Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Association of Symptoms of Attention Deficit and Hyperactivity with Problematic Internet Use among University Students in Wuhan, China During the COVID-19 Pandemic

Yimiao Zhao a,b,1, Zhendong Jiang c,1, Suihuai Guo c, Ping Wu a, Qingdong Lu a,b, Yingying Xu a,b, Lin Liu a,b, Sizhen Su d, Le Shi d, Jianyu Que d, Yan Sun a, Yankun Sun a, Jiahui Deng d, Shiqiu Meng a, Wei Yan d, Kai Yuan d, Siwei Sun d, Li Yang e, Maosheng Ran e, Thomas R Kosten f, John Strang g, Yu Lu i, Guofu Huang c, Lin Lu d,b,*, Yanping Bao a,b,**, Jie Shi a,***

ARTICLE INFO

Keywords:
COVID-19
Problematic internet use
Symptoms of attention deficit and hyperactivity
University students

ABSTRACT

Background: COVID-19 is still spreading worldwide and posing a threat to individuals’ physical and mental health including problematic internet use (PIU). A potentially high-risk group for PIU are those with symptoms of attention deficit and hyperactivity (ADHD symptoms), because of restrictions in their physical activity levels and engagement in computer diversions requiring only short attention spans.

Methods: We used convenience sampling in a cross-sectional survey of university students from 30 universities in Wuhan, Hubei Province, China. We assessed PIU using the Internet Addiction Test and ADHD symptoms using the WHO Adult ADHD Self-Report Screening Scale. Using logistic regression and linear regression analyses we adjusted for demographic, epidemic-related and psychological covariates in models of the association between ADHD symptoms and PIU.

Results: Among 11,254 participants, we found a 28.4% (95% CI, 27.5%-29.2%) prevalence of PIU, relatively higher than before the pandemic. In our final logistic regression model, participants with ADHD symptoms had approximately two times the risk for PIU (OR: 2.31, 95% CI: 1.89-2.83). Similarly, individuals with depression, anxiety, insomnia, PTSD symptoms and feeling stress during the pandemic had a higher risk of PIU, while those exercising regularly during the pandemic had a lower risk.

Limitations: The cross-sectional design and reliance on internet based self-reports for ADHD symptoms and PIU assessments, without direct structured interviews for validation, are limitations.
Conclusions: The prevalence of PIU was high during COVID-19, and those people with ADHD symptoms and other mental illness symptoms appear to be at higher risk of PIU. Regular exercise may reduce that PIU risk and hence should be recommended during the COVID-19 pandemic.

1. Introduction

Up to now, coronavirus disease 2019 (COVID-19), initially detected in December, 2019, has been in control in some countries, whereas in other many countries and regions the pandemic still prolongs and represents a great threat to individuals’ as well as societal physical and mental health (Bao et al., 2020). During the outbreak period, “spatial distancing”, which is strongly promoted to curb the spread, has disrupted many normal personal interactions (Abel and McQueen, 2020; Liu et al., 2020; Sun et al., 2020a). The resulting regulations have profoundly influenced people from all walks of life, including university students. Several studies found that the prevalence of problematic internet use (PIU) or problematic smartphone use or internet addiction for children, adolescents and young adults in countries and regions affected by COVID-19 has mounted substantially (Deslandes and Coutinho, 2020; Dong et al., 2020; Elhai et al., 2020; Rolland et al., 2020; Sun et al., 2020b).

With the temporary closure of universities, the total online time of university students has gone up considerably for studying online and socializing, which may make them more susceptible to PIU. Academic stress, high levels of uncertainty regarding the future, the pressure of job hunting for graduates, confirmed/suspected COVID-19, or close contacting with patients, experiencing quarantine and other series of factors induced by the pandemic could make university students be under unprecedented pressure and be more likely to experience severe psychological distress and mental problems (Király et al., 2020). Experiencing quarantine and other stressors associated with the pandemic can also trigger addictive activities including PIU as ways to alleviate stress, anxiety, depression, and even post-traumatic stress disorder (PTSD) (Blasi et al., 2019; Khantzian, 2013; Király et al., 2020; Wang et al., 2021).

A common comorbidity of PIU is attention deficit hyperactivity disorder (ADHD) (Carl et al., 2013; Tateno et al., 2018; Tateno et al., 2016). It is possible that this association between ADHD and PIU might strengthen during the COVID-19 pandemic. However, to our knowledge, no study has yet investigated the association between ADHD and PIU during the COVID-19 pandemic. Therefore, on the one hand, we want to explore how the association between ADHD and PIU may be influenced by the epidemic-related and other factors. On the other hand, the prevalence of PIU in the previous studies was mostly obtained in the early outbreak stage when people were in a so-called emotional response spike at a time of facing high risk of infection virus as well as uncertainty for future, so we want to know the prevalence of PIU among university students after a long-term quarantine. For the above purposes, we conducted a cross-sectional study after long-term school closure among university students. In this period, the COVID-19 pandemic was largely under control in China except for a small-scale outbreak in several regions occasionally, and meanwhile university students have stayed at home for more than half a year and still didn’t return to campus.

2. Methods

2.1. Study design and participants

We conducted a cross-sectional online study from June 29, 2020, to July 18, 2020 among university students from 30 universities in Wuhan, Hubei Province, China, by convenience sampling method. With the help of the class instructor, our self-administered questionnaire was released to the class Wechat group, to which university students pay attention periodically. The investigation was anonymous with confidentiality assured for all information. This study received the approval from the ethics committee of Peking University Sixth Hospital (Institute of Mental Health) and followed the American Association for Public Opinion Research reporting guidelines. Informed consent was received online before the respondents began the questionnaire.

A total of 65,845 students clicked on the survey link, of whom 11,325 individuals provided the informed consent, resulting in a participation rate of 17.2%. The participants came from 31 province-level regions in China and attended 30 universities in Wuhan, Hubei Province. 71 individuals were excluded because of invalid questionnaires indicated by extreme, out of range values and inconsistent responses to the same questions in different parts of the questionnaire. Thus, we included 11,254 individuals in the final analysis.

2.2. Measurements and covariates

2.2.1. Problematic internet use (PIU)

We measured participants’ PIU using the Internet Addiction Test (IAT), which includes 20 items with a total score from 20 to 100. IAT scores between 20 and 49 reflect average online users, while scores between 50 and 79 reflect problem users and scores between 80 and 100 indicate significant internet use problems (Aboujaoude, 2010). In this study, we applied a cutoff for the PIU of a score of 50 or more.

2.2.2. Symptoms of attention deficit and hyperactivity (ADHD) symptoms

We measured participants’ ADHD symptoms using the WHO Adult ADHD Self-Report Screening Scale (ASRS-V1.1), which consists of 6 items using a 5-point Likert scale: 1, not at all; 2, rarely; 3, sometimes; 4, often; 5, always. Respondents who endorsed at least four out of six items were considered at “elevated” risk for Adult ADHD. (Kessler et al., 2005).

2.2.3. Covariates

As listed in Table 1, we collected nine demographics including gender, age, and nationality. We collected nine epidemic-related variables as also listed in Table 1. Table 1 also lists four psychological variables measured by the Patient Health Questionnaire-9 (PHQ-9) (Sun et al., 2017), Generalized Anxiety Disorder-7 (GAD-7) (Qu and Sheng, 2015), Insomnia Severity Index (ISI) (Morin et al., 2011), and PTSD checklist for DSM-5 (PCL-5) (Wang et al., 2015). The total scores of these scales were interpreted as follows: PHQ-9, normal (0-4), mild (5-9), moderate to severe (10-27) depression symptoms; GAD-7, normal (0-4), mild (5-9), moderate to severe (10-21) anxiety symptoms; ISI, normal (0-7), subthreshold (8-14), moderate to severe (15-28) insomnia symptoms. The cutoff for positive PTSD symptoms was a score of 33 or more.

2.3. Statistical analysis

We used $\chi^2$ tests to compare the prevalence of PIU in different categorical variables and logistic regression analysis for the association of ADHD symptoms with PIU. We presented the adjusted odds ratio and 95% confidential intervals (95% CIs) of ADHD symptoms for PIU populations. We adjusted for different covariates in three models. Model 1 adjusted for demographic characteristics, including gender, age, education level, graduation, and monthly family income. Model 2 adjusted for epidemic-related factors in addition to the covariates in model 1. Model 3 adjusted for psychological factors in addition to the covariates in model 2. We also conducted linear regression analyses to investigate the relationship of ADHD symptoms, other mental illness symptoms and PIU, with regarding PIU, ADHD, depression, anxiety, insomnia, and
Table 1
Demographic Characteristics, Epidemic-related Information and Psychological Factors by Problematic Internet Use Subgroups.

|                       | Total (n=11254) | PIU (n=3191) | Non-PIU (n=8063) | p value<sup>a</sup> |
|-----------------------|-----------------|--------------|------------------|--------------------|
| **Gender**            |                 |              |                  |                    |
| Male                  | 4054 (36.0%)    | 1251 (39.9%) | 2803 (34.8%)     | <0.001             |
| Female                | 7200 (64.0%)    | 1940 (60.1%) | 5260 (65.2%)     |                    |
| **Age, y**            |                 |              |                  | 0.048              |
| 15-20                 | 8139 (72.3%)    | 2350 (73.9%) | 5789 (71.8%)     |                    |
| > 20                  | 3115 (27.7%)    | 841 (26.0%)  | 2274 (28.2%)     |                    |
| **Living area during the COVID-19 pandemic** | | | | <0.001 |
| Hubei Province        | 6960 (61.8%)    | 1890 (58.9%) | 5070 (62.8%)     |                    |
| Other provinces       | 4294 (38.2%)    | 1301 (41.1%) | 2993 (37.2%)     |                    |
| **Nation**            |                 |              |                  | 0.237              |
| Han nationality       | 10421 (92.6%)   | 2940 (91.6%) | 7481 (92.6%)     |                    |
| National minority     | 833 (7.4%)      | 251 (7.4%)   | 582 (7.4%)       |                    |
| **Education level**   |                 |              |                  | <0.001             |
| College or higher     | 8045 (71.5%)    | 2448 (76.8%) | 5597 (69.3%)     |                    |
| Less than college     | 3209 (28.5%)    | 743 (23.2%)  | 2466 (30.7%)     |                    |
| **Major**             |                 |              |                  | 0.71               |
| Medicine              | 824 (7.3%)      | 229 (7.1%)   | 595 (7.4%)       |                    |
| Non-medicine          | 10430 (92.7%)   | 2962 (92.9%) | 7468 (92.6%)     |                    |
| **Graduation**        |                 |              |                  | <0.001             |
| Yes                   | 408 (3.6%)      | 153 (48.3%)  | 255 (32.0%)      |                    |
| No                    | 10846 (96.4%)   | 3038 (95.7%) | 7808 (68.0%)     |                    |
| **Singlehood**        |                 |              |                  | 0.53               |
| Yes                   | 9025 (82.5%)    | 2547 (80.3%) | 6478 (80.2%)     |                    |
| No                    | 2229 (17.5%)    | 644 (19.7%)  | 1585 (19.8%)     |                    |
| **Monthly family income, ¥** | | | | <0.001 |
| ≤ 10,000              | 9290 (82.5%)    | 2593 (81.4%) | 6697 (83.2%)     |                    |
| >10,000               | 1964 (17.5%)    | 596 (18.6%)  | 1368 (16.8%)     |                    |
| **Only child**        |                 |              |                  | 0.202              |
| Yes                   | 4995 (44.4%)    | 1386 (45.9%) | 3609 (44.8%)     |                    |
| No                    | 6259 (55.6%)    | 2173 (64.1%) | 4086 (55.2%)     |                    |
| **Experiencing quarantine** | | | | <0.001 |
| Yes                   | 5215 (46.3%)    | 1564 (49.0%) | 3651 (45.0%)     |                    |
| No                    | 6039 (53.7%)    | 2171 (51.0%) | 3868 (55.0%)     |                    |
| **Living alone during the COVID-19 pandemic** | | | | 0.58 |
| Yes                   | 82 (0.7%)       | 21 (25.6%)   | 61 (24.6%)       |                    |
| No                    | 11172 (99.3%)   | 3170 (28.4%) | 8002 (30.6%)     |                    |
| **Confirmed/suspected COVID-19 or close contacting with patients** | | | | <0.001 |
| Yes                   | 76 (0.7%)       | 22 (29.0%)   | 54 (22.0%)       |                    |
| No                    | 11178 (99.3%)   | 3149 (28.1%) | 8029 (31.9%)     |                    |
| **Family members who are confirmed/suspected COVID-19 or close contacting with patients** | | | | <0.001 |
| Yes                   | 80 (0.7%)       | 24 (30.0%)   | 56 (22.0%)       |                    |
| No                    | 11174 (99.3%)   | 3154 (28.2%) | 8020 (31.8%)     |                    |
| **Acquiring some psychological knowledge during the COVID-19 pandemic** | | | | 0.001 |
| Yes                   | 6746 (59.9%)    | 1832 (27.4%) | 4914 (24.7%)     |                    |
| No                    | 4508 (40.1%)    | 3157 (47.6%) | 1341 (75.3%)     |                    |
| **Receiving psychological interventions during the COVID-19 pandemic** | | | | <0.001 |
| Yes                   | 513 (4.6%)      | 194 (37.8%)  | 319 (62.2%)      |                    |
| No                    | 10741 (95.4%)   | 2997 (27.9%) | 7744 (72.1%)     |                    |
| **Exercising during the COVID-19 pandemic** | | | | <0.001 |
| Yes                   | 4686 (41.7%)    | 1053 (22.4%) | 3634 (44.7%)     |                    |
| No                    | 6558 (58.3%)    | 2138 (37.6%) | 4420 (55.3%)     |                    |
| **Stress during the COVID-19 pandemic** | | | | <0.001 |
| High                  | 2235 (19.9%)    | 911 (40.8%)  | 1324 (59.2%)     |                    |
| Moderate              | 4025 (35.8%)    | 1308 (32.5%) | 2717 (67.5%)     |                    |
| Low                   | 4994 (44.4%)    | 972 (19.5%)  | 4022 (80.5%)     |                    |
| **ADHD symptoms**     |                 |              |                  | <0.001             |
| Yes                   | 579 (5.1%)      | 385 (66.5%)  | 194 (33.5%)      |                    |
| No                    | 10675 (94.9%)   | 2806 (26.3%) | 7869 (73.7%)     |                    |
| **Depression**        |                 |              |                  | <0.001             |
| Moderate              | 1703 (15.1%)    | 1050 (61.7%) | 653 (38.3%)      |                    |
| Mild                  | 2970 (26.4%)    | 1098 (36.5%) | 1882 (63.5%)     |                    |
| Normal                | 6581 (58.5%)    | 1053 (16.0%) | 5528 (84.0%)     |                    |
| **Anxiety**           |                 |              |                  | <0.001             |
| Moderate to severe    | 1033 (9.2%)     | 664 (64.3%)  | 369 (35.7%)      |                    |
| Mild                  | 2633 (23.4%)    | 1176 (44.7%) | 1457 (55.3%)     |                    |
| Normal                | 7588 (67.4%)    | 1351 (17.6%) | 6237 (82.4%)     |                    |
| **Insomnia**          |                 |              |                  | <0.001             |
| Moderate to severe    | 758 (6.7%)      | 458 (60.4%)  | 300 (39.6%)      |                    |
| Subthreshold          | 3181 (28.3%)    | 1456 (45.8%) | 1725 (54.2%)     |                    |
| Normal                | 7315 (65.0%)    | 1277 (17.5%) | 6038 (82.5%)     |                    |
| **PTSD**              |                 |              |                  | <0.001             |
| Yes                   | 952 (8.5%)      | 666 (70.0%)  | 286 (30.0%)      |                    |
| No                    | 10302 (91.5%)   | 2525 (24.5%) | 7777 (75.5%)     |                    |
PTSD as continuous variables. Significance level was set at P<0.05 and all tests were 2-sided. We used SPSS statistical software version 23 (IBM Corp) for all statistical analyses.

3. Results

3.1. Demographics

The 11,254 university students ranged from 15 to 35 years old with a mean (SD) age of 20.0 (1.3) years and included 4,054 males (36.0%). Table 1 provides other details of this sample including that 46.3% (5215) had quarantine experience, 0.7% (76) were confirmed or suspected COVID-19 infected patients or close contacts and 0.7% (80) had family members who were confirmed or suspected COVID-19 infected patients or close contacts.

3.2. Prevalence of PIU among different populations

Overall, 28.4% (95% CI, 27.5%-29.2%) (3191) of participants met the PIU assessment criteria, and PIU was significantly higher, but not impressively higher except among graduates (37.5%), among males (30.9%), students aged 15 to 20 years (28.9%), participants with a college or higher degree (30.4%), and participants with a higher monthly family income (30.4%). We also found higher PIU rates among participants who experienced quarantine (30.0%), participants who were confirmed infected with COVID-19, suspected cases, or close contacts by themselves (55.3%) or their family members (46.3%), and among participants feeling high (40.8%) or moderate (32.5%) stress during the pandemic. In addition, the prevalence of PIU was higher among respondents who received psychological interventions during the pandemic (37.8%) and who had ADHD (66.5%), depression (moderate to severe, 61.7%; mild, 36.6%), anxiety (moderate to severe, 64.3%; mild, 44.7%), insomnia (moderate to severe, 60.4%; subthreshold, 45.8%) or PTSD symptoms (70.0%). In contrast, a lower prevalence of PIU was found amongst individuals who lived in Hubei Province during the pandemic (27.2%), individuals who acquired some psychological knowledge during the pandemic (27.2%), and individuals who exercised regularly during the pandemic (22.4%).

3.3. ADHD symptoms rate and co-occurring with other mental illness symptoms

5.1% (579) of participants met the ADHD symptoms assessment criteria. The prevalence rates of depression (moderate to severe, 56.3%; mild, 26.4%), anxiety (moderate to severe, 41.3%; mild, 33.5%), insomnia (moderate to severe, 30.7%; subthreshold, 40.8%) and PTSD symptoms (39.0%) were higher among participants with ADHD symptoms. Similarly, having any depression, anxiety, insomnia, and PTSD symptoms was more common in individuals with ADHD symptoms and the co-occurring rate was 87.7%. Table 2 presents detailed results of ADHD symptoms co-occurring with other mental illness symptoms.

3.4. Association of ADHD symptoms and PIU

This study indicated that the presence of ADHD symptoms was positively associated with PIU. The unadjusted OR of ADHD symptoms for PIU individuals was 5.57 (95% CI, 4.66-6.65). The adjusted OR reduced slightly from model 1 to model 2. However, adjusting for psychological factors in model 3 substantially reduced the adjusted OR to 2.31 (95% CI, 1.89-2.83).

Model 2, which adjusted for demographics and epidemic-related factors, showed that confirmed or suspected COVID-19-infected patients or those having close contacts with patients demonstrated a higher risk for PIU (OR: 1.90, 95% CI, 1.15-3.13). In contrast, acquiring some psychological knowledge during the pandemic was a protective factor for PIU (OR: 0.88, 95% CI, 0.81-0.96). However, a history of having received a psychological intervention during the pandemic was associated with PIU (OR: 1.46, 95% CI: 1.20-1.78).

In the fully adjusted model 3, male students, graduates and individuals with a higher monthly family income showed a higher risk for PIU, while participants more than 20 years old and with less than a college degree had a lower risk. Respondents who lived in Hubei Province during the pandemic (OR: 0.89, 95% CI: 0.81-0.98) and respondents who exercised regularly during the pandemic (OR: 0.68, 95% CI: 0.62-0.75) had a lower risk of PIU. Participants who felt high (OR: 1.45, 95% CI: 1.27-1.64) or moderate stress (OR: 1.45, 95% CI: 1.30-1.61) during the pandemic had higher risks than those feeling low stress. In addition, individuals with depression (moderate to severe, OR: 2.25 [1.87-2.71]; mild, OR, 1.53 [1.35-1.75]), anxiety (moderate to severe, OR, 1.55 [1.24-1.93]; mild, OR, 1.66 [1.45-1.89]), insomnia (moderate to severe, OR, 2.00 [1.65-2.44]; subthreshold, OR, 2.10 [1.89-2.34]), PTSD symptoms (OR: 1.87, 95% CI: 1.54-2.27) were susceptible to PIU compared with those without these 4 psychological conditions. Table 3 presents detailed results of the logistic regression analyses.

To further examine the association of ADHD symptoms and PIU, we conducted multiple linear regression of IAT scores as a continuous variable and ADHD symptoms and other mental health symptoms as independent variables. The final stepwise multiple linear regression...
Deficit and Hyperactivity and Problematic Internet Use. Logistic Regression Analyses of the Association between Symptoms of Attention Deficit and Hyperactivity and Problematic Internet Use.

### Table 3
Logistic Regression Analyses of the Association between Symptoms of Attention Deficit and Hyperactivity and Problematic Internet Use.

| Variables                                      | OR (95% CI) Model 1 | OR (95% CI) Model 2 | OR (95% CI) Model 3 |
|------------------------------------------------|---------------------|---------------------|---------------------|
| ADHD symptoms                                  |                     |                     |                     |
| Yes                                            | 5.52 (4.62-6.61)**   | 4.62 (3.84-5.56)**  | 2.31 (1.89-2.83)**  |
| No                                             | 1 [Reference]        | 1 [Reference]       | 1 [Reference]       |
| Gender                                         |                     |                     |                     |
| Male                                           | 1.28 (1.17-1.40)**   | 1.36 (1.24-1.49)**  | 1.39 (1.26-1.53)**  |
| Female                                         | 1 [Reference]        | 1 [Reference]       | 1 [Reference]       |
| Age, y                                         |                     |                     |                     |
| >20                                            | 0.81 (0.73-0.89)**   | 0.76 (0.69-0.84)**  | 0.72 (0.65-0.80)**  |
| 15-20                                          | 1 [Reference]        | 1 [Reference]       | 1 [Reference]       |
| Education level                                |                     |                     |                     |
| Less than college                              | 0.65 (0.59-0.72)**   | 0.66 (0.60-0.74)**  | 0.63 (0.57-0.70)**  |
| College or higher                              | 1 [Reference]        | 1 [Reference]       | 1 [Reference]       |
| Graduation                                     |                     |                     |                     |
| Yes                                            | 1.63 (1.31-2.03)**   | 1.51 (1.20-1.89)**  | 1.62 (1.27-2.07)**  |
| No                                             | 1 [Reference]        | 1 [Reference]       | 1 [Reference]       |
| Monthly family income, ¥≤10,000                 | NA                  | 1.15 (1.03-1.29)*   | 1.19 (1.05-1.34)*   |
| Family members who are confirmed/suspected COVID-19 or close contacting with patients | NA                  | 1 [Reference]       | 1 [Reference]       |
| Living area during the COVID-19 pandemic        |                     |                     |                     |
| Hubei Province                                 | 0.89 (0.81-0.97)*    | 0.89 (0.81-0.98)*   |                     |
| Other provinces                                | 1 [Reference]        | 1 [Reference]       |                     |
| Confirmed/suspected COVID-19 or close contacting with patients |                     |                     |                     |
| Yes                                            | 1.90 (1.15-3.13)*    | NA                  | NA                  |
| No                                             | 1 [Reference]        | NA                  | NA                  |
| Exercising during the COVID-19 pandemic         |                     |                     |                     |
| Yes                                            | 0.63 (0.57-0.69)**   | 0.68 (0.62-0.75)**  |                     |
| No                                             | 1 [Reference]        | 1 [Reference]       |                     |
| Stress during the COVID-19 pandemic            |                     |                     |                     |
| High                                           | 2.62 (2.34-2.94)**   | 1.45 (1.27-1.64)**  |                     |
| Moderate                                       | 2.04 (1.85-2.25)**   | 1.45 (1.30-1.61)**  |                     |
| Low                                            | 1 [Reference]        | 1 [Reference]       |                     |
| Acquiring some psychological knowledge during the COVID-19 pandemic |                     |                     |                     |
| Yes                                            | 0.88 (0.81-0.96)*    | NA                  | NA                  |
| No                                             | 1 [Reference]        | NA                  | NA                  |
| Receiving psychological interventions during the COVID-19 pandemic |                     |                     |                     |
| Yes                                            | 1.46 (1.20-1.78)**   | 1.23 (1.00-1.52)    |                     |
| No                                             | 1 [Reference]        | 1 [Reference]       |                     |
| Depression                                     |                     |                     |                     |
| Moderate to severe                             | 2.25 (1.87-2.71)**   |                     |                     |
| Mild                                           | 1.53 (1.35-1.75)**   |                     |                     |
| Normal                                         | 1 [Reference]        |                     |                     |
| Anxiety                                        |                     |                     |                     |
| Moderate to severe                             | 1.55 (1.24-1.93)**   |                     |                     |
| Mild                                           | 1.66 (1.45-1.89)**   |                     |                     |
| Normal                                         | 1 [Reference]        |                     |                     |

Abbreviations: ADHD symptoms, Symptoms of attention deficit and hyperactivity; COVID-19, Coronavirus disease 2019; PTSD, Post-traumatic stress disorder; NA, not available (variables that were not included in the final model of backward regression).

- Adjusted for gender, age, education level, graduation and monthly family income.
- Adjusted for living during the COVID-19 pandemic, confirmed/suspected COVID-19 or close contacting with patients, family members who are confirmed/suspected COVID-19 or close contacting with patients, experiencing quarantine, exercising during the COVID-19 pandemic, stress during the COVID-19 pandemic, acquiring some psychological knowledge during the COVID-19 pandemic and receiving psychological interventions during the COVID-19 pandemic in addition to the covariates in model 1.
- Adjusted for depression, anxiety, insomnia and PTSD symptoms in addition to the covariates in model 2.

4. Discussion

This online cross-sectional survey of university students from universities in Wuhan, Hubei Province, China during the COVID-19 pandemic found that more than one quarter had PIU and that ADHD symptoms and other mental health problems were associated with PIU. Students who were male, were graduates, and individuals with a higher monthly family income were more susceptible to PIU, whereas those acquiring some psychological knowledge and exercising regularly during the pandemic were less likely to have PIU. The severity of ADHD and other mental illness symptoms was associated with the degree of PIU.

Our findings can serve the purpose of making comprehensive intervention measures and consequently alleviate the adverse impact of the pandemic on university students.

Different assessment scales for PIU provide varying prevalence rates across different countries and among different groups. Previous studies reported 13.6% - 17.3% PIU among university students in China (Chi et al., 2016; Wang et al., 2020; Yang et al., 2017), and the overall prevalence of PIU across European and Asian countries was 8.4% (Pal Singh Balhara et al., 2019) before the pandemic. Our prevalence of 28.4% PIU is slightly lower than the 36.0% rate earlier in the outbreak period (Dong et al., 2020), but relatively higher than before the pandemic.
Additional Table 4

Multiple Linear Regression Analyses of the Association between Symptoms of Attention Deficit and Hyperactivity, Other Mental Illness Symptoms and Problematic Internet Use.

| Variables                                      | Unstandardized coefficients | Standardized coefficients | t     | p value |
|------------------------------------------------|-----------------------------|---------------------------|-------|---------|
|                                                 | B 95% CI for B               | β                          |       |         |
| ADHD symptoms                                  | 0.24 (0.22-0.26)            | 0.21                      | 21.25 | <0.001 |
| Depression                                     | 0.34 (0.26-0.41)            | 0.12                      | 8.81  | <0.001 |
| Insomnia                                       | 0.10 (0.07-0.13)            | 0.09                      | 6.99  | <0.001 |
| PTSD                                           | 0.50 (0.44-0.56)            | 0.19                      | 16.89 | <0.001 |
| Gender                                         | 1.54 (1.08-2.01)            | 0.05                      | 6.49  | <0.001 |
| Male                                           | -1.70 (Reference)           | -0.05                     | -6.54 | <0.001 |
| Age, y                                         | -2.88 (1.15-2.21)           | -0.20                     | -16.89| <0.001 |
| >20                                            | -2.38 (1.88-2.88)           | -0.08                     | -9.26 | <0.001 |
| Education level                                | -2.38 (1.88-2.88)           | -0.08                     | -9.26 | <0.001 |
| Less than college                              | 0 [Reference]               | 0 [Reference]             |       |         |
| College or higher                              | 0 [Reference]               | 0 [Reference]             |       |         |
| Graduation                                     | 3.08 (1.88-4.29)            | 0.04                      | 5.02  | <0.001 |
| Monthly family income, ¥                       | 1.10 (0.52-1.69)            | 0.03                      | 3.71  | <0.001 |
| >10,000                                        | 0 [Reference]               | 0 [Reference]             |       |         |
| ≤10,000                                        | 0 [Reference]               | 0 [Reference]             |       |         |
| Living area during the COVID-19 pandemic       | -0.69 (Reference)           | -0.02                     | -2.95 | 0.003   |
| Hubei Province                                 | -1.51 (-0.23)               | -0.02                     | -2.95 | 0.003   |
| Other provinces                                | 0 [Reference]               | 0 [Reference]             |       |         |
| Exercising during the COVID-19 pandemic         | -2.06 (Reference)           | -0.07                     | -8.95 | <0.001 |
| Yes                                            | -2.51 (-1.61)               | -0.07                     | -8.95 | <0.001 |
| No                                             | 0 [Reference]               | 0 [Reference]             |       |         |
| Stress during the COVID-19 pandemic             | 0.41 (Reference)            | 0.08                      | 9.33  | <0.001 |
| Receiving psychological interventions during the COVID-19 pandemic | 1.36 (0.30-2.41) | 0.02 | 2.51 | 0.012 |
| Yes                                            | 0 [Reference]               | 0 [Reference]             |       |         |
| No                                             | 0 [Reference]               | 0 [Reference]             |       |         |

Abbreviations: ADHD symptoms, Symptoms of attention deficit and hyperactivity; COVID-19, Coronavirus disease 2019; PTSD, Post-traumatic stress disorder.

The findings of this survey and analysis show the high burden of PIU among university students in Wuhan after long-term school closure and the association between PIU with ADHD symptoms and other mental symptoms, which highlights the importance of maintaining mental wellbeing among university students during the COVID-19 pandemic. Existing evidence also showed that the impact of COVID-19 associated stress and quarantine experience on PIU during pandemic. Our findings indicate that those acquiring psychological knowledge and exercising regularly during the pandemic were less likely to have PIU. Therefore, comprehensive interventions are needed for vulnerable students to address the high burden of PIU.
alleviate the adverse mental health impact of the pandemic.

4.2. Strength and limitations

Although our participants come from universities in Wuhan, they lived in 31 different province-level regions across China during the pandemic. Our study’s large sample size and extensive geographic coverage are strengths. We identify two limitations. First, using screening self-reports rather than interviews using diagnostic criteria may have biased our estimates of PIU and ADHD prevalence. Second, we cannot determine causality between ADHD and PIU because of the inherent drawback of a cross-sectional design.

5. Conclusions

We found that the prevalence of PIU among university students in China during the COVID-19 pandemic was higher than that reported before the pandemic. The positive association between ADHD symptoms and PIU remained significant after controlling for demographic, epidemic-related and psychological factors including moderate to high stress levels and associated depression, anxiety, insomnia, and PTSD symptoms, which were all individually associated with PIU. Exercising regularly during the COVID-19 pandemic was identified as associated with lower university students’ risk for PIU. We cannot draw any causal conclusions about PIU and ADHD symptoms. Indeed, people with ADHD symptoms before the COVID-19 pandemic may have a higher risk of developing PIU, while others without ADHD symptoms show an association between high levels of internet usage and ADHD symptoms as part of their coping strategy for the stress and symptoms resulting from the COVID-19 pandemic.

Authorship contribution statement

Lu L, Shi J and Bao YP designed this survey, commented on, and revised the manuscript, and made the final version. Zhao YM was responsible for data analysis and writing the initial draft. Jiang ZD, Guo SH, Lu SD, Lu Y, Huang GF contributed to recruiting the participants and data collection. Zhao YM, Guo SH, Wu P, Lu QD, Xu YY, Liu L, Su SZ, Shi L, Que JY, Sun Y, Sun YK, Deng JH, Meng SQ, Yan W, Yuan K, Sun SW, Yang L, Ran MS, Kosten TR, Strang J, Lu Y, Huang GF designed the questionnaire, commented on and revised the manuscript. All authors contributed to the final draft of the manuscript.

Role of the funding source

This study is supported by grants from the National Key Research and Development Program of China (no. 2019YFA0706200), the National Natural Science Foundation of China (no. 81761128036, 81821092 and 31900805), Special Research Fund of PKUHSC for Prevention and Control of COVID-19 and the Fundamental Research Funds for the Central Universities (no. BMU2020HYKZX008).

Declaration of Competing Interest

John Strang is an NIHR Senior Investigator and is supported by the U.K. National Institute for Health Research (NIHR) Biomedical Research Centre for Mental Health at South London and Maudsley NHS Foundation Trust and King’s College London, U.K.

Acknowledgements

None.

References

Abel, T., McQueen, D., 2020. The COVID-19 pandemic calls for spatial distancing and social closeness: not for social distancing! Int J Public Health 65, 231. https://doi.org/10.1007/s00385-020-01366-7.

Aboujaoude, E., 2010. Problematic Internet use: an overview. World Psychiatry 9, 85–90. https://doi.org/10.1002/sdp.201000278.x.

Bao, Y., Sun, Y., Meng, S., Shi, J., Lu, Y. 2020. 2019-nCoV epidemic: address mental health care to empower society. Lancet (London, England) 395, e37–e38. https://doi.org/10.1016/s0140-6736(20)30309-3.

Blast, M.D., Giardina, A., Giordano, C., Cogo, L.G., Tosto, C., Billieux, J., Schimmenti, A., 2019. Problematic video game use as an emotional coping strategy: Evidence from a sample of MMORPG gamers. J Behav Addict 8, 25–34. https://doi.org/10.1556/2056.2019.0.092.

Carli, V., Dunke, T., Wasserman, D., Hadlaczky, G., Despaulis, R., Kramarz, E., Wasserman, C., Sarchiapone, M., Hoven, C.W., Brunner, R., Kees, M., 2013. The association between pathological internet use and comorbid psychopathology: a systematic review. Psychopathology 46, 1–13. https://doi.org/10.1027/1615-1999.2013.0003.

Castellanos, F.X., Tannock, R., 2002. Neuroscience of attention-deficit/hyperactivity disorder: the search for endophenotypes. Nature Reviews Neuroscience 3, 617–628. https://doi.org/10.1038/nrn96.

Chi, X., Lin, L., Zhang, P., 2016. Internet Addiction Among College Students in China: Prevalence and Psychosocial Correlates. Cyberpsychol Behav Soc Netw 19, 567–573. https://doi.org/10.1089/cyber.2016.0234.

Deslandes, S.F., Coutinho, T., 2020. The intensive use of the internet by children and adolescents in the context of COVID-19 and the risks for self-inflicted violence. Cien Saude Colet 25, 2479–2486. https://doi.org/10.1590/1413-812320202556.11472902.

Diamond, A., 2005. Attention-deficit disorder (attention-deficit/hyperactivity disorder without hyperactivity): a neurologically and behaviorally distinct disorder from attention-deficit/hyperactivity disorder (with hyperactivity). Dev Psychopathol 17, 807–825. https://doi.org/10.1017/S0954579405005388.

Dong, H., Yang, F., Lu, X., Hao, W., 2020. Internet Addiction and Related Psychological Factors Among Children and Adolescents in China During the Coronavirus Disease 2019 (COVID-19) Epidemic. Front Psychiatry 11, 00751. https://doi.org/10.3389/fpsyg.2020.00751.

Elhai, J.D., Yang, H., McKay, D., Asmundson, G.J., 2020. COVID-19 anxiety symptoms associated with problematic smartphone use severity in Chinese adults. J Affect Disord 274, 576–582. https://doi.org/10.1016/j.jad.2020.05.090.

Faraone, S.V., Asherson, P., Banaschewski, T., Biederman, J., Puig-Antich, J., Ramos-Quiroga, J.A., Rohde, L.A., Sonuga-Barke, E.J., Tannock, R., Franke, B., 2015. Attention-deficit/hyperactivity disorder. Nature reviews. Disease primers 15, 1020. https://doi.org/10.1038/nrdp.2015.20.

Gao, L., Gan, Y., Whittall, A., Lippe, S., 2020. Problematic Internet Use and Perceived Quality of Life: Findings from a Cross-Sectional Study Investigating Work-Time and Leisure-Time Internet Use. Int J Environ Res Public Health 17. https://doi.org/10.3390/ijerph17114056.

Kessler, R.C., Adler, L., Ames, M., Demler, O., Faraone, S., Hiripi, E., Howes, M.J., Jin, R., Secnik, K., Spencer, T., Ustun, T.B., Walters, E.E., 2005. The World Health Organization Adult ADHD Self-Report Scale (ASRS): a short screening scale for use in general population. Psychol Med 35, 245–256. https://doi.org/10.1017/s003329170400278x.

Lei, L., Shi, J., Lu, Y., Huang, GF designed the questionnaire, commented on and revised the manuscript. All authors contributed to the final draft of the manuscript.

Role of the funding source

This study is supported by grants from the National Key Research and Development Program of China (no. 2019YFA0706200), the National Natural Science Foundation of China (no. 81761128036, 81821092 and 31900805), Special Research Fund of PKUHSC for Prevention and Control of COVID-19 and the Fundamental Research Funds for the Central Universities (no. BMU2020HYKZX008).

Declaration of Competing Interest

John Strang is an NIHR Senior Investigator and is supported by the U.K. National Institute for Health Research (NIHR) Biomedical Research Centre for Mental Health at South London and Maudsley NHS Foundation Trust and King’s College London, U.K.

Acknowledgements

None.
Ra, C.K., Cho, J., Stone, M.D., De La Cerda, J., Goldenson, N.I., Moroney, E., Tung, I., Lee, S.S., Leventhal, A.M., 2018. Association of Digital Media Use With Subsequent Symptoms of Attention-Deficit/Hyperactivity Disorder Among Adolescents. Jama 320, 255–263. https://doi.org/10.1001/jama.2018.8931.

Rolland, B., Haesebaert, F., Zante, E., Benyamina, A., Haesebaert, J., Franck, N., 2020. Global Changes and Factors of Increase in Caloric/Salty Food Intake, Screen Use, and Substance Use During the Early COVID-19 Containment Phase in the General Population in France: Survey Study. JMIR Public Health Surveill 6, e19630. https://doi.org/10.2196/19630.

Shi, L., Lu, Z.-A., Que, J.-Y., Huang, X.-L., Liu, L., Ran, M.-S., Gong, Y.-M., Yuan, K., Van, W., Sun, Y.-K., Shi, J., Bao, Y.-F., Lu, L., 2020. Prevalence of and Risk Factors Associated With Mental Health Symptoms Among the General Population in China During the Coronavirus Disease 2019 Pandemic. Jama Network Open 3. https://doi.org/10.1001/jamanetworkopen.2020.14053.

Sun, Y.X., Li, Y.X., Yu, C.Q., Li, L.M., 2017. Reliability and validity of depression scales of Chinese version: a systematic review. Zhonghua liu xing bing xue za zhi = Zhonghua liuxingbingxue zazhi 38, 110–116. https://doi.org/10.3760/cma.j.issn.0254-6450.2017.01.021.

Sun, Y., Bao, Y., Lu, L., 2020a. Addressing mental health care for the bereaved during the COVID-19 pandemic. Psychiatry and Clinical Neurosciences 74, 406–407. https://doi.org/10.1111/pcn.13008.

Tateno, M., Tateno, Y., Kamikobe, C., Monden, R., Sakaoka, O., Kanazawa, J., Kato, T.A., Saito, T., 2018. Internet Addiction and Attention-Deficit/Hyperactivity Disorder Traits among Female College Students in Japan. Soa Chongsonyong Chongsin Uihak 29, 144–148. https://doi.org/10.5765/jkasap.180011.

Tateno, M., Teo, A.R., Shirasuka, T., Tayama, M., Watabe, M., Kato, T.A., 2016. Internet addiction and self-evaluated attention-deficit hyperactivity disorder traits among Japanese college students. Psychiatry Clin Neurosci 70, 567–572. https://doi.org/10.1111/pcn.12454.

Wang, L., Zhang, L., Armour, C., Cao, C., Qing, Y., Zhang, J., Liu, P., Zhang, B., Wu, Q., Zhao, Z., Fan, G., 2015. Assessing the underlying dimensionality of DSM-5 PTSD symptoms in Chinese adolescents surviving the 2008 Wenchuan earthquake. Journal of Anxiety Disorders 31, 90–97. https://doi.org/10.1016/j.janxdis.2015.02.006.

Wang, Q., Liu, Y., Wang, B., An, Y., Wang, H., Zhang, Y., Mast, K., 2020. Problematic internet use and subjective sleep quality among college students in China: Results from a pilot study. J Am Coll Health 1–9. https://doi.org/10.1080/07448481.2020.1754831.

Wang, Y., Shi, L., Que, J., Lu, Q., Liu, L., Lu, Z., Xu, Y., Liu, J., Sun, Y., Meng, S., Yuan, K., Ran, M., Lu, L., Bao, Y., Shi, J., 2021. The impact of quarantine on mental health status among general population in China during the COVID-19 pandemic. Molecular Psychiatry. https://doi.org/10.1038/s41380-020-01019-y.

Wathelet, M., Duhem, S., Vaiva, G., Baubet, T., Habran, E., Veerapa, E., Debien, C., Molenda, S., Horn, M., Grandgenette, P., Notredame, C.E., D’Hondt, F., 2020. Factors Associated With Mental Health Disorders Among University Students in France Confined During the COVID-19 Pandemic. JAMA Netw Open 3, e2025591. https://doi.org/10.1001/jamanetworkopen.2020.25591.

Yang, T., Yu, L., Oliffe, J.L., Jiang, S., Si, Q., 2017. Regional contextual determinants of internet addiction among college students: a representative nationwide study of China. Eur J Public Health 27, 1032–1037. https://doi.org/10.1093/eurpub/ckx141.