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FULL-LENGTH REPORT



Problematic internet-related behaviors mediate the associations between levels of internet engagement and distress among schoolchildren during COVID-19 lockdown: A longitudinal structural equation modeling study

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ABSTRACT

Background and aims: Due to the rapid spread of the novel coronavirus disease 2019 (COVID-19), policies based on the nature of “spatial distancing” have been implemented and have resulted in school suspensions and online learning among schoolchildren. In order to examine the impact of such policies on schoolchildren, the aims of the present study were to (i) assess changes in the level of engagement in three internet-related activities (smartphone use, social media use, and gaming) before and during the COVID-19 outbreak, including prolonged and problematic engagement in these activities; (ii) investigate the differences of psychological distress before and after COVID-19 outbreak; and (iii) to use structural equation modeling to investigate the mediating roles of problematic internet-related behaviors in the causal relationships of psychological distress and time spent on internet-related activities. **Methods:** Self-report measures were used to assess internet-related activities and psychological distress. Time spent on internet-related activities, problematic use of internet-related activities, and psychological distress were collected from primary school students ($N = 535$; 265 boys; M age = 10.32 years [$SD = 0.84$]). The data were first collected before the COVID-19 outbreak (i.e., early November 2019) and then collected again during the school suspension due to COVID-19 outbreak (i.e., end of March 2020) for comparisons of changes. **Results:** Schoolchildren spent significantly more time on the smartphone (increased 1.02 h daily; $P < 0.001$) and social media (increased 0.73 h daily; $P < 0.001$) but not gaming (increased 0.14 h daily; $P = 0.07$) during the school suspension compared to the baseline. Schoolchildren who increased by 15 or 30 min daily on internet-related activities showed an increased level of psychological distress. The association between problematic use of social media and psychological distress was stronger during the school suspension ($\beta = 0.584$) than at the baseline ($\beta = 0.451$; $P < 0.001$). **Conclusion:** Increased problematic use of internet-related activities among schoolchildren was associated with greater psychological distress. Parents should therefore monitor internet-related activities and psychological distress of their children to support their mental health.

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KEYWORDS

child, COVID-19, problematic internet use, psychological distress, school suspension

INTRODUCTION

With the rapid spread of the novel coronavirus disease 2019 (COVID-19) worldwide (World Health Organization, 2020a), many governments have implemented policies, such as travel and border controls, self-quarantine, requirement of citizens to stay at home, spatial distancing, personal protective equipment coordination, face mask wearing, and discouragement of outdoor activities (Alvarez, 2020; Lin & Cheng, 2020; Rieger, 2020; Shrivastava & Shrivastava, 2020) to control the transmission rate. These actions are based on the perspective of public health and have been implemented to prevent individuals from being infected by COVID-19. These implemented policies emphasize the importance of “spatial distancing” to avoid the possibility of COVID-19 infection (Abel & McQueen, 2020). Without direct physical contact, the infection rate of COVID-19 is likely to reduce and minimize the threat of high mortality rate.

Although the spatial distancing policies may be effective for infection control, they may not resolve psychological consequences resulting from the COVID-19, such as fear (Ahorsu et al., 2020), insomnia (Xiao, Zhang, Kong, Li, & Yang, 2020), and anxiety (Nathiya et al., 2020; Wang et al., 2020). Therefore, healthcare providers and governments should not ignore individuals’ psychological health because fear may result in unintended negative consequences (Lin, 2020; Ren, Gao, & Chen, 2020). Spatial distancing policies restrict individuals from direct physical contacts, and such policies may lead to psychological distress among some individuals. Indeed, a recent position paper specifically recommended that research was needed to understand the effects of spatial distancing on individuals’ mental health (Holmes et al., 2020), especially for vulnerable populations such as schoolchildren. Therefore, governments need information regarding whether spatial distancing policies impact upon individuals’ psychological health, especially for schoolchildren who have undergone school suspensions during the COVID-19 pandemic. More specifically, children have been found to be experiencing some emotional problems (e.g., worry, anxiety, and fear) due to the feelings of isolation and low perceived social support (European Society for Child and Adolescent Psychiatry, 2020; World Health Organization, 2020b).

Mainland China was the first country to implement the policy of school suspension. During the school suspension period, Chinese schoolchildren have had to learn through online teaching instead of physical contact with their teachers or classmates. With online learning and prolonged home stay, primary schoolchildren in mainland China have been required to spend a substantial amount of time online because they are housebound with a good reason for

increased internet use. However, parents may not be fully aware of what internet activities their children are really engaged in. Therefore, schoolchildren may be engaged in increased non-educational internet use, which may result in problematic use and subsequently cause mental health problems (Alimoradi et al., 2019; Király et al., 2020; Wong et al., 2020).

The associations between psychological distress and amount of time spent on internet could be bidirectional. More specifically, a recent longitudinal study found that university students who had higher levels of problematic smartphone/internet use experienced more psychological distress in the follow-up (Chen et al., 2020b). In another longitudinal study, Yu and Shek (2018) also reported similar findings that internet addiction among Hong Kong adolescents at Wave 1 predicted their life satisfaction and hopelessness at Wave 2. Individuals with a high level of problematic use of internet-related activities may have impaired offline social relationship which consequently influences their psychological wellbeing (Kraut et al., 1998; Yu & Shek, 2018). In other words, the preoccupation with online activities could prevent an individual from normal socializing behaviors and cause psychological distress.

However, some primary schoolchildren may be at risk of problematic use of internet-related activities or be addicted to internet-related activities because they may experience the fear of missing out from their circle of friends during the period without physical contact (Elhai, Dvorak, Levine, & Hall, 2017; Wegmann, Oberst, Stodt, & Brand, 2017; Wong et al., 2020). Thus, according to the Interaction of Person-Affect-Cognition-Execution (I-PACE) model (Brand et al., 2019; Young & Brand, 2017), past psychological distress may induce problematic use of internet-related activities and subsequently result in increased screen time use. Elhai, Yang, McKay, and Asmundson (2020) recently found that COVID-19 anxiety was positively associated with problematic smartphone use although the association became nonsignificant when controlling for general anxiety and depression. However, little is known regarding the engagement of specific types of internet-related activities (i.e., online gaming and social media use investigated in the present study) during the COVID-19 pandemic outbreak, especially for schoolchildren. Furthermore, it is unclear whether schoolchildren’s psychological distress has changed since the COVID-19 outbreak. Moreover, it is unknown whether the elevated psychological distress during the COVID-19 outbreak could lead to increased engagement of internet use via problematic internet use, as posited by the I-PACE model.

Consequently, the present study had three aims. First, to investigate the changes in time spent on use of internet-related activities, changes in problematic use of internet-related activities, and changes in psychological distress before and during the school suspension period due to the COVID-19 outbreak. Second, to investigate the differences of psychological distress in three groups of schoolchildren differentiated by the time spent on internet-activities using two cutoffs (15 and 30 min) utilizing a dimensional approach. Third, to construct several models to investigate



the associations between time spent on internet-related activities, problematic use of internet-related activities, and psychological distress. More specifically, two directions were applied to examine the associations: (i) time spent on internet-related activities leading to psychological distress via problematic use of internet-related activities at two time points; before the COVID-19 outbreak and during the school suspension period due to the COVID-19 outbreak; (ii) psychological distress leading to time spent on internet-related activities via problematic use of internet-related activities during the school suspension period.

METHODS

Participants, procedure, and important timeline during the COVID-19 outbreak

The study used data from two waves (i.e., baseline [Time 1] and five-month after baseline [Time 2]) from an ongoing longitudinal project. Data from the first wave (Time 1) in the longitudinal project were collected from end of October to early November 2019. After collecting the Time 1 data, Chinese primary school students completed their Autumn semester in mid-January 2020 and the COVID-19 outbreak occurred around February 2020. Therefore, the present study's participants were housebound from February 2020 and later received online teaching in March 2020 due to the educational policy implemented by the Education Bureau in the Sichuan Province. Data from the second wave (Time 2) in the longitudinal project were collected during a two-week period in March 2020, while the present study's participants were still suspended from school. The longitudinal project examines schoolchildren's engagement in internet-related activities (gaming, social media, and smartphone applications) and whether their problematic use of these activities is associated with psychological distress. Through convenience sampling (i.e., three primary schools were collaborators of the present authors and the schools assisted in selecting several classes in their school to participate in the study), 550 schoolchildren were approached and all participated in the survey at Time 1. They were then approached again for the survey at Time 2 and 543 completed the survey (response rate at 98.7%).

Several teachers of three primary schools in Sichuan province helped in the data collection, including baseline and follow-up assessments. In the baseline assessment (Time 1), teachers first distributed the study information to schoolchildren and their parents. Through the written informed consent signed by the children and one of the parents, the willingness to participate in the longitudinal study was provided. Following this, the teachers distributed several questionnaires, including psychometric scales and a background information sheet, to the eligible students and supervised them to complete in the classroom. At follow-up assessment (Time 2), the research team generated an online survey that contained the same questions as those at Time 1. The schoolteachers then distributed the hyperlink of the

online survey to those who participated in the baseline assessment. Eligible schoolchildren were third to sixth graders who fulfilled two inclusion criteria: (i) having sufficient cognition to understand the meaning of written Chinese to complete the questions without difficulty; (ii) having at least one smartphone with internet access during the study period. The cognition was assessed by experienced schoolteachers based on their interactions with students.

Measures

Background information. Participants' demographics and characteristics were collected including their age (students reported their birthdays and then the age was calculated), grade (third, fourth, fifth, or sixth grade), ethnicity (Han or other), gender (male or female), health condition (currently sick or currently healthy), self-reported perceived academic performance (below the average in class, around average in class, or above average in class), and time spent on gaming, social media use and smartphone (number of h/min daily using an open-ended question).

Smartphone Application-Based Addiction Scale (SABAS). Using six items that correspond to the criteria of the addiction components model (i.e., salience, mood modification, tolerance, withdrawal conflict and relapse) proposed by Griffiths (2000, 2005), the SABAS assesses problematic smartphone-application use. All SABAS items are rated on a six-point Likert scale, and a higher SABAS score indicates a higher level of problematic smartphone-application use. The robust psychometric properties of the SABAS have been demonstrated in prior studies across different language versions (Altundağ, Yandi, & Ünal, 2019; Csibi, Demetrovics, & Szabo, 2016; Csibi, Griffiths, Cook, Demetrovics, & Szabo, 2018; Gökler & Bulut, 2019; Lin, Imani et al., 2019; Sojević, Pećanac, & Latas, 2018; Soraci, Ferrari, Urso, & Griffiths, 2020; Yam et al., 2019), including the Chinese SABAS on schoolchildren (Chen, Ahorsu, Pakpour, Griffiths, & Lin, 2020). The internal consistency of the Chinese SABAS in the present study was very good (Time 1 $\alpha = 0.81$; Time 2 $\alpha = 0.87$).

Bergen Social Media Addiction Scale (BSMAS). Again using six items that correspond to the criteria in addiction components model (i.e., salience, mood modification, tolerance, withdrawal conflict and relapse) proposed by Griffiths (2000, 2005), the BSMAS assesses problematic social media use. All BSMAS items are rated on a five-point Likert scale, and a higher BSMAS score indicates a higher level of problematic social media use. The robust psychometric properties of the BSMAS have been demonstrated in prior studies across different language versions (Andreassen et al., 2016; Bányai et al., 2017; Chen et al., 2020c; Leung et al., 2020; Lin, Broström, Nilsen, Griffiths, & Pakpour, 2017; Monacis, de Palo, Griffiths, & Sinatra, 2017; Yam et al., 2019), including the Chinese BSMAS on schoolchildren (Chen et al., 2020b). The internal consistency of the Chinese BSMAS in the present study was good to very good (Time 1 $\alpha = 0.71$; Time 2 $\alpha = 0.89$).



Internet Gaming Disorder Scale-Short Form (IGDS-SF9). Using nine items that correspond to the internet gaming disorder [IGD] criteria defined in the DSM-5 (American Psychiatric Association, 2013), the IGDS-SF9 assesses problematic gaming use. All IGDS-SF9 items are rated on a five-point Likert scale, and a higher IGDS-SF9 score indicates a higher level of problematic gaming use. The robust psychometric properties of the IGDS-SF9 have been demonstrated in prior studies across different language versions (Arıcak, Dinç, Yay, & Griffiths, 2019; Beranuy et al., 2020; Evren et al., 2018; Monacis, de Palo, Griffiths, & Sinatra, 2016; Pontes, Macur, & Griffiths, 2016; Pontes & Griffiths, 2015; Pontes, Stavropoulos, & Griffiths, 2017; T'ng & Pau, 2020; Wu et al., 2017; Yam et al., 2019), including the Chinese IGDS-SF9 on schoolchildren (Chen et al., 2020b). Moreover, a recent review concluded that IGDS-SF9 is one of the best measures for assessing gaming disorder (King et al., 2020). The internal consistency of the Chinese IGDS-SF9 in the present study was very good to excellent (Time 1 $\alpha = 0.84$; Time 2 $\alpha = 0.92$).

Depression, Anxiety, Stress Scale-21 (DASS-21). Using 21 items embedded within three subscales of depression (seven items), anxiety (seven items), and stress (seven items), the DASS-21 assesses psychological distress. All DASS-21 items are rated on a four-point Likert scale, and a higher DASS-21 score indicates a higher level of psychological distress. The robust psychometric properties of the DASS-21 have been demonstrated in prior studies across different language versions (Shaw, Campbell, Runions, & Zubrick, 2017; Wang et al., 2016). The present study used the entire DASS-21 score rather than its three subscales to assess psychological distress and the internal consistency of the Chinese DASS-21 in the present study was excellent (Time 1 $\alpha = 0.91$; Time 2 $\alpha = 0.92$).

Data analysis

As it is questionable that schoolchildren would be reporting an extremely high number of hours of daily internet use, those who reported a use of 20 h or above daily use were removed from all data analyses ($n = 8$). Therefore, 535 participants' data were retained for analyses. No significant differences were found in demographic information ($P = 0.16$ for gender; $P = 0.55$ for age; $P = 0.36$ for Time 1 health condition; $P = 0.71$ for Time 2 health condition; $P = 0.53$ for Time 1 perceived academic performance; and $P = 0.93$ for Time 2 perceived academic performance) between analyzed and unanalyzed participants (including those who did not participate in Time 2 survey and those who reported questionable daily internet use). Participants' characteristics and scores on the respective measures were analyzed using descriptive statistics, including means (and SDs) and frequencies (and percentages). To examine the first study aim, paired t -tests were applied to examine the differences of time spent on internet-related activities, problematic use of internet-related activities, and psychological distress before the COVID-19 outbreak and during the school suspension after the COVID-19 outbreak.

To examine the second study aim, participants were classified into three groups according to daily *changes* in the time spent on internet-related activities. Group 1 included schoolchildren who had increased daily time spent on internet-related activities by over 15 min; Group 2 included schoolchildren who had spent approximately the same daily time on internet-related activities within 15 min; Group 3 included schoolchildren who had decreased daily time spent on internet-related activities by over 15 min. The 15-min daily time difference was used because it indicated a statistically significant difference between baseline and follow-up assessments based on the present sample. More specifically, with the type I error at 0.05, power at 0.8, and sample size of 535 in the paired- t test, the required effect size to detect statistical significance should be 0.12. Using the baseline SDs observed in the present sample (SD = 1.69 h/day for smartphone use; 1.25 h/day for social media use; and 2.03 h/day for gaming) to multiply the required effect size (i.e., 0.12), the estimated significant differences were 0.20 h/day for smartphone use; 0.15 h/day for social media use; and 0.24 h/day for gaming. Therefore, the difference of 0.25 h/day (i.e., 15 min on daily basis) was selected as the period of time to highlight significant increases or decreases in time spent on internet-related activities.

However, in order to provide clinically relevant information, a dimensional approach was also adopted to understand the changes. Therefore, another cutoff at 30 min was used to regroup the participants. More specifically, (i) New Group 1 included schoolchildren who had increased daily time spent on internet-related activities by over 30 min; (ii) New Group 2 included schoolchildren who had spent approximately the same daily time on internet-related activities within 30 min; and (iii) New Group 3 included schoolchildren who had decreased daily time spent on internet-related activities by over 30 min. Analysis of variance with Bonferroni comparisons were used to examine the differences of *changes* in SABAS, BSMAS, IGDS-SF9, and DASS-21 scores between the three groups.

To examine the third study aim, Pearson correlation coefficients were firstly used to assess the relationships between the studied variables at Time 1 and Time 2, respectively. Afterward, three models (Fig. 1) were constructed and evaluated using the multi-group (i.e., Time 1 and Time 2) structural equation modeling (SEM) to examine the first part of the third study aim. More specifically, the three models shared the same outcome of psychological distress and independent variables of background information (age, gender, health condition, and self-reported perceived academic performance) but different independent variables of time spent on internet-related behaviors (time spent on smartphone, social media use, and gaming) and mediators (problematic smartphone-application use, problematic social media use, and problematic gaming). The controlled variables of background information were from their respective time points (i.e., Time 1 background information for Time 1 model; Time 2 background information for Time 2 model). The multi-group SEM was applied to examine the path coefficients at Time 1 and Time 2. Moreover, inferential



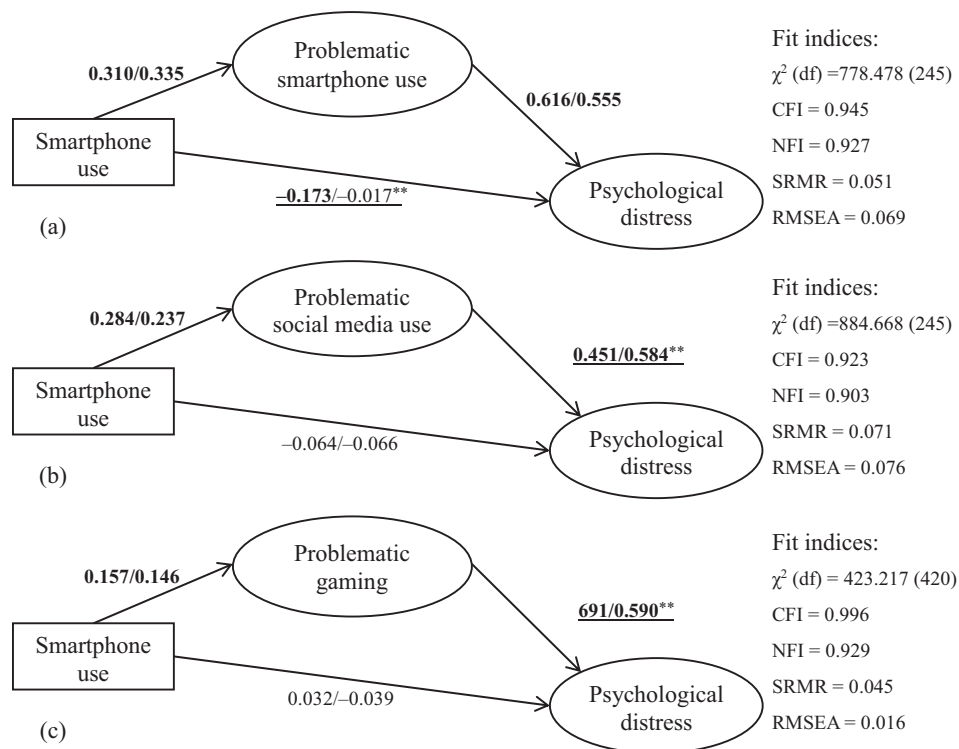


Fig. 1. Time spent on internet-related behavior (observed variables) impacted on psychological distress (latent construct) via problematic use of internet-related behavior (latent constructs) controlling for age, gender (Ref: boy), health condition (Ref: currently healthy), self-reported perceived academic performance, and psychological distress. (a) Time spent on smartphone use and problematic smartphone-application use; (b) Time spent on social media use and problematic social media use; (c) Time spent gaming and problematic gaming use. Problematic smartphone use assessed using Smartphone Application-Based Addiction Scale; Problematic social media use assessed using Bergen Social Media Addiction Scale; Problematic gaming assessed using Internet Gaming Disorder Scale-Short Form; Psychological distress assessed using Depression, Anxiety, Stress Scale-21. CFI = comparative fit index; NFI = Normed fit index; SRMR = standardized root mean square residual; RMSEA = root mean square error of approximation. Path coefficients were presented for Time 1 standardized coefficient/Time 2 standardized coefficient. Significant coefficients are presented using **bold fonts**. Significant differences between Time 1 and Time 2 standardized coefficients are presented using underlined

testing was used to assess whether the path coefficients were different between Time 1 and Time 2.

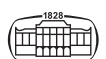
Then, another three models (Fig. 2) using Time 2 variables were constructed to examine the second part of the third study aim. More specifically, the three models shared the predictor of psychological distress and independent variables of background information (age, gender, health condition, and self-reported perceived academic performance) but different outcome variables of time spent on internet-related behaviors (time spent on smartphone, social media use, and gaming) and mediators (problematic smartphone-application use, problematic social media use, and problematic gaming). All the models used latent constructs for the problematic smartphone-application use, problematic social media use, problematic gaming, and psychological distress. Moreover, the sample size in the present study fulfilled the adequate sample size utilizing [N]-to-parameters [q] ratio for SEM; the N:q in the present study is 12.44:1, where 20:1 is ideal and 10:1 is adequate (Kline, 2015).

Fit indices of comparative fit index >0.9, Normed fit index >0.9, standardized root mean square residual <0.08,

and root mean square error of approximation <0.08 were used to understand whether the proposed models were supported (Chen et al., 2020c; Leung et al., 2020; Yam et al., 2019). In addition, χ^2 difference tests were used to examine whether full mediation or partial mediation supported each proposed model. More specifically, another set of models without a direct path between psychological distress and time spent on internet-related activities was constructed to compare with the proposed models. A significant χ^2 difference test indicates partial mediation; nonsignificant test indicates full mediation. LISREL 8.8 (Scientific Software International, Lincolnwood, IL, USA) and IBM SPSS Statistical version 24.0 (IBM Corp., Armonk, NY) were used for data analyses.

Ethics

The research proposal was approved by the Ethics Committee of the Hong Kong Polytechnic University's ethics committee (IRB ref: HSEARS20190718001) and the Institutional Review Board of the Jianxi Psychological Consultant Association (IRB ref: JXSL-2020-J013). Before data collection, all ethical considerations including description of



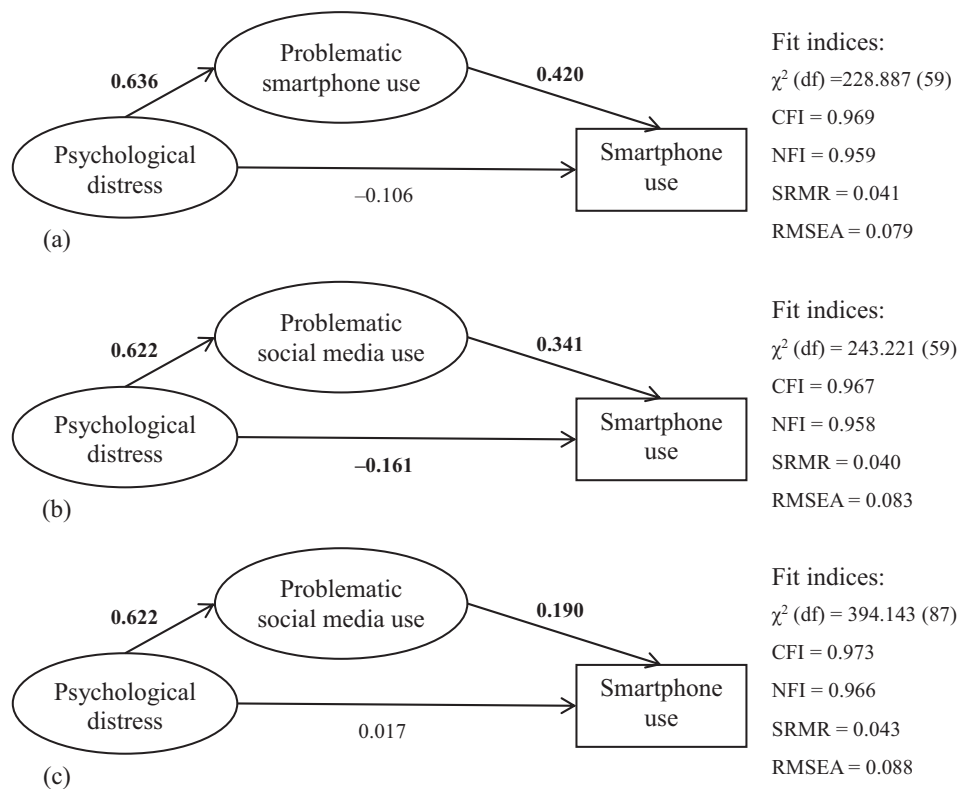


Fig. 2. Psychological distress (latent construct) impacted on time spent on internet-related behavior (observed variables) via problematic use of internet-related behavior (latent constructs), controlling for age, gender (Ref: boy), health condition (Ref: currently healthy), self-reported perceived academic performance, and psychological distress. (a) Time spent on smartphone use and problematic smartphone-application use; (b) Time spent on social media use and problematic social media use; (c) Time spent gaming and problematic gaming use. Problematic smartphone use assessed using Smartphone Application-Based Addiction Scale; Problematic social media use assessed using Bergen Social Media Addiction Scale; Problematic gaming assessed using Internet Gaming Disorder Scale-Short Form; Psychological distress assessed using Depression, Anxiety, Stress Scale-21. Path coefficients were presented for Time 2 standardized coefficient

the study, privacy and confidentiality of data, anonymity, and freedom of participation (or withdrawal) were fully explained. Additionally, all participants provided written informed consent.

RESULTS

The mean age of the schoolchildren was 10.32 years ($SD = 0.84$) at baseline ($N = 535$ with 265 [49.5%] boys). Moreover, their time spent on smartphones at Time 2 (mean = 1.81 h daily [$SD = 1.81$]) was significantly longer than their time spent on smartphones at Time 1 (mean = 0.79 h daily [$SD = 1.31$]; $P < 0.001$); time spent on social media at Time 2 (mean = 0.99 h daily [$SD = 1.58$]) was significantly longer than their time spent on social media at Time 1 (mean = 0.26 h daily [$SD = 0.68$]; $P < 0.001$); time spent on gaming at Time 2 (mean = 0.74 h daily [$SD = 1.27$]) was similar to their time spent on gaming at Time 1 (mean = 0.60 h daily [$SD = 1.23$]; $P = 0.07$). The distribution of the time spent on different internet-related activities is also illustrated in Fig. 3. Moreover, Appendix Figs 1–3 illustrate the daily time spent on different internet-related activities at Time 1 and Time 2 for three different groups: Group 1 (i.e., who

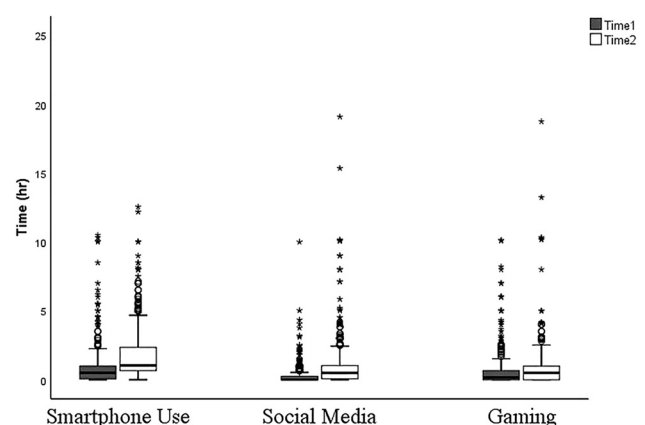


Fig. 3. Time spent engaging in internet-related activities in Time 1 (baseline assessment) and Time 2 (assessment during the COVID-19 outbreak)

increased daily time spent on internet-related activities), Group 2 (i.e., who spent approximately the same daily time on internet-related activities), and Group 3 (i.e., who decreased daily time spent on internet-related activities).

In relation to scores on the three internet-related psychometric scale scores, apart from problematic smartphone-

application use (mean = 1.81 [SD = 0.91] for Time 1 and mean = 1.86 [SD = 0.92] for Time 2; $P = 0.26$), the schoolchildren reported that they had higher levels of problematic social media use (mean = 1.57 [SD = 0.59]) and problematic gaming (mean = 1.42 [SD = 0.55]) at Time 1 as compared with those at Time 2 (mean = 1.41 [SD = 0.62] for problematic social media use, and mean = 1.32 [SD = 0.51] for problematic gaming; both $P < 0.001$). Results also showed that the schoolchildren had greater psychological distress at Time 2 (mean = 1.22 [SD = 0.30]) compared with that at Time 1 (mean = 0.46 [SD = 0.49]; $P < 0.001$) (Table 1).

After the participants were classified into three groups according to their difference of time spent on internet-related activities between Time 1 and Time 2, Group 1 (i.e., increased time spent on internet-related activities) had significantly greater levels of problematic internet-related behavior use and psychological distress than Group 3 (i.e., decreased time spent on internet-related activities) (Table 2). A similar trend was observed in the New Groups (i.e., grouping the schoolchildren using a 30-min cutoff). The relationships between studied variables at Time 1 and Time 2 respectively, were calculated using Pearson correlation coefficients (Table 3). In sum, all coefficients were significant.

All the SEM models had acceptable fit indices (Figs 1 and 2). Time spent on smartphones significantly explained problematic smartphone-application use ($\beta = 0.310$ at Time 1 and 0.335 at Time 2); problematic smartphone-application use subsequently explained psychological distress ($\beta = 0.616$ at Time 1 and 0.555 at Time 2). Similarly, time spent on social media significantly explained problematic social media use ($\beta = 0.284$ at Time 1 and 0.237 at Time 2); problematic social media use subsequently explained psychological distress ($\beta = 0.451$ at Time 1 and 0.584 at Time 2). Time spent gaming significantly explained problematic gaming ($\beta = 0.157$ at Time 1 and 0.146 at Time 2); problematic gaming subsequently explained psychological distress ($\beta = 0.691$ at Time 1 and 0.590 at Time 2). Moreover, the path coefficient between problematic social media

use and psychological distress at Time 1 ($\beta = 0.451$) was significantly less than that at Time 2 ($\beta = 0.584$; $t = 12.14$; $P < 0.001$); the path coefficient between problematic gaming and psychological distress at Time 1 ($\beta = 0.691$) was significantly greater than that at Time 2 ($\beta = 0.590$; $t = 7.27$; $P < 0.001$). Moreover, health condition was consistently associated with psychological distress because follow-up associations were significantly larger than baseline associations ($\beta = 0.006$ to 0.114 for baseline; $\beta = 0.233$ to 0.438 for follow-up; $t = 4.29$ to 13.48 ; $P < 0.001$).

In the SEM models, the findings concurred with the I-PACE model (Fig. 2) using Time 2 data. Psychological distress significantly explained problematic use of internet-related activities ($\beta = 0.622$ – 0.636) and problematic use of internet-related activities subsequently explained time spent on internet-related activities ($\beta = 0.190$ – 0.420). In addition, χ^2 difference tests showed full mediation in Fig. 1b ($\chi^2[2] = 1.16$; $P = 0.56$), 1c ($\chi^2[2] = 0.78$; $P = 0.68$), 2a ($\chi^2[1] = 1.48$; $P = 0.22$), 2b ($\chi^2[1] = 3.76$; $P = 0.053$), and 2c ($\chi^2[1] = 0.10$; $P = 0.75$); partial mediation for Fig. 1a ($\chi^2[2] = 6.82$; $P = 0.03$).

DISCUSSION

The present study's finding showed that primary schoolchildren in mainland China increased their time spent on smartphones and social media during the school suspension period. However, schoolchildren did not increase their time spent gaming. Therefore, the increased time spent on smartphones might possibly be due to the need to facilitate online learning and virtual social networking. Although the schoolchildren may use desktop computers for online learning, they may prefer using their smartphone because of the user-friendly features, including portability and accessibility with various learning apps (Uther & Ylinen, 2019). Apart from learning, schoolchildren may have the desire and craving to interact with their friends because social interaction is human nature (Ybarra et al., 2008). Moreover, the schoolchildren were unable have physical contact with

Table 1. Time spent engaging in internet-related behavior, problematic internet-related behavior use, and psychological distress between Time 1 (baseline assessment) and Time 2 (assessment during the COVID-19 outbreak; $N = 535$)

	Longitudinal data			
	Time 1 Mean (95% CI)	Time2 Mean (95% CI)	<i>t</i> -value	<i>P</i> -value
Smartphone use ^a	0.79 (0.68, 0.90)	1.81 (1.66, 1.97)	10.99	<0.001
Social media use ^a	0.26 (0.22, 0.32)	0.99 (0.83, 1.13)	9.65	<0.001
Gaming ^a	0.60 (0.49, 0.71)	0.74 (0.63, 0.85)	1.83	0.07
Problematic smartphone use	1.81 (1.72, 1.88)	1.86 (1.78, 1.94)	1.13	0.26
Problematic social media use	1.57 (1.52, 1.62)	1.41 (1.36, 1.46)	4.88	<0.001
Problematic gaming	1.42 (1.37, 1.47)	1.32 (1.28, 1.36)	3.73	<0.001
Psychological distress	0.46 (0.42, 0.50)	1.22 (1.19, 1.25)	32.32	<0.001

Problematic smartphone use assessed using Smartphone Application-Based Addiction Scale; Problematic social media use assessed using Bergen Social Media Addiction Scale; Problematic gaming assessed using Internet Gaming Disorder Scale-Short Form; Psychological distress assessed using Depression, Anxiety, Stress Scale-21.

^a Presented using daily hours spent on smartphones, social media use, and gaming.

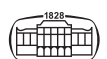


Table 2. Comparing problematic internet-related behaviors use and psychological distress among groups with increased, maintained, or decreased time spent on internet-related behaviors

	Group 1	Group 2	Group 3	F-value	Bonferroni comparison
Smartphone use time at 15-min difference	N = 359	N = 103	N = 73		
Problematic smartphone use ^a	0.23 (1.08)	-0.11 (0.85)	-0.60 (1.09)	20.61**	1 > 2 > 3
Problematic social media use ^a	-0.07 (0.78)	-0.25 (0.58)	-0.49 (0.79)	10.42**	1 > 3
Problematic gaming ^a	-0.02 (0.64)	-0.15 (0.43)	-0.46 (0.75)	15.21**	1 > 3, 2 > 3
Psychological distress ^a	0.76 (0.53)	0.72 (0.44)	0.63 (0.52)	1.90	
Social media time use at 15-min difference	N = 288	N = 190	N = 57		
Problematic smartphone use ^a	0.23 (1.11)	-0.09 (0.88)	-0.34 (1.33)	9.05**	1 > 2, 1 > 3
Problematic social media use ^a	-0.04 (0.80)	-0.28 (0.56)	-0.37 (0.99)	8.51**	1 > 2, 1 > 3
Problematic gaming ^a	-0.05 (0.63)	-0.11 (0.48)	-0.37 (0.96)	5.61**	1 > 3, 2 > 3
Psychological distress ^a	0.74 (0.53)	0.77 (0.44)	0.55 (0.62)	4.25*	1 > 3, 2 > 3
Gaming time at 15-min difference	N = 199	N = 220	N = 116		
Problematic smartphone use ^a	0.34 (1.07)	-0.08 (0.95)	-0.19 (1.22)	12.37**	1 > 2, 1 > 3
Problematic social media use ^a	0.02 (0.86)	-0.20 (0.64)	-0.39 (0.73)	11.14**	1 > 2, 1 > 3
Problematic gaming ^a	0.04 (0.67)	-0.14 (0.55)	-0.29 (0.68)	10.18**	1 > 2, 1 > 3
Psychological distress ^a	0.77 (0.51)	0.74 (0.48)	0.63 (0.57)	3.00	
	New Group 1	New Group 2	New Group 3	F-value	Bonferroni comparison
Smartphone use time at 30-min difference	N = 324	N = 152	N = 59		
Problematic smartphone use ^a	0.28 (1.08)	-0.19 (0.93)	-0.58 (1.09)	22.87**	1 > 2 > 3
Problematic social media use ^a	-0.04 (0.78)	-0.33 (0.67)	-0.47 (0.74)	12.29**	1 > 2, 1 > 3
Problematic gaming ^a	-0.01 (0.64)	-0.13 (0.51)	-0.56 (0.69)	19.99**	1 > 3, 2 > 3
Psychological distress ^a	0.76 (0.53)	0.72 (0.45)	0.5* (0.53)	2.65	
Social media time use at 30-min difference	N = 251	N = 245	N = 39		
Problematic smartphone use ^a	0.25 (1.13)	-0.07 (0.93)	-0.36 (1.42)	8.61**	1 > 2, 1 > 3
Problematic social media use ^a	-0.01 (0.83)	-0.28 (0.59)	-0.34 (1.04)	9.11**	1 > 2, 1 > 3
Problematic gaming ^a	-0.05 (0.65)	-0.11 (0.51)	-0.46 (1.02)	7.06**	1 > 3, 2 > 3
Psychological distress ^a	0.74 (0.55)	0.75 (0.45)	0.52 (0.64)	4.58*	1 > 3, 2 > 3
Gaming time at 30-min difference	N = 169	N = 271	N = 95		
Problematic smartphone use ^a	0.35 (1.05)	-0.01 (1.01)	-0.27 (1.21)	11.70**	1 > 2, 1 > 3
Problematic social media use ^a	0.06 (0.85)	-0.23 (0.68)	-0.37 (0.70)	11.85**	1 > 2, 1 > 3
Problematic gaming ^a	0.05 (0.67)	-0.13 (0.58)	-0.32 (0.66)	11.13**	1 > 2 > 3
Psychological distress ^a	0.78 (0.51)	0.74 (0.50)	0.63 (0.54)	2.81	

Problematic smartphone use assessed using Smartphone Application-Based Addiction Scale; Problematic social media use assessed using Bergen Social Media Addiction Scale; Problematic gaming assessed using Internet Gaming Disorder Scale-Short Form; Psychological distress assessed using Depression, Anxiety, Stress Scale-21. Group 1 = Time spent on internet-related behaviors use increased 15 min after COVID-19 outbreak; Group 2 = Time spent on internet-related behaviors use within a difference between 15 min after COVID-19 outbreak; Group 3 = Time spent on internet-related behaviors use decreased 15 min after COVID-19 outbreak; New Group 1 = Time spent on internet-related behaviors use increased 30 min after COVID-19 outbreak; New Group 2 = Time spent on internet-related behaviors use within a difference between 30 min after COVID-19 outbreak; New Group 3 = Time spent on internet-related behaviors use decreased 30 min after COVID-19 outbreak.

* $P < 0.01$; ** $P < 0.01$.

^a Different scores between Time 1 and Time 2; that is, Time 2 score minus Time 1 score.

their classmates or friends during the school suspension period, and may have feared missing out from their circle of friends (Elhai et al., 2017; Wegmann et al., 2017; Wong et al., 2020). Therefore, time spent on smartphones and social media was increased but time spent gaming was not.

However, surprisingly, schoolchildren in the present study significantly decreased problematic social media use and problematic gaming during the COVID-19 outbreak period. Although there is no obvious reason for why the

decreases occurred, a potential explanation is that parents may have allowed schoolchildren to engage more in social media use and gaming during the suspension period than during the normal schooling period. If the schoolchildren were allowed to “freely” engage in social media use and gaming, they may not have had strong urges to engage in these behaviors. In contrast, the schoolchildren may have yearned for the activities they were not allowed to engage in (e.g., schooling). Such speculation needs empirical evidence to support such a claim.



Table 3. Pearson correlation matrix between time spent on internet-related behavior, problematic internet-related behavior use, and psychological distress in Time 1 (baseline assessment) and Time 2 (assessment during the COVID-19 outbreak)

	Pearson correlation coefficient in Time 1/Pearson correlation coefficient in Time 2						
	Problematic smartphone use	Problematic social media use	Problematic gaming	Psychological distress	Smartphone use time	Social media use time	Gaming time
Problematic smartphone use	–						
Problematic social media use	0.50/0.61	–					
Problematic gaming	0.72/0.70	0.52/0.64	–				
Psychological distress	0.53/0.52	0.43/0.54	0.64/0.44	–			
Smartphone use time	0.36/0.35	0.29/0.29	0.38/0.25	0.19/0.20	–		
Social media use time	0.20/0.21	0.29/0.25	0.33/0.14	0.20/0.15	0.43/0.56	–	
Gaming time	0.25/0.20	0.26/0.20	0.28/0.26	0.22/0.13	0.58/0.25	0.35/0.13	–

All P -values < 0.01.

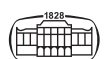
Problematic smartphone use assessed using Smartphone Application-Based Addiction Scale; Problematic social media use assessed using Bergen Social Media Addiction Scale; Problematic gaming assessed using Internet Gaming Disorder Scale-Short Form; Psychological distress assessed using Depression, Anxiety, Stress Scale-21.

Another possibility explaining the decreased problematic social media use and problematic gaming is potential dishonest reporting by the schoolchildren during the COVID-19 pandemic outbreak period. It is possible that the schoolchildren might have been worried about being restricted from engaging in internet-related activities during the COVID-19 pandemic outbreak period and therefore reported a lower score in these problematic uses of internet-related activities. Therefore, future studies incorporating independent or corroborative parent-reported information (e.g., ‘Did your child change the time spent on internet-related activities during the period of school suspension?’ using response options such as ‘increased more than an hour per day’, ‘increased between 0.5 and 1 hour per day’, ‘approximately the same amount’, ‘decreased between 0.5 and 1 hour per day’, and ‘decreased more than an hour per day’) are needed for further clarification. In addition, future studies may want to ask parents regarding their monitoring and regulating practices concerning their children’s internet-related behaviors.

Consistent to prior research which has shown that some individuals have reported psychological problems during the COVID-19 outbreak period (Ahorsu et al., 2020; Wang et al., 2020; Xiao et al., 2020), the present study found that primary schoolchildren reported significantly higher psychological distress during this period than the period prior to the COVID-19 outbreak. Moreover, the increased DASS-21 score of 0.73 in a four-point Likert scale equated to a minimal clinically important change (MCID) compared to a previous study on adolescents aged between 10 and 19 years (MCID = 0.32–0.45) (Silva et al., 2016). The increased psychological distress may be due to the high COVID-19 transmission and mortality rates reported (Ahorsu et al., 2020; World Health Organization, 2020a). Indeed, the association between illness status and psychological distress

was higher during the COVID-19 outbreak period than before the COVID-19 outbreak. Another possibility is the increased time spent on internet-related activities. The present study showed that schoolchildren who increased time spent on either smartphones, social media, or gaming had significantly elevated psychological distress than those with decreased time spent on these internet-related activities. As prior evidence has demonstrated that time spent on internet-related activities is associated with problematic use and psychological distress (Chen et al., 2020c; Leung et al., 2020; Wong et al., 2020), primary schoolchildren in the present study might have greater levels of psychological distress due to their increased time spent on internet-related activities. The Pearson correlations and SEM results in the present study also concur with prior findings (Chen et al., 2020c; Leung et al., 2020; Wong et al., 2020) on the associations between time spent on internet-related activities, problematic use of internet-related activities, and psychological distress.

With many governments implementing the policy of school suspensions, the findings in the present study may provide some directions for healthcare providers and educators to help ease and/or reduce primary schoolchildren’s psychological distress. Although online activities cannot be prohibited because of the learning needs for schoolchildren, it is recommended that parents and caregivers pay attention to what online activities their children are engaging in as has recently been noted elsewhere by a group of international scholars working in the field of problematic internet use (Király et al., 2020). It may be necessary for parents and caregivers to encourage children to engage less in social media and gaming activities, and the time they spend on social media and gaming should be monitored. Moreover, it is suggested that parents and caregivers try to talk with their children about the information their children obtain from



social media. Consequently, misinformation or misconceptions may be quickly corrected and prevent children from elevated psychological distress. Healthcare providers, educators, and governments should be proactive in providing social media information. More specifically, they should clarify the incorrect information posted in the social media as soon as possible and routinely provide transparent information with correct knowledge in all kinds of social media to reach all potential users including schoolchildren.

There are some limitations in the present study. First, participants in this study were recruited from three primary schools of a Chinese province. Therefore, the generalizability of the findings is restricted. For example, children between East and West have different learning systems and lifestyles. Moreover, the implementation of school suspension and online teaching may vary across countries. Therefore, studies from other ethnic populations are needed to corroborate the results found in the present study. Second, all the outcome measures were self-reported by the children. Therefore, recall bias and social desirability are potential threats to the validity of present study's findings. More specifically, the participants might tend to underreport their time spent on internet-related activities and problematic use of internet-related activities. Additionally, single-rater bias cannot be avoided because all the measures were rated by the schoolchildren. Third, the participation rate was relatively low, which may bias the findings. Fourth, the directions tested in the present study could be the reverse (i.e., psychological distress leading to problematic use in internet-related activities and subsequently increased screen time use) (Elhai et al., 2017; Wegmann et al., 2017). Future studies are therefore needed to investigate the direction using a more robust study design. Fifth, Time 1 data collection used a paper-based survey method and Time 2 data collection used an online survey method. Therefore, there may have been a potential data collection bias. However, given that using a paper-based survey method was impossible during the COVID-19 lockdown period, using an online survey at Time 2 survey was the only method available to collect longitudinal data. However, prior research has reported measurement invariance across online and offline paper-based survey methods (Martins, 2010). Therefore, using different methods in data collection may not have seriously influenced the present study's findings. Finally, parenting style (whether parents set any screen time rules for their children) is an important factor (Lin et al., 2020; Lin, Fung et al., 2019) and this information was not collected in the present study.

CONCLUSIONS

The present study showed that primary schoolchildren in mainland China increased their time spent on smartphones and social media but not gaming during the school suspension period. Moreover, schoolchildren who had increased time spent on internet-related activities during the school suspension period were at higher risk of having

greater psychological distress than those who had decreased time spent on internet-related activities. Parents and caregivers need to understand and monitor their children's use of internet-related activities, which may help prevent their children experiencing psychological distress.

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APPENDIX

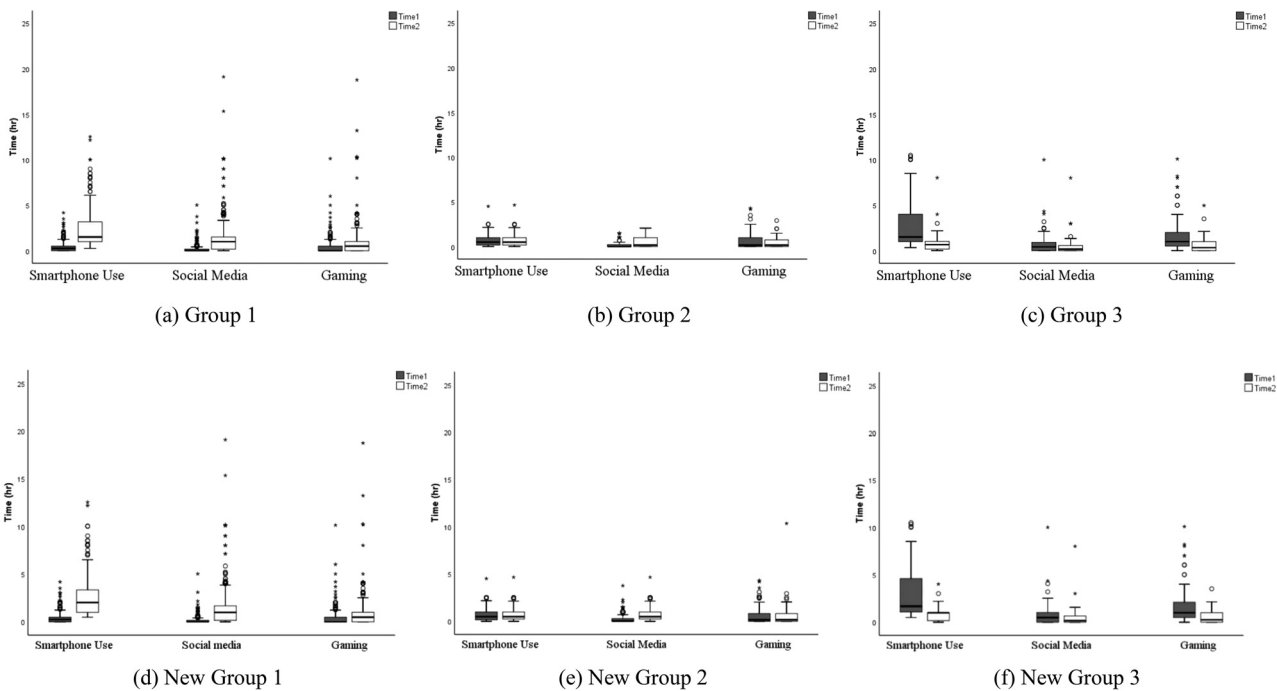


Fig. A1. Time spent engaging in internet-related activities in Time 1 (baseline assessment) and Time 2 (assessment during the COVID-19 outbreak). (a) Group 1 = Time spent on smartphone use increased 15 min after COVID-19 outbreak; (b) Group 2 = Time spent on smartphone use within a difference between 15 min after COVID-19 outbreak; (c) Group 3 = Time spent on smartphone use decreased 15 min after COVID-19 outbreak; (d) New Group 1 = Time spent on smartphone use increased 30 min after COVID-19 outbreak; (e) New Group 2 = Time spent on smartphone use within a difference between 30 min after COVID-19 outbreak; (f) New Group 3 = Time spent on smartphone use decreased 30 min after COVID-19 outbreak.



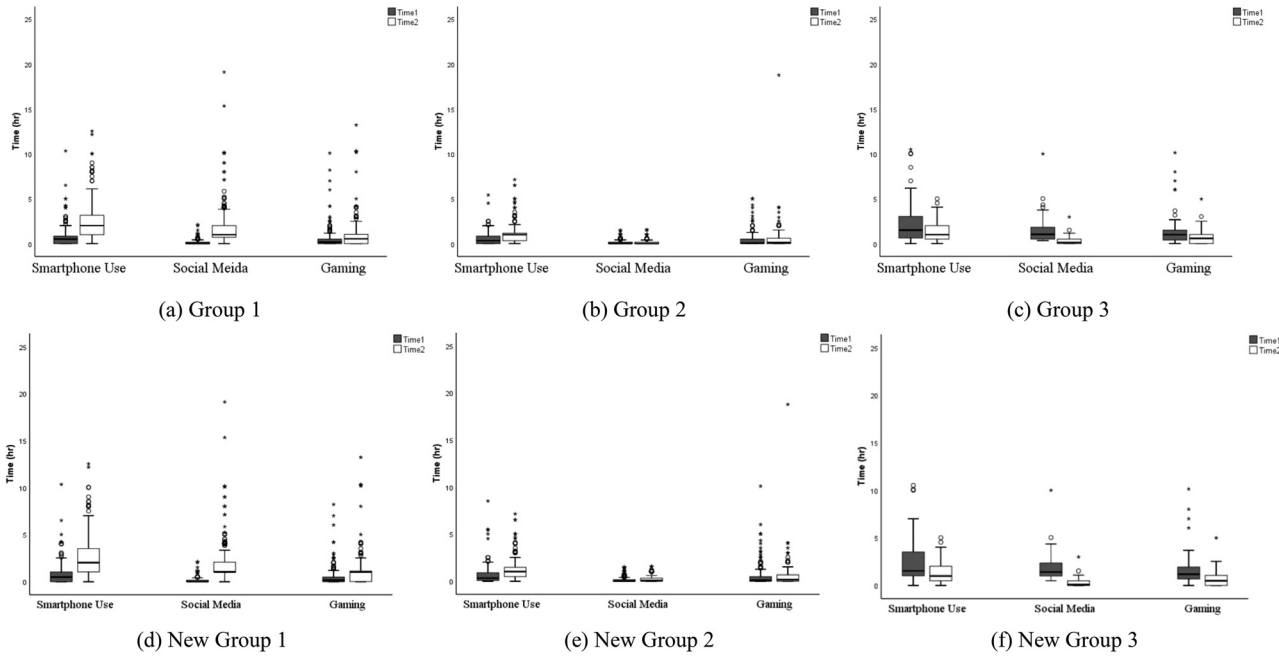


Fig. A2. Time spent engaging in internet-related activities in Time 1 (baseline assessment) and Time 2 (assessment during the COVID-19 outbreak). (a) Group 1 = Time spent on social media use increased 15 min after COVID-19 outbreak; (b) Group 2 = Time spent on social media use within a difference between 15 min after COVID-19 outbreak; (c) Group 3 = Time spent on social media use decreased 15 min after COVID-19 outbreak; (d) New Group 1 = Time spent on social media use increased 30 min after COVID-19 outbreak; (e) New Group 2 = Time spent on social media use within a difference between 30 min after COVID-19 outbreak; (f) New Group 3 = Time spent on social media use decreased 30 min after COVID-19 outbreak

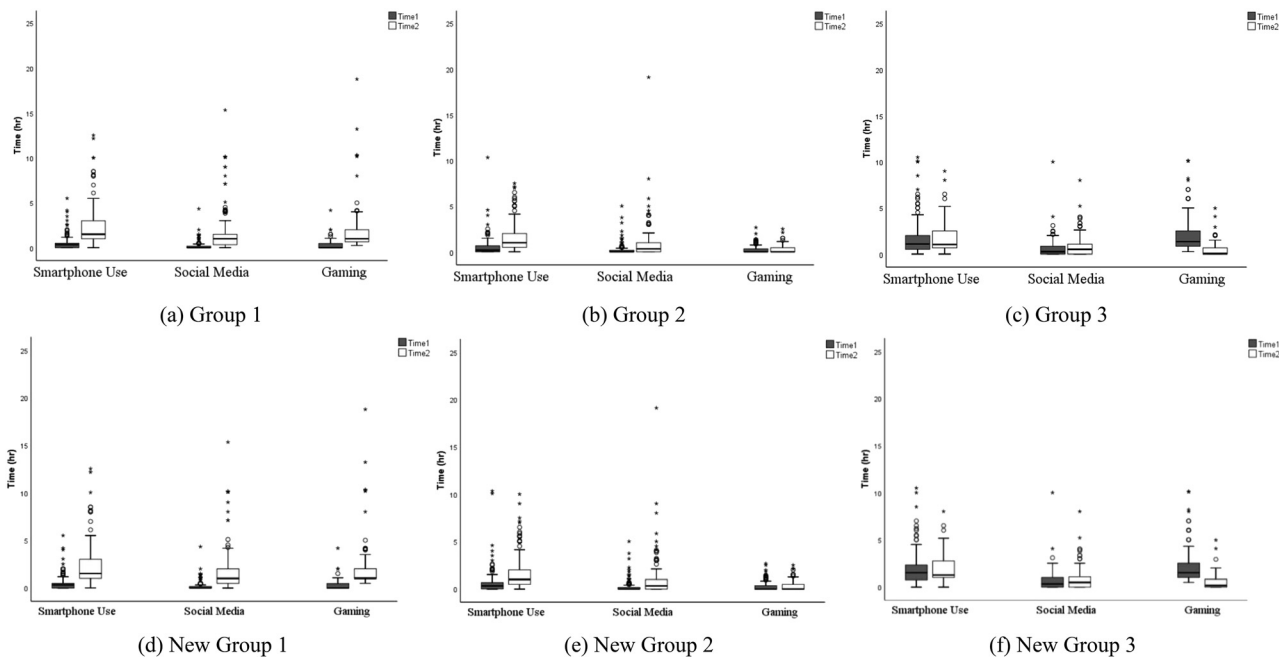


Fig. A3. Appendix Fig. 3. Time spent engaging in internet-related activities in Time 1 (baseline assessment) and Time 2 (assessment during the COVID-19 outbreak). (a) Group 1 = Time spent gaming increased 15 min after COVID-19 outbreak; (b) Group 2 = Time spent gaming within a difference between 15 min after COVID-19 outbreak; (c) Group 3 = Time spent gaming decreased 15 min after COVID-19 outbreak; (d) New Group 1 = Time spent gaming increased 30 min after COVID-19 outbreak; (e) New Group 2 = Time spent gaming within a difference between 30 min after COVID-19 outbreak; (f) New Group 3 = Time spent gaming decreased 30 min after COVID-19 outbreak.

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