaningless*', and '*Down-hearted*' were identified as the most central symptoms of depression, whereas '*Preoccupation*' and '*Tolerance*' were the two most central symptoms of IGD. The bridge symptoms in the combined network model were '*Gaming for escape or mood relief*' from the IGD cluster and '*No initiative*' and '*Down-hearted*" from the depression cluster. The current study was the first to investigate the relationship between depression and IGD symptoms among adolescents utilizing a symptom network perspective. Also, it highlighted key bridge symptoms in understanding how IGD and depression contribute to each other.

1. Introduction

Adolescence is a critical developmental period in which an individual experiences drastic physical, psychological, and biological changes (Dahl, 2004), making one susceptible to mental health challenges. About half of the individuals who experience psychiatric illness have their first onset by age 18 (Caspi et al., 2020). Depression is the most common mental disorder around the world (World Health Organization, 2017). It is characterized by persistent depressive mood and loss of interest, accompanied by cognitive, social, and behavioral impairment (American Psychiatric Association, 2013). Amidst the COVID-19 pandemic, the global prevalence of clinically elevated depressive symptoms is approximately 25.2% among children and adolescents (Racine et al., 2021). However, the prevalence of depressive symptoms in China is comparatively higher than the global rate. Meta-analytic reviews showed that the prevalence of depressive symptoms before the pandemic increased from 24.3% (Tang et al., 2019) to 28.3% (Chen et al., 2022) during the pandemic amongst Chinese adolescents. Meanwhile, depression is highly comorbid with other mood disorders (e.g., anxiety) and behavioral problems (e.g., substance abuse) (Cummings et al., 2014; Essau and de la Torre-Luque, 2019), and related to several adverse outcomes among adolescents, including suicidal ideation and attempts (Conejero et al., 2018), lower quality of life (Kolovos et al., 2016), lower academic attainment (Wickersham et al., 2021), and less perceived social support (Ren et al., 2018). Hence, more attention needs to be paid to adolescent mental health and psychopathology.

People living with depressive symptoms cope with their distress using various strategies. According to Lazarus and Folkman (1984),

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coping refers to the cognitive and behavioral reactions of individuals for managing the sources or demands of a stressful situation. Coping strategies have been commonly delineated into two categories in terms of their functions, which are problem-focused coping and emotion-focused coping (Lazarus and Folkman, 1984; Skinner et al., 2003). Problem-focused coping refers to an individual's attempt to directly modify the sources of the problem or demands of the events that caused stress (Cong et al., 2021; Schneider et al., 2018; Skinner et al., 2003). Emotion-focused coping is used when individuals aim to regulate their emotional responses to a stressful event and is often used when active strategies may not appear feasible (Gattino et al., 2015; Skinner et al., 2003; Van den Brande et al., 2016). Previous research found that problem-focused coping was associated with positive psychological outcomes, whereas emotion-focused coping was associated with greater depressive symptoms (McMahon et al., 2013). In a sample of children, Völlink et al. (2013) demonstrated that emotion-focused coping was positively associated with elevated level of depressive symptoms. Horwitz et al. (2011) found that behavioral disengagement was positively related to severity of depressive symptoms in a sample of adolescents. Furthermore, problem-focused coping was negatively associated with depressive symptoms among Malaysian adolescents (Cong et al., 2021). Given the global transition to the digital age, digital technology has provided new ways to engage in emotion-focused coping strategies, which may contribute to the development of technology-related behavior and mood problems.

Individuals who suffered from depressive symptoms often seek recreational activities, such as video gaming, to relieve their stress. Video gaming is considered a common emotion-focused coping strategy (Blasi et al., 2019; Milani et al., 2018). However, when some individuals spend too much time on video gaming and are unable to control their gaming, such coping behavior might lead to internet gaming disorder (IGD) (Paulus et al., 2018). IGD is a mental disorder in the eleventh revision of the International Classification of Diseases (ICD-11) and proposed in The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5). It is comorbid with mood problems, and affects 3.05% of youth globally (Stevens et al., 2021). IGD is comprised of heterogenous symptoms such as preoccupation, tolerance, and withdrawal from reality. The prevalence of IGD among Chinese youth varys from 9.9% among Chinese young adults (Zhang et al., 2019) to up to 20.3% among Chinese adolescents aged 13 to 21 in Macao (Chang et al., 2022). It is particularly important to examine adolescents' mental health and behavioral concerns under the COVID-19 context. Lockdowns and school suspension due to COVID-19 may lead to increased use of internet video gaming in adolescents. Donati et al. (2021) found that 89% of juveniles engaged in video gaming during lockdown. More video game use during the COVID-19 pandemic resulted in greater depressive symptoms in adolescents over time (Liu et al., 2022). Given the high prevalence of depression and IGD among adolescents (Chang et al., 2022; Racine et al., 2021), especially during the pandemic, it is crucial to understand the interaction between these two disorders.

Depression and IGD are commonly comorbid (Ostinelli et al., 2021). A large body of evidence revealed strong positive associations between IGD and depression severity among youth (Hyun et al., 2015; Laconi et al., 2017; Liu et al., 2018; Wong et al., 2020), suggesting that youth who report IGD symptoms are also susceptible to depressive symptoms. Previous studies also showed a strong dose-response association between depression severity and IGD symptoms (Männikkö et al., 2020; Sussman et al., 2018), validating the potential comorbidity between depression and IGD. For example, studies have shown that individuals engaged in video gaming and adopted maladaptive coping strategies, such as escapism, were more likely to be at a high risk of developing problematic video gaming (Billieux et al., 2015; Laconi et al., 2017; Loton et al., 2016). This is because they would use gaming as a maladaptive coping strategy to help them relieve stress in life and obtain pleasure (Laier et al., 2018). After individuals developed IGD symptoms, they tended to adopt more dysfunctional coping strategies, such as denial and behavioral disengagement (Dreier et al., 2017; Schneider et al., 2018), which further resulted in developing depressive symptoms. Hence, a vicious cycle of IGD and depression occurred.

Besides empirical research, different theoretical models also argued for the reciprocal relationship between depressive symptoms and IGD symptoms. Compensatory internet use theory (CIUT; Kardefelt-Winther, 2014) suggests that individuals overuse the internet because of negative life situations and negative affect. Individuals want to reduce their negative affect, so they compensate through excessive internet use. However, such excessive use of the internet might lead to a higher level of psychological distress (e.g., depression). This theory helps to understand why individuals continue to engage in internet gaming despite the repercussion of maladaptive use. Meanwhile, the Interaction of Person-Affect-Cognition-Execution (I-PACE) model explains why individuals with mood difficulties use the Internet excessively (Brand et al., 2019, 2016). The I-PACE model proposes that addictive behavior is developed from interactions between individuals' predisposing factors (e.g., psychopathological and biological features), affective and cognitive reactions to perceived external or internal triggers, use of expectancy and dysfunctional coping, and execution and decision making. Eventually, individuals gain gratification and compensation through engaging in addictive behaviors. Then, the rewarded gratification or compensation from the addictive behavior reinforces the predisposing factors, including psychopathological vulnerability and dysfunctional coping (Brand et al., 2016). In other words, individuals who are affected by psychological distress (e.g., depression) tend to participate in internet gaming as a coping strategy to gain pleasure or compensate for negative affect, which further increases their level of psychological distress and maladaptive pattern of using internet gaming as a coping strategy.

The existence of comorbidity is mostly supported by research findings of IGD-depression relationships using different methodologies, including regression analysis approaches (Hyun et al., 2015; Wong et al., 2020), autoregressive cross-lagged modeling (Liu et al., 2018), and latent class analysis and multinomial logistic regression (Chang et al., 2022). Yet, these approaches do not address the interaction between two disorders at the symptom level. Network analysis is one of the methodological techniques that can estimate associations among symptoms of mental disorders and has been widely applied in the psychopathology and clinical field (Borsboom and Cramer, 2013). From the network theory perspective, network analysis provides a novel understanding of the interaction between symptoms of mental disorders, estimating causal networks of symptoms, and evaluating comorbidity between disorders (Cramer et al., 2010; Hofmann et al., 2016). A network model consists of a set of nodes connected by a set of edges. The nodes represent symptoms of a disorder, whereas the edges represent connections between symptoms (Hofmann et al., 2016). The central symptom node is used to determine the most essential symptoms for a disorder (Mitchell et al., 2017). Furthermore, comorbidity between disorders is determined by symptoms that are overlapping and related to both disorders, which are known as bridge symptoms (Cramer et al., 2010). Some recent studies investigated comorbid relationships of depressive symptoms and problematic internet use. For example, Cai et al. (2022) found several symptoms (e.g., 'anticipation for future online activities') from an internet addiction network cluster playing an important role in connecting internet addiction and depression in adolescents. In college students, the depressive symptom 'guilty' and internet addiction symptom 'escape' were identified as bridge symptoms in the comorbid network (Zhao et al., 2022). In addition, Granero et al. (2022) adopted the network approach to understanding the connection of different sociodemographic and clinical profiles in treatment-seeking individuals with gaming disorder and found that psychological distress, age, and onset of gaming-related problems had a central impact on the network. However, their findings could not be generalized to depression and the IGD network or other populations due to the different characteristics of the mental disorder and the study sample.

The network approach has not been used to examine comorbid

relationships between depression and IGD in adolescents. Given emotional crises are more likely to occur during adolescence and are frequently accompanied by periods of depressive symptoms, and adolescents could be more susceptible to excessive internet use as a coping strategy during this vulnerable period (Karacic and Oreskovic, 2017), we utilized network analysis to explore and illustrate relations among symptoms of depression and IGD and their potential comorbidity among Chinese adolescents. In order to understand how these two disorders are associated, we also identified bridge symptoms. Due to the uniqueness of the studied sample, we also illustrated the network structure of depression and IGD separately to understand how symptoms interplay with each other within the individual network in this sample before estimation of comorbid network of the two disorders. No specific hypotheses were specified given the exploratory nature of network analysis.

2. Methods

2.1. Participants and procedure

In the 2019/2020 academic year, 26,396 high school students studied in Macao, China. A total of 4,597 of these students from 11 high schools were reached between June and July 2020, and 2,555 (55.80%) provided parental consent for participation. In the end, 1,785 valid responses with parental consent and assent were collected through Qualtrics. Four hundred and twenty-three were excluded as they did not report playing video games, resulting in a sample of 1,362 adolescents (Mean age = 15.19 ± 1.67; range 13–21; 39.79% female, 56.02% male, 4.19% not disclosed; 59.25% junior high school students, 40.75% senior high school students) included in the current project. It is also important to note that the data collection occurred during the COVID-19 epidemic after school suspension. The study obtained research ethics approval from the Research Ethics Committee of University of Macau.

2.2. Measures

2.2.1. Depression symptoms

Depressive symptoms were measured by the Chinese version of the 21-item Depression Anxiety Stress Scale's depression subscale (Lovibond and Lovibond, 1995; Moussa et al., 2001). The depression subscale contains 7 items measuring depressive symptoms in the past week, with a rating scale from 0 (*did not apply to me at all*) to 3 (*applied to me very much, or most of the time*). Higher scores indicate greater levels of depression. The measure previously demonstrated good reliability and validity among Chinese adolescents (Wang et al., 2016). Internal consistency of the depressive subscale in the present study was Cronbach's α = 0.86.

2.2.2. IGD symptoms severity

Internet gaming disorder symptoms were assessed by the Chinese version of the Internet Gaming Disorder Scale (IGDS), a 9-item, self-report dichotomous measure (*No* = 0, *Yes* = 1), developed based on DSM-5 diagnostic criteria of IGD (Lemmens et al., 2015). The IGDS measures internet gaming activities in the past year, and higher total scores imply greater IGD severity. The Chinese version was previously validated in a Chinese sample (Sigerson et al., 2017), and demonstrated good internal consistency in the current study, KR-20 = 0.77.

2.3. Data analysis

Descriptive statistics were used to summarize demographic variables. Because the optimal way to model trichotomous items in network analysis is debatable (Fried et al., 2015), we dichotomised the DASS-21 depression items as '0' and '1' to indicate absence (original depression item value of '0') or presence of symptoms (original depression item value of '1', '2', or '3'). Network models of IGD, DASS-21-depressive symptoms, and the combined network model were estimated using the *Ising* package for Ising model (binary data) (van Borkulo et al., 2014) in R. Network visualization was performed using *qgraph* package in R (Epskamp et al., 2012; R Core Team, 2018), and *spring* layout or Fruchterman-Reinglod algorithm was used to plot the networks (Fruchterman and Reingold, 1991). The eLASSO (Enhanced Least Absolute Shrinkage and Selection Operator) was to limit spurious or false positives and enhance interpretability of networks with a sparse network. Model selections were based on Extended Bayesian information criterion (EBIC).

Expected influence (EI) was used to evaluate network centrality and identify the most influential node in the network (Robinaugh et al., 2016). Different from other centrality indices, EI distinguishes between positive and negative edges and assesses cumulative influence of a node. Nodes with highest EI values were considered the most important/influential nodes in the symptom network. We first computed individual networks for IGD and depressive symptoms, respectively. Then, we computed the combined network model to explore comorbidity between IGD and depression. To identify most influential node that bridge IGD and depression, bridge centrality indices would be appropriate (Burger et al., 2022). The *networktools* package (Jones, 2018) was used to compute the bridge expected influence (BEI; Jones et al., 2021) to identify bridge nodes between IGD and depression symptom communities. Nodes with highest BEI values were considered bridge nodes in the combined symptoms network of IGD and depression. Bridge nodes were selected using an 80th percentile cut-off on BEI value (Jones et al., 2021). Accuracy and stability of each network model were evaluated using the *bootnet* package (Epskamp and Fried, 2015, 2018). A 1000 case-dropping bootstraps was used to estimate centrality stability of each network model. A correlation stability coefficient (*CS*-coefficient) was obtained for EI and BEI for each network from the bootstrapping procedure. The CS-coefficient indicated the proportion of cases that could be dropped from analyses while preserving a correlation of at least $r = 0.70$, within a 95% confidence interval, and A CS-coefficient should not be below 0.25 and 0.5 indicates good network stability (Epskamp et al., 2018). Edge-weight accuracy was estimated with 95% confidence interval (Epskamp et al., 2018). Network comparison was conducted to examine the network characteristic differences between boys and girls. The Network Comparison Test was utilized to evaluate global connectivity and local connectivity between two gender network models with the R package *NetworkComparisonTest* (Van Borkulo et al., 2022) with 1000 iterations.

Table 1
Description, Mean, and SD for network nodes and overall scales.

Node name	Item content/ overall scales	*Mean*	*SD*
D1	No positive	0.46	0.50
D2	No Initiative	0.58	0.49
D3	No look forward	0.47	0.50
D4	Down-hearted	0.48	0.50
D5	Not enthusiastic	0.39	0.49
D6	Worthless	0.28	0.45
D7	Meaningless	0.31	0.46
IGD1	Preoccupation	0.46	0.50
IGD2	Withdrawal	0.31	0.46
IGD3	Tolerance	0.23	0.42
IGD4	Loss of control	0.22	0.41
IGD5	Loss of non-gaming interest	0.15	0.35
IGD6	Gaming despite harms	0.43	0.50
IGD7	Deception of others about gaming	0.15	0.35
IGD8	Gaming for escape or mood relief	0.48	0.50
IGD9	Conflict due to gaming	0.10	0.30
	Depression scale	8.86	8.83
	IGD scale	2.51	2.29

Note. All nodes were coded as 0 or 1. IGD=internet gaming disorder.

3. Results

Table 1 shows mean, *SD*, name, and description for each node of IGD and depression scale. Table A.1 shows correlation coefficients of all nodes within the network.

3.1. Depression network model

The network structure of depression and the expected influence (EI) for each node are displayed in Fig. 1. Other centrality indices are showed in Fig. A.1. The CS-coefficient of EI value [$CS = 0.673$] indicates node expected influence was stable. *Worthless* (D6) was the most influential node in the network model, followed by *Meaningless* (D7) and *Down-hearted* (D4). *No initiative* (D2) was the least central node. The strongest edges were between *Worthless* (D6) and *Meaningless* (D7); and between *No positive* (D1) and *Down-hearted* (D4). Bootstrapped confidence intervals (CIs) of the edge weights are shown in Fig. A.2. The stability of centrality indices using case-dropping bootstrap is showed in Fig. A.3.

3.2. IGD network model

The network structure of IGD and the EI values for each node are displayed in Fig. 2. Other centrality indices are shown in Fig. A.4. The IGD network structure demonstrated acceptable stability, supported by CS-coefficients for EI value [$CS = 0.439$]. *Preoccupation* (IGD1) was the most influential node in the network model, followed by *Tolerance* (IGD3). *Gaming for escape or mood relief* (IGD8) was the least central node. The strongest edges were between *Preoccupation* (IGD1) and *Tolerance* (IGD3), *Loss of non-gaming interest* (IGD5) and *Conflict due to gaming* (IGD9), *Preoccupation* (IGD1) and *Withdrawal* (IGD2), and *Tolerance* (IGD3) and *Loss of control* (IGD4) Bootstrapped confidence intervals (CIs) of the edge weights are shown in Fig. A.5. The stability of centrality indices using case-dropping bootstrap is showed in Fig. A.6.

3.3. Combined IGD and depression network

A network was estimated that combined IGD and depressive symptoms; the bridge expected influence (BEI) values for each node are displayed in Fig. 3. Other centrality indices are showed in Fig. A.7. Stability analysis of the combined network indicated that the combined network demonstrated acceptable stability based on CS-coefficients for BEI value [$CS = 0.439$]. *Down-hearted (D4), No initiative* (D2), and *Gaming for escape or mood relief* (IGD8) had the largest 1-step value and emerged as bridge nodes in the combined network model. Bootstrapped confidence intervals (CIs) of the bridge edge weights are shown in Fig. A.8. The stability of centrality indices using case-dropping bootstrap is showed in Fig. A.9.

3.4. Network comparison between boys and girls

The combined network models of the two genders are shown in Fig. A.10. Comparison of the two networks was not significantly different in global network strength (boys: 31.104 versus girls: 29.532; $S = 1.571$, $p = .602$) or distribution of edge weights ($M = 1.97$, $p = .14$) (Fig. A.11).

4. Discussion

The current study examined the network structure of depression and IGD symptoms and relationships between these symptom communities among Chinese adolescent gamers. To the best of our knowledge, this is the first study to examine the depression- IGD symptom network in a large sample of adolescent gamers in the modern digital age in the COVID-19 context.

The depression network model revealed that *Worthless (D6), Meaningless* (D7), and *Down-hearted* (D4) were the most influential nodes in the sample, which is similar to previous depression networks, in which sadness (Gijzen et al., 2021; Mullarkey et al., 2019) was identified as most central node among adolescents, despite variation in measurements for depression. *Guilt* was identified as a central node in depression symptoms network using PHQ-9 during COVID-19 (Cheung et al., 2021). The results also align with typical clinical presentation and criteria for a DSM-5 major depression diagnosis, in which feeling worthless and inappropriate guilt were combined as one item (American Psychiatric Association, 2013; Thapar et al., 2012). It is likely that the emergence of adolescence causes drastic hormonal changes that affect brain and behavior, making the individual more vulnerable to development of depression in stressful situations (Blakemore et al., 2010; Thapar et al., 2012). *Meaningless* (D7) was one of the most central nodes in the depressive symptom network and may indicate the specific impact of COVID-19 on how adolescents perceive their life. Indeed, adolescents reported various difficulties during the COVID-19 pandemic, such as academic challenges, less contact with friends, and less participation in healthy and joyful activities (Luijten et al., 2021; Ravens-Sieberer et al., 2022), which might trigger feeling meaningless (Shek, 2021). When searching for meaning in life, adolescents also tend to be more distressed (Chen et al., 2021; Li et al., 2019). Altogether, these findings support why *Worthless (D6), Meaningless* (D7) and *Down-hearted* (D4) are the

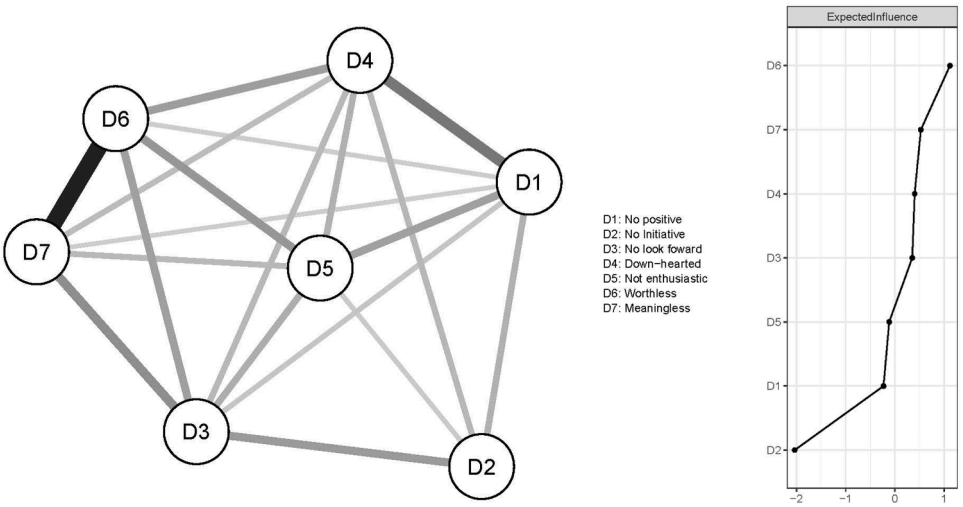

Fig. 1. Network structure of DASS-D and standardized value (z-score) of expected influence (EI) for each node.

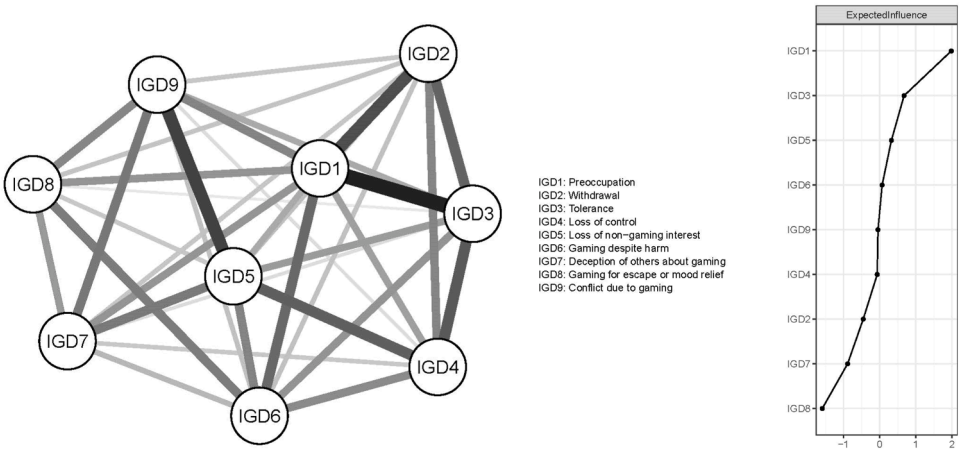

Fig. 2. Network structure of IGD and standardized value (z-score) of expected influence (EI) for each node.

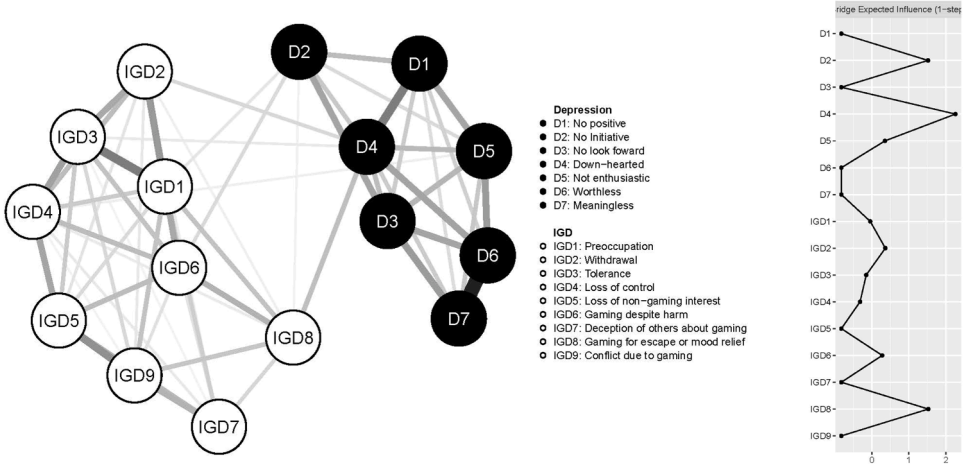

Fig. 3. Network structure of combined model and standardized value (z-score) of bridge expected influence (BEI) for each node.

most important nodes in the depression symptoms network.

The IGD network model revealed that *Preoccupation* (IGD1) and *Tolerance* (IGD3) were the two most influential nodes in the sample, which is consistent with a previous IGD network, in which *Preoccupation* was identified as the most central node among a sample of Chinese university students (Yuan et al., 2021). Similar to Liu et al. (2022), we identified *Tolerance* as one of the most central or influential nodes. Gomez et al. (2022) identified *Loss of control* as one of the most central nodes, which was not the most influential node in our IGD network. Despite this inconsistency, we found that its expected influence was not significantly different from that of *Tolerance* (IGD3). These findings indicate that *Preoccupation, Tolerance*, and *Loss of control* are cognitive and behavioral factors that aid our understanding of the maintenance of IGD (Dong and Potenza, 2014). However, in contrast to Liu et al. (2022), we identified *conflict* as the least central node. This inconsistency may be due to a different sample (i.e., U.S. adult gamers) being used. Different from U.S. adult gamers, *Conflict* is least important in understanding the development or maintenance of IGD in adolescents who are deemed to have less power in family and value peer relationship. Our results suggest that preoccupation with and increased time for gaming are crucial for the development and maintenance of IGD. According to the I-PACE model (Brand et al., 2019, 2016) and CUIT (Kardefelt-Winther, 2014), it is possible that adolescents are prone to cope with stress experienced during COVID-19 by participating in gaming activities. Due to the COVID-19 pandemic restrictions, adolescents experienced more social distancing and lockdown thus had more access to the internet in their free time. With the increasing stress amidst the pandemic, adolescents might feel more motivated to use gaming to avoid negative feelings. When tolerance is developed, adolescents need to spend more time on gaming activities or participate more in such activities to gain satisfaction or alleviate distress. Additionally, researchers found a neurobiological connection between IGD and depression (Liu et al., 2018; Weinstein and Lejoyeux, 2020), such as impairment of emotion and executive functioning, indicating possible neuropsychopathological overlap between IGD and depression.

Within the combined model, we identified three key bridge symptoms linking IGD and depression, which are *Down-hearted* (D4), *No initiative* (D2), and *Gaming for escape or mood relief* (IGD8). *Down-hearted* (D4) and *Gaming for escape or mood relief* (IGD8) is most strongly connected to each other; *No initiative* (D2) is most strongly connected to *Gaming despite harm* (IGD6). Adolescents are prone to sensation seeking, which is associated with various behavioral problems and adverse health outcomes (Byck et al., 2015). Internet gaming is one of the emotion-coping strategies adopted by youth (Blasi et al., 2019; Milani et al., 2018). Seeking pleasure and enjoyment from internet gaming could be related to preoccupation with gaming and increased use of gaming for mood relief (Gomez et al., 2022) and could result in increased depressive symptoms (Telzer et al., 2014). These findings may explain how feeling *Down-hearted* (D4) and *No initiative* (D2) may motivate adolescents to engage in gaming activities with consequences. On the other hand, *Gaming for escape or mood relief* (IGD8) from IGD had a great contribution to the development or maintenance of depression.

These results aligned with CIUT (Kardefelt-Winther, 2014) that suggests individuals game to escape stressful events or alleviate negative mood, thus leading to problematic gaming symptoms. Notably, *No initiative* (D2) and *Gaming for escape or mood relief* (IGD8) were identified as the least central node in the individual network of depression and IGD, meaning that their impact could be marginal within their symptom network. However, these nodes along with *Down-hearted* (D4) showing strong BEI in the combined network, suggesting that they play a central role in this comorbidity. Interventions target these symptoms could alleviate the severity of comorbidity of depression and IGD. Research investigated comorbid relationships between depression and IGD (Hyun et al., 2015; Ostinelli et al., 2021; Wong et al., 2020), and our findings extend the literature on depression and IGD comorbidity from the construct/disorder level to a symptom level. Since this is the first study to examine the depression-IGD symptom network, results from the comorbid network are not comparable with previous networks investigating comorbidity of depression or IGD. For instance, a previous symptom network of problematic internet use and depression found that the internet addiction symptom "escape" and depression symptoms "guilt" are two bridge items and the only symptoms connected two symptoms cluster in their comorbidity network (Zhao et al., 2022). But we identified different depression symptoms as bridge nodes connecting combined network of depression and IGD and more connections between bridge symptoms and comorbid symptoms. Also, previous studies found *Anticipation for future online activities* as the most crucial bridge symptoms linking depression and problematic internet use, and *Difficulty concentrating* and *Conflict due to gaming* were most key symptoms linking IGD and PTSD (Cai et al., 2022; Yuan et al., 2022). It may be due to the nature of these studies focusing on different comorbidities as well as their different underlying mechanism of comorbidities. The key bridge symptoms (e.g., *Down-hearted* [D4] and *Gaming for escape or mood relief* [IGD8]) highlight how this population falls into the trap of gaming to feel better emotionally. The network comparison test did not find significant gender differences in the combined network structure, and the connection between *Down-hearted* (D4) and *Gaming for escape or mood relief* (IGD8) exists in both gender networks, suggesting a similar potential mechanism of comorbidity of depression and IGD in adolescents, regardless their gender. Although gaming brings pleasure, it also leads to adverse consequences (e.g., lack of time management, poor social relationship, low self-esteem, low psychological well-being) when it becomes excessive and problematic (Paulus et al., 2018).

Several limitations of the current study should be noted. Data from the present study was cross-sectional, which limits causal inferences regarding associations among symptoms. Future studies should explore causal symptom relationships using a longitudinal study design. In addition, generalizability to the clinical population should be cautiously made. Although IGD symptoms were measured by the Internet Gaming Disorder Scale, which was developed based on DSM-5 diagnostic criteria, it is a self-report measure. Moreover, symptoms of depression did not capture all DSM-5 depression diagnostic criteria. DASS-21 depression subscale was used because it is validated for Chinese adolescents and widely used in Chinese community (Mellor et al., 2014; Moussa et al., 2001; Wang et al., 2016). Future studies are suggested to adopt other tools to assess symptoms of mental disorders aligned with diagnostic criteria in DSM-5 or ICD-11. The use of clinician-rated assessment may enhance clinical credibility and quality of the data. However, unfortunately, clinical interviews were not feasible due to COVID-19 pandemic prevention controls in place. Researchers could consider an objective or clinician-rated approach for future network analytic studies to reduce self-report bias.

Despite the shortcomings of the methodology, the current study provided several important implications in understanding associations of depressive and IGD symptoms in adolescents. First, our sample consisted of a relatively large sample of adolescents, covering a broader age range to enhance the generalizability of the findings (Kinghorn et al., 2018; Patton et al., 2016). Second, the current study highlighted key bridge symptoms in understanding how IGD and depression contributed to each other. Internet gaming is common in Chinese adolescents (Chang et al., 2022), and it would become an issue if one excessively relied on it to cope with stress or negative mood, eventually worsening symptoms of both IGD and mood problems. To break the vicious cycle, adolescent mental health practitioners can consider addressing the motivational and mood issues raised in this study with behavioral activation techniques, which target symptoms that cut across both disorders, *Gaming for escape or mood relief* of IGD and *Down-hearted* and *No initiative* of depression.

CRediT authorship contribution statement

Hao Fong Sit: Conceptualization, Methodology, Data collection, Formal analysis, Investigation, Writing - original draft. **Chi Ian Chang**: Formal analysis and investigation, Data collection, Writing - original draft preparation. **Guangzhe Frank Yuan**: Conceptualization, Methodology. **Chun Chen**: Writing - review & editing; **Lixian Cui**: Writing - review & editing. **Jon D. Elhai**: Writing - review & editing; **Brian J. Hall**: Conceptualization, Writing - review & editing, Supervision.

Declaration of Competing Interest

None.

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Supplementary materials

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2023.115097.

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