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Prevalence and risk factors of internet gaming disorder and problematic internet use before and during the COVID-19 pandemic: A large online survey of Japanese adults

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A R T I C L E I N F O

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A B S T R A C T

Internet gaming disorder (IGD) and problematic internet use (PIU) are becoming increasingly detrimental to modern society, with serious consequences for daily functioning. IGD and PIU may be exacerbated by lifestyle changes imposed by the coronavirus 2019 (COVID-19) pandemic. This study investigated changes in IGD and PIU during the pandemic and risk factors for them. This study is a part of a larger online study of problematic smartphone use in Japan, originally planned in 2019, and expanded in August 2020 to include the impact of COVID-19. 51,246 adults completed an online survey during the pandemic (August 2020), in Japan. Of these, 3,938 had also completed the survey before the onset of the pandemic (December 2019) and were used as the study population to determine how the pandemic has influenced IGD and PIU. IGD was assessed using the Internet Gaming Disorder Scale (IGDS). PIU was measured using the Compulsive Internet Use Scale (CIUS). The prevalence of probable IGD during COVID-19 was 4.1% overall [95%CI, 3.9%–4.2%] (N = 51,246), and 8.6% among younger people (age $<$ 30), 1–2.5% higher than reported before the pandemic. Probable PIU was 7.8% overall [95%CI, 7.6%–8.1%], and 17.0% [95%CI, 15.9%–18.2%] among younger people, 3.2–3.7% higher than reported before the pandemic. Comparisons before and during the pandemic, revealed that probable IGD prevalence has increased 1.6 times, and probable PIU prevalence by 1.5 times (IGD: $\chi^2 = 619.9$, $p < .001$, PIU: $\chi^2 = 594.2$, $p < .001$). Youth (age $<$ 30) and COVID-19 infection were strongly associated with IGD exacerbation (odds ratio, 2.10 [95%CI, 1.18 to 3.75] and 5.67 [95%CI, 1.33 to 24.16]). Internet gaming disorder and problematic internet use appear to be aggravated by the pandemic. In particular, younger persons and people infected with COVID-19 are at higher risk for Internet Gaming Disorder. Prevention and treatment of these problems are needed.

1. Introduction

The coronavirus 2019 (COVID-19) pandemic has affected all aspects of society (Holmes et al., 2020; McGinty et al., 2020). Previous studies have suggested that stressors due to the pandemic contribute to increased addictive behaviors, such as substance use, alcohol, food, and social media (Bonny-Noach and Gold, 2020; Panno et al., 2020). The World Health Organization (WHO) has warned that during the COVID-19 pandemic, screen time and game-playing time may increase. This increases the risk of Internet and gaming addiction (World health organization, 2020). Increased video gameplay and internet use among young people have been reported (Schmidt et al., 2020), possibly because of pandemic-induced lifestyle changes, e.g., staying at home, quarantines, closed workplaces, and schools (King et al., 2020b; World

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health organization, 2020). While video games and the internet provide entertainment and convenience, maladaptive engagement in these activities can lead to various mental health problems, including internet gaming disorder (IGD) and problematic internet use (PIU). IGD is a disorder in which people lose control over their gaming engagement. The American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders 5th edition (DSM-5) (American Psychiatric Association, 2013) is considering adding IGD as an official psychiatric diagnosis. PIU is a general term for internet addiction and compulsive internet use, which is reported to be a modern social problem, although not yet defined by DSM-5 or the International Classification of Diseases (ICD). PIU is a multidimensional psychological complex concept, characterized by 1) uncontrolled time spent on using the internet, 2) withdrawal symptoms when the internet is unavailable, and 3) the desire to engage in online activities even if it may damage offline social relationships (Senol-Durak and Durak, 2017). IGD and PIU are associated with greater psychological distress, poorer sleep quality, and severe social withdrawal, known in Japan as *'hikikomori'* (Kato et al., 2020; Wong et al., 2020; Fazeli et al., 2020). Possible risk factors for them include parental marital conflicts and attachment, psychiatric symptoms, and maladaptive coping strategies (Bányai et al., 2021; Jeong et al., 2020; Teng et al., 2020).

Despite governmental and institutional efforts to prevent and to ameliorate these internet-related afflictions, IGD and PIU have become major societal problems (Sim et al., 2021). Several opinion papers have cautioned that increased severity of IGD and PIU during a pandemic could persist after its subsidence, which may prolong poor quality of life for those affected and may impose a heavy economic burden on society (King et al., 2020b; Ko and Yen, 2020). Király et al. (2020) warned that psychological stress associated with the COVID-19 pandemic may contribute to thoughts that rationalize inappropriate internet use, leading to PIU and IGD as coping strategies. They also warned that effects may linger even after the situation returns to normal (Király et al., 2020). Young people have an especially great risk of internet-related problems and psychological distress during the pandemic (Chen et al, 2020, 2021; Fazeli et al., 2020; Sun et al., 2020). Such epidemiological studies are important in formulating policies for prevention and early intervention. However, to the best of our knowledge, most previous studies have employed cross-sectional approaches or surveys for children and adolescents. One study, which included only adolescents, found increased rates of internet-related problem behaviors in March 2020, compared with November 2019 (Chen et al., 2021). While previous reports revealed worsening IGD during COVID-19 among children and adolescents (Teng et al., 2021; Kim et al., 2021), the effects of the pandemic on internet-related problems among adults remain unclear. Since the motivation for such internet-related problem behaviors differs between children/adolescents and adults (Kircaburun et al., 2020), these should be examined independently for adults as well.

Research questions remaining unanswered are as follows:

1) Have IGD and PIU been exacerbated during the COVID-19 pandemic?
2) If so, what are the risk factors for their exacerbation?

To answer these questions, we employed online survey data from 51,246 adults. First, we investigated baseline prevalence of IGD and PIU. The influence of the COVID-19 pandemic on IGD and PIU was further assessed by comparing online survey data from a subsample of 3,938 adults collected before and during the pandemic.

2. Material and methods

2.1. Participants and procedures

This investigation was part of a larger study on the association between problematic smartphone use and multidimensional psychiatric states that was initiated in 2019 and later expanded to examine the impact of COVID-19 (Fig. 1). Details of original surveys can be found in the Supplementary Methods. The study was approved by the Ethics Committee of the Advanced Telecommunications Research Institute International (Japan) (approval No.21-195 for the original study and No.21-749 for this extended study).

99,156 participants participated in the pre-pandemic survey regarding demographic and smartphone use information. The detailed survey population of 5,995 participants was screened to include equal numbers of individuals in each quintile relative to their problematic smartphone use score in December 2019, immediately before the advent of the COVID-19 pandemic. Respondents reported their multidimensional psychiatric states, including IGD and PIU. In order to assess changes in multiple psychiatric states during the pandemic, we conducted a follow-up survey in July 2020 that contained additional questions related to COVID-19 (e.g., Do you think that you have ever been infected by COVID-19?). 52,737 people responded to the July 2020 survey, including people who participated in December 2019 (Fig. 1). 1,647 participants dropped out (defined as the drop-out population). Of the latter, 410 participants were excluded (defined as excluded population). Of these,198 participants were excluded because of inconsistencies in their answers: 1) sleep time was reported the same as wake-up time in a single survey (N = 185)). There were inconsistencies in their self-reported sex (i.e. T1 sex $\neq$ T2 sex) (N = 1). Participants answered "yes" to the statement, "I'm not a heavy drinker", but also "yes" to, "I'm a heavy drinker" (N = 12). An additional 212 participants were excluded because they responded identically to all items, using only the maximum or minimum values. In the end, 3,938 respondents were included in the current analyses (Fig. 1).

2.2. Measures

IGD was measured according to the Japanese-version Internet Gaming Disorder Scale (IGDS), which consists of questions corresponding to each of the nine IGD symptoms defined in DSM-5 (American Psychiatric Association, 2013). Using a binary response format, items assessed the presence of each IGD symptom during the preceding 12 months. The nine items defined in DSM-5 are as follows: "Preoccupation", "Tolerance", "Withdrawal", "Persistence", "Escape", "Problems", "Deception", "Displacement", and "Conflict" (Lemmens et al., 2015). At least five symptoms are required to return a diagnosis of probable IGD. The reliability and validity of IGDS have been demonstrated with a Cronbach's alpha of 0.93 (Lemmens et al., 2015) and IGDS had empirical support for its ability to screen IGD (King et al., 2020a). The reliability and validity of Japanese version has also been demonstrated (Sumi et al., 2018). In our sample, Cronbach's alpha is 0.84, which indicates strong internal reliability.

PIU was measured using the Compulsive Internet Use Scale (CIUS), which has a Cronbach's alpha of 0.89. Construct validity has been confirmed by the strong correlation with the Online Cognition Scale (r = 0.70, $p < .001$) and moderate correlation with the amount of time spent online (r = 0.33, $p < .001$) (Meerkerk et al., 2009). The reliability and validity of the Japanese version has been confirmed (Yong et al., 2017). In our sample, Cronbach's alpha is 0.94, which indicates strong internal reliability. We defined probable IGD as a total IGDS $\geq$ 5, and probable PIU as a total CIUS score of $\geq$ 29 (Meerkerk et al., 2009).

2.3. Statistical analysis

Average IGDS and CIUS scores and the prevalence of probable IGD and PIU based on these scales were calculated for each age group and sex for both T1 (December 2019, before COVID-19) and T2 (July 2020, during COVID-19) (N = 3,938). Changes in prevalence of probable IGD and probable PIU were analyzed using Chi-square tests. We also analyzed each IGD item similarly. Cramer's ϕ was used as effect size in these analyses. Magnitudes of Cramer's ϕ are usually interpreted as

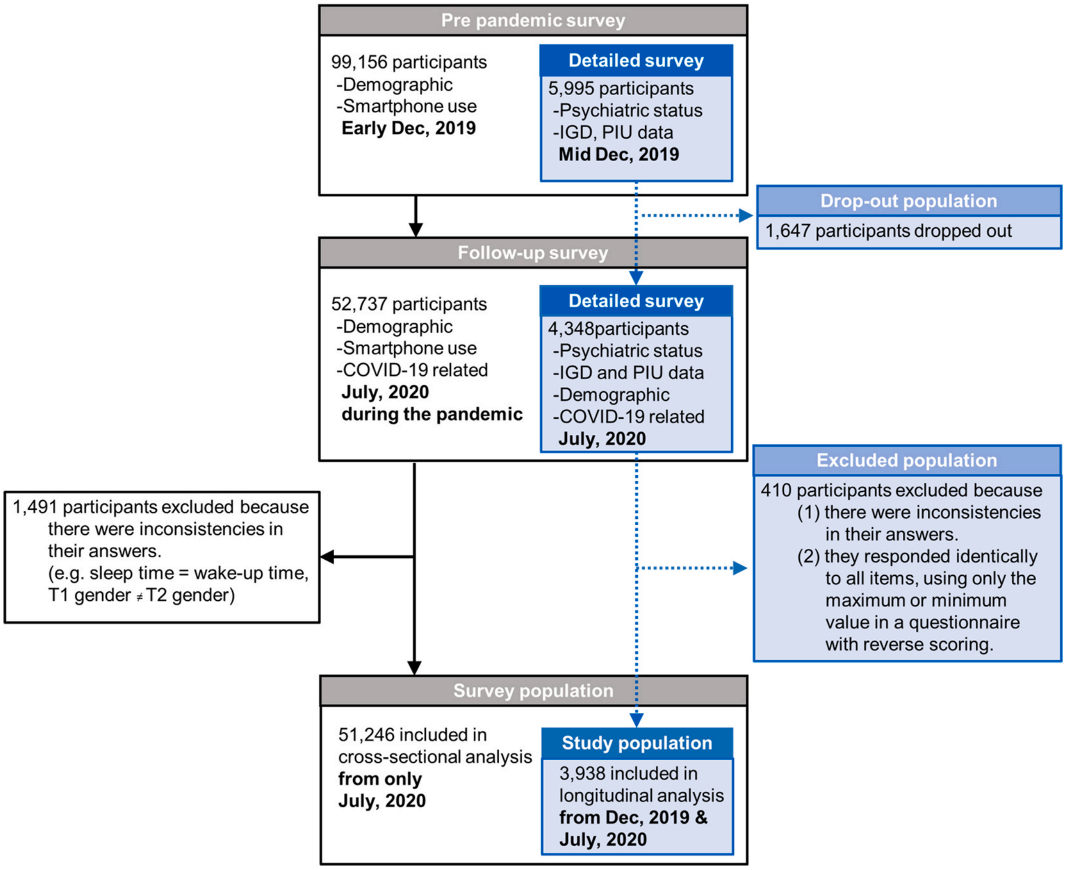

Fig. 1. Flow chart showing numbers of participants and criteria for exclusion from analyses.

follows: small < 0.1, medium < 0.3, large < 0.5. Bonferroni correction was used to adjust multiple comparisons for analysis of each IGD item. Further, to explore effects of demographic characteristics and infections of COVID-19 on IGD and PIU status, we conducted multiple logistic regression analyses to predict who developed probable IGD and probable PIU during the period between T1 and T2. To do so, participants without probable IGD or PIU at T1 were excluded for each analysis, separately. As a result, 3793 and 3626 individuals were included in the analysis of IGD and PIU, respectively. Demographic characteristics were selected and included in the analyses consistent with previous studies (Pierce et al., 2020; van der Velden et al., 2021): sex, marital status, the existence of children, the status of living with someone, age groups, household income, and employment status. Further, we included COVID-19-related statuses (Aniko, 2021; Sun et al., 2020) that are likely to affect psychiatric states or internet-related problems in the analyses: changes in the amount of communication with family from T1 to T2 (face-to-face and online, separately) (Jeong et al., 2021); changes in smartphone use time from T1 to T2 (weekdays and weekends, separately) (Chen et al., 2021) (see Supplementary Table 1 for details).

2.3.1. Model specification

logit (IGD or PIU) = Intercept + sex + marital status + the existence of children + living with someone + age groups + household income + employment status + the status of COVID-19 infection + changes in the amount of face-to-face communication with family from T1 to T2 + changes in the amount of online communication with family from T1 to T2 + change in smartphone use time from T1 to T2 on weekdays + change in smartphone use time from T1 to T2 on weekends.

**IGD and PIU* denote the state of probable IGD or probable PIU at T2, respectively.

All demographic characteristics were treated as categorical variables. The odds ratio (OR) of each group for a given variable was calculated against the reference group. Reference groups were decided according to previous studies (Shen et al., 2020; Tsumura et al., 2018). To confirm the impact of depression and anxiety on results, we also analyzed the above model with the addition of changes in these disorders from T1 to T2. We further performed similar multiple logistic regression to confirm factors related to probable IGD and PIU at T1 (see the Supplementary Methods for details). To examine factors influencing change in severity, we also conducted multiple regression analysis predicting changes of severity in IGD and PIU from T1 to T2. To test potential selection bias, Pearson correlation analysis was performed for the prevalence of probable IGD and probable PIU in each age and sex group between the survey population and the study population. Statistical analyses were performed using Matlab version R2019b. Statistical tests assumed a significance level α of 5%, except for analysis of the difference of IGD items from T1 to T2, for which Bonferroni correction was used.

3. Results

3.1. Sample characteristics

The average age of the survey population was 46.6 years [standard deviation (SD) = 11.8], and 49.9% were male (Table 1). The prevalence of probable IGD was 4.1% (95%CI [3.9%–4.2%]) and that of PIU was 7.8% (95%CI [7.6%–8.0%]). The probable prevalence of IGD among young people (<30 age) was 8.6% (95%CI [7.8%–9.5%]) and that of PIU was 17.0% (95%CI [15.9%–18.2%]).

Demographic characteristics of the study population are shown in Supplementary Table 2. Among adults, prevalence of probable IGD increased 1.5 times during the pandemic ($\chi^2 = 619.9$, $p < .001$, $\phi = 0.40$) and PIU increased 1.6 times ($\chi^2 = 582.3$, $p < .001$, $\phi = 0.38$). In young people, IGD prevalence increased 1.8 times during the pandemic

Table 1
Demographic characteristics of the survey population of the COVID-19 online survey.

		Sample size	Unweighted profile	Weighted profile	Mean IGDS score (95% CI)	Proportion with probable IGD (95% CI)	Mean CIUS score (95% CI)	Proportion with probable PIU (95% CI)
Total sample		51246	100%	100%	0.62 (0.61-0.63)	4.1% (3.9–4.2)	14.1 (14.1-14.1)	7.8% (7.6–8.0)
Age	Sex							
<20	Male	59	0.1%	0.2%	1.54 (0.99-2.10)	13.6% (4.6–22.6)	19.9 (17.4-22.4)	15.3% (5.8–24.7)
	Female	172	0.3%	0.2%	0.97 (0.73-1.20)	6.4% (2.7–10.1)	21.3 (19.7-22.9)	25.0% (18.5–31.5)
20-29	Male	818	1.6%	4.0%	1.85 (1.69-2.01)	16.5% (14.0–19.1)	19.9 (19.2-20.7)	19.4% (16.7–22.2)
	Female	3,129	6.1%	3.7%	1.04 (0.97-1.10)	6.6% (5.7–7.5)	19.1 (18.8-19.5)	16.0% (14.7–17.3)
30-39	Male	2,762	5.4%	9.4%	1.37 (1.29-1.44)	10.3% (9.2–11.5)	17.5 (17.1-17.9)	13.9% (12.6–15.2)
	Female	6,657	13.0%	9.0%	0.75 (0.72-0.79)	4.3% (3.8–4.8)	17.6 (17.4-17.9)	12.3% (11.5–13.1)
40-49	Male	7,211	14.1%	14.5%	0.80 (0.76-0.84)	6.2% (5.7–6.8)	14.8 (14.6-15.0)	8.8% (8.1–9.4)
	Female	7,472	14.6%	14.2%	0.53 (0.50-0.56)	2.9% (2.5–3.2)	14.7 (14.5-14.9)	7.5% (6.9–8.1)
50-59	Male	8,957	17.5%	14.3%	0.41 (0.39-0.44)	3.0% (2.6–3.3)	12.1 (11.9-12.3)	5.2% (4.7–5.6)
	Female	5,662	11.0%	14.2%	0.39 (0.37-0.42)	1.9% (1.5–2.2)	12.2 (12.0-12.5)	4.2% (3.7–4.7)
60-69	Male	5,519	10.8%	7.6%	0.26 (0.23-0.28)	1.4% (1.1–1.8)	10.0 (9.8-10.3)	2.3% (1.9–2.7)
	Female	2,470	4.8%	8.0%	0.26 (0.22-0.29)	1.3% (0.8–1.7)	9.9 (9.6-10.2)	2.7% (2.0–3.3)
70>	Male	254	0.5%	0.3%	0.24 (0.12-0.36)	2.0% (0.2–3.7)	9.2 (8.2-10.2)	3.1% (1.0–5.3)
	Female	104	0.2%	0.4%	0.38 (0.14-0.61)	1.9% (−0.8-4.6)	9.0 (7.4-10.6)	1.9% (0–4.6)

	Sample size	Unweighted profile	Mean IGDS score (95% CI)	Proportion with probable IGD (95% CI)	Mean CIUS score (95% CI)	Proportion with probable PIU (95% CI)
Employment status	51246					
Employee	25041	49%	0.67 (0.65-0.69)	4.8% (4.5–5.0)	14.4 (14.2-14.5)	8.0% (7.6–8.3)
Executive	1095	2%	0.45 (0.38-0.53)	2.7% (1.8–3.7)	11.1 (10.6-11.7)	3.9% (2.8–5.1)
Self-employment/ Freelance	3594	7%	0.53 (0.49-0.58)	3.8% (3.2–4.4)	12.5 (12.2-12.8)	5.9% (5.2–6.7)
Homemaker	7731	15%	0.54 (0.51-0.57)	3.0% (2.6–3.4)	14.4 (14.2-14.6)	7.8% (7.2–8.4)
Part-time job	8244	16%	0.58 (0.55-0.61)	3.3% (2.9–3.7)	14.1 (13.9-14.3)	7.0% (6.5–7.6)
Student	833	2%	1.26 (1.13-1.38)	8.0% (6.2–9.9)	21.2 (20.5-21.9)	23.5% (20.6–26.4)
Other	1510	3%	0.62 (0.55-0.70)	4.0% (3.0–5.0)	14.1 (13.6-14.6)	9.1% (7.7–10.6)
No employee	3198	6%	0.50 (0.46-0.54)	2.8% (2.3–3.4)	12.8 (12.5-13.2)	7.5% (6.6–8.5)
Existence of child(ren)						
No children	21508	42%	0.71 (0.69-0.73)	4.5% (4.2–4.8)	15.4 (15.2-15.5)	9.9% (9.5–10.3)
Have child(ren)	29738		0.55 (0.54-0.57)	3.8% (3.5–4.0)	13.2 (13.1-13.4)	6.3% (6.1–6.6)
Marital status						
Not married	17664	34%	0.72 (0.69-0.74)	4.5% (4.2–4.8)	15.5 (15.4-15.7)	10.3% (9.9–10.8)
Married	33582	66%	0.57 (0.55-0.58)	3.8% (3.6–4.0)	13.4 (13.3-13.5)	6.5% (6.2–6.8)
Household income, $						
~39999	11962	23%	0.65 (0.62-0.68)	4.1% (3.8–4.5)	14.3 (14.1-14.5)	8.5% (8.0–9.0)
40000–80000	17872	35%	0.61 (0.59-0.63)	4.0% (3.8–4.3)	14.2 (14.0-14.3)	7.7% (7.3–8.1)
80000–120000	4687	9%	0.62 (0.58-0.67)	4.9% (4.3–5.5)	13.6 (13.3-13.9)	7.0% (6.3–7.8)
~120000	4508	9%	0.63 (0.58-0.68)	4.7% (4.1–5.3)	13.2 (12.9-13.5)	6.8% (6.1–7.5)
Missing	12217	24%	0.59 (0.57-0.62)	3.5% (3.1–3.8)	14.4 (14.2-14.6)	8.1% (7.6–8.6)
Living with someone or alone						
Living with someone	43249	84%	0.61 (0.60-0.62)	4.0% (3.8–4.2)	14.1 (14.0-14.2)	7.5% (7.3–7.8)
Alone	7997	16%	0.66 (0.62-0.69)	4.3% (3.9–4.8)	14.6 (14.3-14.8)	9.4% (8.7–10.0)
The status of COVID-19 infection						
Thinking negative themselves	44360	87%	0.56 (0.54-0.57)	3.4% (3.2–3.5)	14.1 (14.0-14.2)	7.6% (7.3–7.8)
Received a diagnosis	270	1%	3.38 (3.03-3.73)	39.3% (33.4–45.1)	20.6 (19.4-21.8)	19.6% (14.9–24.4)
Thinking positive themselves	1136	2%	1.41 (1.28-1.54)	12.5% (10.6–14.4)	18.7 (18.0-19.3)	15.6% (13.5–17.7)
Missing	5480	11%	0.81 (0.77-0.86)	6.1% (5.5–6.8)	13.41(13.1-13.7)	7.8% (7.1–8.5)

($\chi^2 = 70.9$, $p < .001$, $\phi = 0.13$) and PIU prevalence increased 1.6 times ($\chi^2 = 77.9$, $p = .001$, $\phi = 0.14$). To determine the effects of drop-out and exclusion, we respectively analyzed demographic differences between the study population and the drop out/excluded population. Although there were significant differences in demographics of study population with drop-out and excluded populations, the effects sizes were small overall (Supplementary Table 3).

3.2. Changes in each IGD item between before and during the pandemic

All IGD symptoms increased significantly during the pandemic with medium or large effect sizes (Fig. 2, also see Supplementary Table 4 for the detailed statistics). Percentages of respondents reporting each IGD symptom in the population who developed probable IGD at T2 are shown in the Supplementary Fig. 1.

3.3. Multiple logistic regression analyses

Multiple logistic regression analyses were used to examine the effects of demographic factors on development of probable IGD and PIU (Table 2). The odds ratio (OR) for probable IGD development in males was 2.21 (95%CI [1.42 to 3.42]), whereas the OR among young people (<30) relative to people 40–49 years was 2.10 (95%CI [1.18 to 3.75]). The OR in those who decreased face-to-face communication-time with

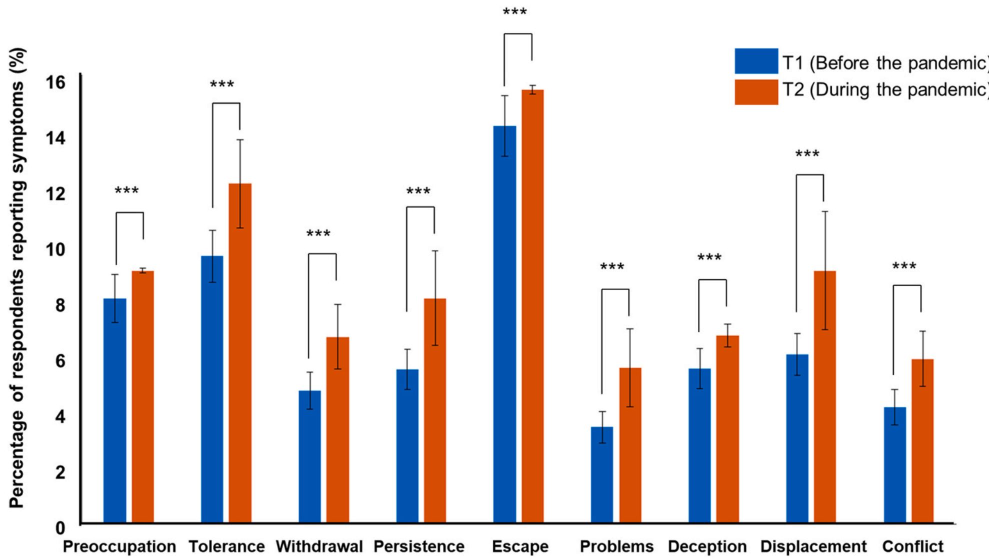

Fig. 2. Comparison of percentage of respondents reporting symptoms before and during the pandemic in the study population. These 9 symptoms are defined in DSM-5 (American Psychiatric Association, 2013). ***$p \leq .001$.

family was 1.71 (95%CI [1.15 to 2.53]) relative to those who reported no change in communication time. Also, the OR among those who decreased online communication time with family was 1.52 (95%CI [1.04 to 2.24]). The OR of those suffering COVID-19 infections was 5.67 (95%CI [1.33 to 24.16]) relative to those without COVID-19 infections.

The OR of people 30–39 years for probable PIU development relative to those aged between 40 and 49 was 1.50 (95%CI [1.09 to 2.07]). That of people who increased face-to-face-communication time with their families relative to those who reported no change was 1.38 (95%CI [1.03 to 1.84]). In regard to smartphone use, the OR of people who reported increases in their weekday smartphone use relative to that of those who reported no change was 1.46 (95%CI [1.05 to 2.02]). The OR of people who reported increased weekend smartphone use was 1.51 (95%CI [1.07 to 2.12]) while that of people who reported a decrease was 1.49 (95%CI [1.00 to 2.21]).

Adding changes in depression and anxiety to the logistic regression analyses above as dependent variables did not compromise the result, which indicates that results were not driven by confounding effects of depression or anxiety (Supplementary Table 5). In the multiple logistic regression analysis predicting probable IGD at T1, factors related to probable IGD and probable PIU are shown in Supplementary Table 6. The results showed that being male and young are significant risk factors for probable IGD, but not for probable PIU. Communication time with family and time spent using smartphones have significant impacts on probable IGD and PIU at T1. Results of multiple regression analysis predicting severities of IGD and PIU at T2 are shown in Supplementary Table 7. Time spent on using smartphones is associated with PIU severity changes.

4. Discussion

This is the first online survey to assess changes in prevalence of probable Internet gaming disorder (IGD) and problematic internet use (PIU) during the COVID-19 pandemic in Japan. Probable IGD prevalence in the survey population (N = 51,246) was 4.1% during the pandemic. Analyses revealed that probable IGD prevalence increased more than 1.6 times (from 3.7% to 5.9%) during the pandemic. Probable IGD prevalence during the pandemic was higher than reported (1–2.5% (Pontes et al., 2016; Przybylski et al., 2017; Wu et al., 2018)) before the pandemic. Probable PIU prevalence was 7.8% during the pandemic in the survey population (N = 51,246) (Fig. 1). Analyses of the study population (N = 3,938) revealed that probable PIU prevalence increased more than 1.5 times (from 7.9% to 11.6%) during the pandemic. Probable PIU prevalence was also higher than reported in studies before the pandemic (3.2–3.7% (Kuss et al., 2013a, 2013b)). Prevalence of probable IGD among younger people (<30 years old) was 8.6% in the survey population, higher than reported in studies among children and adolescents (1.2–7.5% (Jeong et al., 2021; Rehbein et al., 2015; Taechoyotin et al., 2020; Wartberg et al., 2020) before the pandemic. It increased more than 1.8 times (from 7.7% to 13.8%) during the pandemic.

All symptoms of IGD increased during the pandemic. Importantly, we observed changes with medium effect sizes in tolerance and withdrawal (Rehbein et al., 2015; King et al., 2018), the core symptoms of which are strongly relevant to IGD diagnosis and related to abstinence failure for game dependence. Thus, the greater number of individuals with IGD is likely not just a transitory problem during the COVID-19 pandemic.

We also found that younger people (<30) were at 2.1 times greater risk of IGD than more mature persons (40–49 years). This suggests that young people are more vulnerable to internet-gaming-related problems. Decreased face-to-face and online communication time with family members were also associated with a higher risk of exacerbated IGD during the pandemic, relative to persons whose screen time did not change (1.71 times and 1.52 times, respectively). These findings may suggest that loneliness or boredom due to decreasing time with family drove people to play games and become addicted. Additionally, we found that individuals infected with COVID-19 were at 5.67 times greater risk of progression in IGD than uninfected individuals. This suggests that stress and lifestyle changes caused by COVID-19 infection exacerbate IGD remarkably. Infected individuals reported an increase in IGD, possibly because they used the internet or games to avoid or to cope with stress associated with the infection (Fazeli et al., 2020; Lee et al., 2017). These results were not driven by confounding effects of depression or anxiety. We further found that identified risk factors differed from those for IGD and PIU at T1. Age had only a limited effect on probable PIU at T1, but it had a strong effect on development of probable PIU from T1 to T2. Conversely, communication and time spent on using smartphones had a strong effect on probable IGD and PIU at T1, but they had only a limited effect on development of probable IGD and PIU from T1 to T2. These results suggest that age influences PIU through an interaction with stress, while communication and using smartphones have a weaker interaction with stress. Therefore, it is important to focus on communication and using smartphones in low-stress standard

Table 2
Results of logistic regression analysis predicting exacerbation of probable IGD and PIU (probable IGD development, N = 3793; probable PIU development, N = 3626).

Resource	Probable IGD by Resources			Probable PIU by Resources		
	Sample size	OR (95% CI)	p value	Sample size	OR (95% CI)	p value
Sex						
Female	1,811	1 [Reference]	NA	1,702	1 [Reference]	NA
Male	1,982	2.21 (1.42-3.42)	<.001	1,924	1.38 (1.01-1.89)	.043
Marital status						
Not married	1,336	1 [Reference]	NA	1,258	1 [Reference]	NA
Married	2,457	1.68 (1.00-2.84)	.051	2,368	0.83 (0.56-1.22)	.338
The existence of children						
No children	1,551	1 [Reference]	NA	1,464	1 [Reference]	NA
Have child(ren)	2,242	0.65 (0.42-1.00)	.051	2,162	1.22 (0.87-1.71)	.256
Living with someone or alone						
Living with someone	3,166	1 [Reference]	NA	3,030	1 [Reference]	NA
Alone	627	0.92 (0.52-1.60)	.757	596	1.12 (0.75-1.68)	.581
Age groups						
20-29	287	2.10 (1.18-3.75)	.012	279	1.25 (0.77-2.03)	.365
30-39	725	1.34 (0.86-2.09)	.189	690	1.50 (1.09-2.07)	.014
40-49	1,095	1 [Reference]	NA	1,053	NA	NA
50-59	1,091	0.55 (0.34-0.89)	.015	1,035	0.68 (0.49-0.96)	.029
60-	595	0.32 (0.15-0.69)	.004	569	0.36 (0.21-0.61)	<.001
Household income ($)						
~39999	942	1 [Reference]	NA	877	1 [Reference]	NA
40000~80000	1,482	1.20 (0.75-1.94)	.446	1,422	1.04 (0.73-1.48)	.828
80000~120000	341	1.26 (0.65-2.44)	.495	332	1.18 (0.72-1.95)	.513
Missing	310	1.11 (0.55-2.26)	.766	304	1.67 (1.03-2.70)	.037
~120000	718	0.83 (0.47-1.47)	.525	691	0.98 (0.66-1.46)	.929
Employment status						
Employee	1,928	1 [Reference]	NA	1,855	1 [Reference]	NA
Executive	71	0.31 (0.04-2.30)	.250	69	0.40 (0.10-1.69)	.214
Self-employment/Freelance	272	0.64 (0.29-1.43)	.281	271	0.97 (0.57-1.64)	.908
Homemaker	593	0.66 (0.31-1.38)	.271	551	1.34 (0.86-2.10)	.194
Part-time job	576	1.05 (0.59-1.88)	.858	552	1.08 (0.72-1.64)	.706
Student	37	1.65 (0.54-5.02)	.375	36	0.71 (0.20-2.54)	.603
Other	94	1.19 (0.41-3.45)	.754	89	2.38 (1.25-4.52)	.008
No employee	222	1.02 (0.41-2.56)	.968	203	1.17 (0.61-2.26)	.635
The status of COVID-19 infection						
Thinking negative themselves	3,528	1 [Reference]	NA	3,371	1 [Reference]	NA
Received a diagnosis	13	5.67 (1.33-24.16)	.019	15	2.94 (0.79-10.95)	.108
Thinking positive themselves	80	3.95 (1.98-7.89)	<.001	74	1.69 (0.82-3.49)	.155
Missing	172	2.38 (1.32-4.28)	.004	166	2.62 (1.69-4.06)	<.001
Face communication time changes (T2-T1)						
No change	2,051	1 [Reference]	NA	1,957	1 [Reference]	NA
Increased	899	1.26 (0.83-1.93)	.281	875	1.38 (1.03-1.84)	.032
Decreased	843	1.71 (1.15-2.53)	.008	794	1.03 (0.75-1.43)	.842
Online communication time changes (T2-T1)						
No change	2,186	1 [Reference]	NA	2,080	1 [Reference]	NA
Increased	677	1.39 (0.89-2.16)	.144	660	1.30 (0.95-1.78)	.102
Decreased	930	1.52 (1.04-2.24)	.033	886	1.05 (0.77-1.43)	.742
Time difference spent using smartphones on weekdays (T2-T1)						
No change	1,754	1 [Reference]	NA	1,698	1 [Reference]	NA
Increased	1194	1.14 (0.73-1.76)	.567	1141	1.46 (1.05-2.02)	.024
Decreased	845	1.06 (0.64-1.76)	.806	787	0.96 (0.64-1.42)	.822
Time difference spent using smartphones on weekends (T2-T1)						
No change	1,526	1 [Reference]	NA	1,473	1 [Reference]	NA
Increased	1,388	1.30 (0.83-2.03)	.252	1,317	1.51 (1.07-2.12)	.018
Decreased	879	1.32 (0.79-2.20)	.292	836	1.49 (1.00-2.21)	.049

situations (before or after the pandemic), whereas it is important to understand that certain age groups are at risk in high-stress situations (during the pandemic). Timely and specific countermeasures against stress may benefit such risk populations. These may include remote consultation or psychotherapies.

Increased smartphone use both on weekdays and weekends was associated with a greater risk of PIU development (weekdays: 1.46 times, weekends 1.51 times). These results were consistent with multiple regressions predicting changes in PIU severity. Data from the Japanese Ministry of Internal Affairs and Communications shows increases in smartphone use on weekdays and weekends under states of emergency (Ministry of Internal Affairs and Communications, Japan, 2020). A previous study showed increases in smartphone use due to the pandemic (Chen et al., 2021). Our results may reflect forgoing non-essential and non-urgent activities due to the pandemic. On the other hand, those who decreased their smartphone use time on weekends still showed 1.49 times more PIU. This may reflect a shift from smartphone use away from home to use of personal computers or tablet computers at home. Therefore, simply monitoring smartphone use is not sufficient for early detection of PIU. Instead, we need to monitor screen time regardless of the device. People who increased face-to-face communication time with family were still at 1.38 times higher risk of PIU development relative to people with no change. This result is inconsistent with a previous study that reported face-to-face communication may protect against internet-related behavior problems (Kim et al., 2015). Further studies are required to further illuminate the underlying basis for this inconsistency, such as differences in culture or momentum of the pandemic.

As shown above, most of the risks are common to both IGD and PIU, but some factors seem to have different effects on those risks. For example, a decrease in face-to-face communication time with family was a significant risk factor of IGD. In contrast, an increase in face-to-face communication time with family was a significant risk factor for PIU. Thus, approaches for early detection and prevention of internet-related problems may differ in each group. This should be examined in future research.

There are several limitations to this study. First, this is a survey using an online recruiting method, and there may be some sampling bias. The study population (N = 3,938) was extracted from the survey population (N = 51,246) such that the study population included equal numbers of individuals in each quintile relative to the problematic smartphone use score. However, Pearson correlations of the prevalence of probable IGD and probable PIU in each age and sex group between the survey population and the study population were significant ($r = 0.94$, $p < .001$, $r = 0.90$, $p < .001$). This shows the reliability of probable IGD and probable PIU as ratio scales, even if the raw value was overestimated. There are significant differences in demographics, between the survey and drop-out/excluded populations. However, it is reported that attrition effects can be ignored when the attrition rate is less than 40% (Hansten et al., 2000). Since our sample fulfills this condition (Supplementary Table 8), we considered that effects of drop-out can be ignored in our analyses. Second, this survey was taken in Japan. Instead of locking down the city, the Japanese government declared a state of emergency to control the spread of the COVID-19 pandemic. People were encouraged, but not forced to stay home. Therefore, it is unclear whether the results of this Japanese study apply equally to other countries, especially those that locked down to control the pandemic. It is important to compare these results with data from other countries having different ethnicities and government strategies. Despite these limitations, this study shows increasing IGD and PIU and identifies at-risk populations for internet-related problems.

5. Conclusion

In summary, IGD and PIU increased in prevalence 1.6 and 1.5 times during the COVID-19 pandemic, respectively. Young people and those infected with COVID-19 are at greater risk for IGD. The pandemic has seriously changed people's lives, and some of the changes induce problematic internet-related behaviors. It is essential to mitigate pandemic impacts to promote healthier societies.

Declaration of competing interest

This study was funded by KDDI Corporation. There are no other disclosures to report.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2021.07.054.

Ethics

Prospective participants received information by Email about informed consent. Completion of the questionnaire was considered to indicate a participant's consent. This study is a part of a larger study on problematic smartphone use, which was approved by the Ethics Committee of the Advanced Telecommunications Research Institute International (Japan).

Data availability

Statistical data that support findings of this study are available in Supplementary Data. Owing to company cohort data sharing restrictions, individual-level data cannot be publicly posted. Data are, however, available from the authors upon reasonable request and with permission of KDDI Corporation.

Author contributions

TO, TH and TC made substantial contributions to the study conception and design. TO, TH, NK, YM, MH, and TC contributed significantly to data acquisition. TO, NK, TK, and TC conducted statistical analyses. TO, MK, and TC made substantial contributions to interpretation of data. TO drafted the first version of the manuscript. All authors contributed to critical revisions and approved the final version of the manuscript. TC assumes responsibility for the integrity of the work.

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