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.

Journal of Psychiatric Research 153 (2022) 229–235

Contents lists available at ScienceDirect

Journal of Psychiatric Research

journal homepage: www.elsevier.com/locate/jpsychires

The COVID-19 pandemic and problematic usage of the internet: Findings from a diverse adult sample in South Africa

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A B S T R A C T

Background: The coronavirus disease 19 (COVID-19) has led to increased reliance on the internet. How problematic usage of the internet (PUI) and COVID-19 related stress and other clinical variables relate, is unknown. We hypothesised that higher PUI level would be significantly associated with higher levels of: (i) pandemic-related stress; and (ii) impulsive and compulsive symptoms and traits.
Methods: An online community-based cross-sectional survey was used for data collection. Relationships between PUI level and other variables were characterised using correlational analyses. Regression analyses determined the cumulative explanatory power of variables, with partial least squares structural equation modelling (PLS-SEM) to explore path loadings. ANOVA was used to investigate PUI level at varying lockdown levels.
Results: Data from 2110 participants (64.5% female), aged 18–64 years (mean: 24.3, SD: 8.1) suggested that approximately a quarter (n = 489, 23.2%) had medium to high level internet use problems. Impulsive and compulsive symptoms and traits, pandemic-stress, and age were all significantly related to PUI ($p < 0.01$). These associations (medium effect sizes) cumulatively explained 29% of PUI variance. PLS-SEM indicated significant contributory effects, with the association between age and PUI level mediated by impulsivity, pandemic-stress and compulsivity.
Discussion: Pandemic-stress, impulsive-compulsive symptoms and traits and age were related to PUI level. Enhancing resilience to stress, particularly in vulnerable populations, through lifestyle changes and implementation of adaptive coping strategies, is key to reduce risk for PUI during the COVID-19 pandemic and beyond.

1. Introduction

The coronavirus disease 19 (COVID-19) is an often severe and sometimes fatal syndrome caused by the worldwide spread of the severe acute respiratory coronavirus 2 (SARS-CoV-2). The magnitude of the crisis was acknowledged by the World Health Organization (WHO) by declaring the disease a pandemic early in 2020 (World Health Organization, 2020). Despite the availability of vaccinations in many countries, there continue to be newly diagnosed COVID-19 cases across the globe daily. Once considered amongst the top ten in the world in terms of the number of confirmed cases, South Africa is considered one of the worst-affected countries in Africa (Coronatracker, 2021). Moreover, a variant of the virus that carries a much more contagious mutation called N501Y emerged in South Africa, possibly increasing the likelihood of transmission.

Governments in most countries have adhered to WHO guidelines, with varying degrees of *lockdown* strategies becoming the norm (Abel and McQueen, 2020). Globally, lifestyles were forced to change, with dramatically increased usage of the internet one of the most significant sequalae (e.g., De' et al., 2020; Park et al., 2021). Life without the internet has increasingly become unthinkable. Towards the end of 2019, just before pandemic-onset, it was estimated that 51% of the global

Abbreviations: problematic usage of the internet, PUI; coronavirus disease 19, COVID-19; South Africa, SA.

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https://doi.org/10.1016/j.jpsychires.2022.06.035
Received 1 November 2021; Received in revised form 3 May 2022; Accepted 24 June 2022
Available online 28 June 2022

population, or 4 billion people, were internet users (International Telecommunications Union, 2021). In July 2020, 56.3% of the South African population were internet users, with this rate projected to grow to 62.3% in 2025 (Statista.com, 2021). Considering the unprecedented circumstances caused by COVID-19, with many IT companies offering deals to help South Africans to stay connected during lockdown, the percentage of internet users is now likely an underestimation.

While many individuals can use the internet without untoward consequences, it is increasingly recognised that a vulnerable subset can develop problematic usage of the internet (PUI). PUI is an umbrella term referring to excessive compulsive use of the internet leading to marked functional impairment (Fineberg et al., 2018), and which may include gaming, gambling, online buying/shopping, cybersex/pornography use, social media use, cyberchondria, cyberhoarding, cyberstalking, and online streaming (e.g. Brand et al., 2020; Gola et al., 2020). Internet use does not only become problematic when it is time-consuming or interferes with work/task-completion, but it can also become problematic when the *nature* of the activity causes distress or impairment, e.g., financial and relationship difficulties associated with uncontrollable gaming, gambling, buying/shopping, or cybersex/pornography watching (e.g., (Billieux et al., 2015; Ioannidis et al., 2018). Many of these behaviours develop into habits that are difficult to break (e.g., King et al., 2020; Ko and Yen, 2020; Mestre-Bach et al., 2020), and which can be referred to as PUI (Aboujaoude, 2010; Shapira et al., 2003). Most PUI research has been conducted in high income countries, with prevalence rates ranging widely - between 1.5 and 8.0% (Weinstein and Lejoyeux, 2010), likely due to inconsistencies in methodology and sampling. During COVID-19, some of these problematic behaviours may have increased (Sun et al., 2020). There is an emerging body of research that suggests that changes in PUI may be predicted by, or otherwise related to, COVID-19-/lockdown-related stress (Albertella et al., 2021), behavior-specific factors, such as pre-existing severity (Dubey et al., 2020; Håkansson, 2020; Sidor and Rzymski, 2020) and impulsivity/-compulsivity (Albertella et al., 2021; Chamberlain et al., 2018; Tiego et al., 2019a), as well as sociodemographic characteristics such as age and sex (Kuss et al., 2014). To what extent these findings may hold in South Africa, is unknown.

Moreover, internet usage and PUI may also vary according to the level of restriction to curb the spread of the virus. South Africa is considered one of the countries with the most stringent lockdown regulations at the time of writing, comparable to those implemented in the Philippines and Jordan (e.g., Greyling et al., 2021). Locally, there have been five levels of restriction, starting with Alert Level 5 as the tightest, and gradually relaxing to Alert Level 1. Regulations included the controversial "ban" on alcohol and cigarettes during Level 5, restrictions on leisure, the closure of schools, universities and other educational institutes, restricted attendance of funerals and other gatherings of family and friends, and a curfew. Arguably, these tight restriction levels forcing individuals to stay at home constitutes a life stressor that may increase internet usage in healthy individuals as well as those with already existing PUI, similar to other addictive and compulsive behaviours that increase with rising stress. Indeed, stress may facilitate progression toward such problematic compulsive behaviors by promoting a shift toward habit learning (e.g., Garami et al., 2019; Koob and Schulkin, 2019; Schwabe and Wolf, 2009; van der Straten et al., 2020; Wirz et al., 2018). Arguably, high stress may effectively shorten the window of time that a behavioral pattern is malleable (Albertella et al., 2021). The ways in which COVID-19 related stress have impacted internet use and PUI in South Africa, from the initial stages of lockdown to late in 2020, are not known, however.

Therefore, using an online survey, the current study investigated PUI level during the COVID-19 pandemic in South Africa, a low-to middle-income country (LMIC). Specially, we explored the associations of age, COVID-19 related stress, impulsivity and compulsivity, with PUI level, and variations in these associations according to sex. We hypothesised that higher PUI level during the pandemic would be significantly associated with higher levels of (i) pandemic-related stress; and (ii) impulsive and compulsive symptoms and traits.

2. Methods

2.1. Participants and recruitment

Recruitment proceeded via the internet and media advertisements (online and offline). The language of invitations was neutral to avoid participation bias (i.e., not saying the study was about negative aspects of internet use). Convenience and snowballing sampling strategies were employed. To maximize inclusivity, the researchers recruited participants across several online platforms to obtain a general population sample with varying degrees of internet use, using a combination of approaches to generate a more diverse sample. The survey was also distributed to students and staff at four South African universities. Criteria for inclusion were age 18–65 years and having internet access.

2.2. Procedures and assessments

Participants completed the survey via a unique website link. This link was accessible to all mainstream technological devices, and useable in multiple Web browsers such as Google Chrome and Safari. The average time taken to complete the survey was 45 min. The informed consent form stated that respondents could log off and on again without losing already entered responses, thereby enabling breaks. On completion, participants could be entered into a lucky prize draw.

The survey included items on demographics. Assessment of the current level of PUI comprised the 10-item version of the Internet Addiction Test (Joint Expert Group, JEG-IAT-10), developed from the full 20-item IAT (Young, 1998), the most widely used and researched measure of generalized PUI to date, and measured on a 5-point Likert-scale ranging from 1 (rarely) to 6 (always). The JEG-IAT-10 taps into motivations of escape and mood regulation, social and emotional consequences, such as symptoms of affective withdrawal, and secrecy, defensiveness, and interpersonal conflict – all in relation to internet use (Tiego et al., 2021). Precise definitions have not yet been defined; however, JEG-IAT-10 cut-offs have been operationalized as follow: totals ranging between 10 and 20 indicate low level, 21 to 40 medium level, and 41 to 50 high level of internet problems. Comparisons with gold-standard in-person clinical assessments are pending. The JEG-IAT-10 exhibit superior psychometric properties as compared against the full-length IAT (Tiego et al., 2021).

The 22-item Impact of Event Scale - Revised (IES-R) (Weiss and Marmar, 1997) was included to assess intrusive and avoidant cognitions. It is frequently used to evaluate stress reactions after traumatic events, with items rated from 0 (not at all) to 4 (extremely). The IES-R was used as an index of COVID-19-specific distress, with instructions focused on COVID-19/lockdown: "Please read each item, and then indicate how frequently those comments were true for you during the past 7 days with respect to your experience of COVID-19." The output measure was the total IES-R score, with higher scores suggesting greater concern for health and well-being consequences. Studies in several trauma populations have shown this scale to have good psychometric properties (Beck et al., 2008; Creamer et al., 2003; Sveen et al., 2010).

Two questionnaires were used to quantify impulsive and compulsive symptoms and traits, relevant to addictive online behaviours, i.e., the Southampton Chicago Impulsivity Screener (S–CIS) and the Cambridge Chicago Trait Compulsivity Scale (CHI-T). The S-CIS is a 12-item screener to identify presence of often overlooked impulsive-compulsive symptoms and disorders, including compulsive buying/shopping, compulsive stealing, trichotillomania, skin-picking disorder, nail-biting disorder, gambling disorder, pyromania, compulsive sex disorder, binge-eating disorder, PUI, non-suicidal self-injury, and intermittent explosive disorder (Chamberlain and Grant, 2018). S–CIS total is calculated from the number of yes-answers, which indicate the

number of impulsive-compulsive symptom types present. We used this new tool because other impulsivity scales such as the Barratt Impulsivity Scale may have unstable factor structures (Hook et al., 2021) whereas scales such as the Short UPPS were deemed to be too long, given the pragmatic constraints on the length of the survey, and focus more on the level of deep psychological/personality tendencies. These other instruments also do not operate at the level of symptoms particularly closely, whereas S–CIS does. Also included was the CHI-T, a 15-item comprehensive trans-diagnostic measurement of compulsivity symptoms/traits, previously validated and shown to be psychometrically sound (Chamberlain and Grant, 2018), including at large scale (Hampshire et al., 2021). The Cronbach alphas (α) of these 4 scales ranged, in the dataset, between 0.74 (S–CIS) and 0.93 (IES-R), with JEG-IAT-10: $\alpha = 0.82$, CHIT: $\alpha = 0.78$, suggesting satisfactory internal consistency.

2.3. Data analyses

Descriptive analyses rendered demographic and clinical characteristics data. Correlational analyses determined the associations between variables of interest. Linear multivariate regression analysis examined the cumulative contribution of the independent variables, i.e., impulsive symptoms (S–CIS total), COVID-19 related stress (IES-R total), compulsive symptoms/traits (CHI-T total) and age, on the dependent variable, i.e., mean PUI-level (JEG-IAT-10 total). This was followed by a partial least squares structural equation modelling (PLS-SEM) path model, incorporating the variables shown by the regression to significantly influence PUI (formative indicators), to explore potential directionality of effects statistically. Multi Group Analysis was subsequently conducted to test whether gender had a moderating effect in the relationships highlighted by the PLS SEM model. Finally, ANOVA compared cross-sectional data on PUI level, impulsive symptoms, COVID-19 related stress, and compulsive symptoms/traits, collected at different time-points of the study period, under varying lockdown levels.

2.4. Ethics

The investigation was carried out in accordance with the latest version of the Declaration of Helsinki. Study procedures and consent forms were approved by the Institutional Review Board of Stellenbosch University, South Africa. Informed consent was obtained from all participants after the procedures had been explained, and before entering survey responses. The consent form clearly stated that data would be anonymized. Participants were free to discontinue the survey at any point.

3. Results

3.1. Demographic and clinical findings

Data were collected during the period 26 March to October 5, 2020. From the 4644 participants that read the introduction to the survey, 4110 gave consent to take part, 4068 completed the section on demographics, 3254 proceeded to and completed the first questionnaire (JEG-IAT-10), and 2110 completed the entire survey. Two thousand (2000; 51% of the total dataset) participants that consented to take part, dropped out before completing the survey. Seventy five percent (1496; 75%) of those provided demographic information (i.e., mostly females [63%], from diverse ethnic backgrounds, aged between 18 and 22 years). The 2110 participants (1361, or 64.5%, female) were from diverse ethnic backgrounds, and aged 18–64 years (mean: 24.3, SD: 8.1) (supplementary materials: Table 1, Fig. 1). Males had higher rates of PUI on the JEG-IAT-10 than females ($F(1, 2099) = 10.9$, $p \leq 0.01$), Cohen's $d = 0.15$. Age was significantly and negatively correlated with PUI level ($r = -0.2$, $p < 0.01$; small effect size).

Total scores on the JEG-IAT-10 ranged from 10 to 50, with a mean (SD) of 17.3 (6.2). Based on working cut-offs (Tiego et al., 2021), the majority of the sample had no or mild PUI (n = 1621, 76.8%), with approximately a quarter (n = 489, 23.2%) reporting medium to high level internet use problems (supplementary materials: Table 2). Descriptive data collected using the other assessment measures (IES-R, S–CIS and CHI-T) are summarized in Table 3 in the supplementary materials.

Table 1
Linear multivariate regression analysis indicated significant roles for age, COVID-19-related stress (IES-R total score), impulsivity (S–CIS total) and compulsive traits (CHI-T total) in statistically explaining PUI, accounting for inter-play between variables.

Variables (N = 2090)	Standardized coefficients		Unstandardized coefficients		*t*	*p*
	β	Standard Error of β	β	Standard Error of β		
Age	−0.10	0.02	−0.08	0.01	−5.30	<0.01
Impulsive symptoms (S–CIS total)	0.33	0.02	1.02	0.07	15.39	<0.01
COVID-19 related stress (IES-R total)	0.22	0.02	0.08	0.01	10.49	<0.01
Compulsive symptoms/traits (CHI-T total)	0.10	0.02	0.11	0.02	5.07	<0.01

3.2. Correlational and regression analyses

PUI scores were significantly and positively correlated with the level of distress due to COVID-19 ($r = 0.38$, $p < 0.01$; medium effect size), impulsive-compulsive symptoms and traits (S–CIS: $r = 0.47$, $p < 0.01$, medium effect size; CHI-T: $r = 0.31$, $p < 0.01$, medium effect size) and negatively with age ($r = -0.2$, $p < 0.01$, small-medium effect size). Linear multivariate regression analysis suggested significant roles for all independent variables in PUI-level, explaining 29% of the variance ($R = 0.54$, $R^2 = 0.29$, $F(4,2085) = 209.2$, $p < 0.001$; Table 1).

Model assumptions were met, including absence of notable multi-collinearity (supplementary materials, Table 4).

Partial least squares structural equation modelling (PLS-SEM) results:

Results of the partial least squares path modelling results are shown in Fig. 1 (also see Table 5 in the supplementary materials). In terms of measured constructs, the average variance extracted (AVEs) were less than 0.5, which indicates that convergent validity did not hold, but the composite reliability scores were higher than 0.7, suggesting that the convergent validity of the constructs was still adequate (Fornell and Larcker, 1981). Path modelling indicated that the following variables all significantly directionally contributed to higher PUI levels in the sample (from higher to lower influence): impulsive symptoms (S–CIS), COVID-19-related stress (IES-R), compulsive symptoms/traits (CHI-T)) and age. The path coefficients of the first three were positive, suggesting that as these values increase, PUI level would also increase as well. The path loading of age was negative, suggesting that with younger age, PUI level would increase. In addition, impulsive symptoms, COVID-19-related stress and compulsive symptoms/traits may act as mediators influencing the association between age and PUI level, suggesting that a change in age cause a change in these mediator variables, which, in turn, result in PUI level change. Younger age may thus be associated with increased levels of impulsivity, COVID-19-related stress and compulsivity, which in turn result in higher PUI levels.

The SEM model was applied in males and females separately, and path coefficients compared. The findings suggested that the sexes did not differ in terms of any of these paths, and path coefficients for the sexes were similar to the group as a whole (supplementary materials:

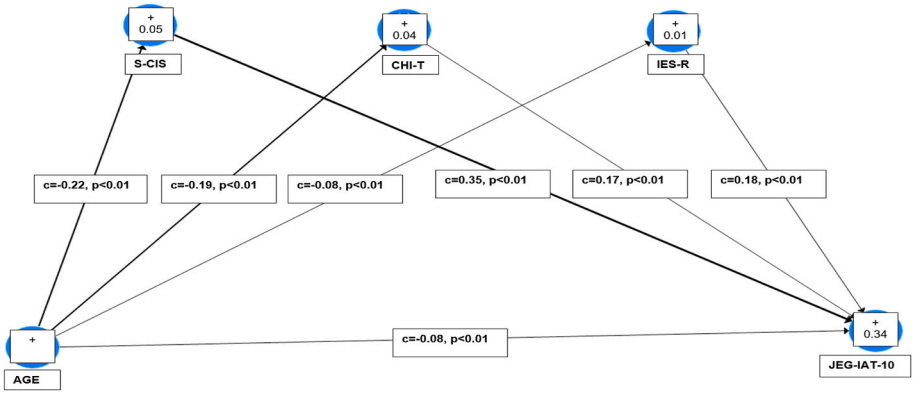

Fig. 1. A graphic representation of the PLS structural equations model with PUI level as the dependent variable, including path coefficients and p-values for each independent variable*
* The constructs are shown as circles (including R^2 and direction of path loading [positive/negative]), and the number between constructs is the coefficient value (c) with the p-value (p) in brackets.
* PUI-level, impulsive symptoms, compulsive symptoms/traits, and COVID-10-related stress as indicated by totals on the JEG-IAT-10, S–CIS, CHI-T and IES-R, respectively.

Table 6).

3.3. Comparison of cross-sectional data on PUI level, collected under varying lockdown levels

We also explored PUI rates at 5 different timepoints, considering the different lockdown levels that were enforced in South Africa 2020. The numbers of participants per lockdown level were calculated on the days that marked the end of each level of lockdown: April 30, 2020 (n = 654, end of lockdown level 5), May 30, 2020 (n = 350, end of lockdown level 4), August 17, 2020 (n = 917, end of lockdown level 3), 20 September (n = 110, end of lockdown level 2), and October 5, 2020 (n = 79, end of lockdown level 1). There were significant differences in PUI level at these different lockdown levels ($F(4, 2105) = 6.7$, p=<0.01), with PUI level assessed during lockdown level 3 (mean [SD]: 18.1 [6.7]) significantly higher than that of participants taking part during lockdown level 4 (mean [SD]: 16.6 [5.5]; Cohen's D: 0.23) and 5 (mean [SD]: 16.7 [5.6]; Cohen's D: 0.22) (both $p < 0.01$), respectively. COVID-19-related stress also differed significantly at the various lockdown levels ($F(4, 2105) = 8.6$, p=<0.01), with stress level assessed during lockdown level 3 (mean [SD]: 24.7 [17.4]) higher than that of participants taking part during all other lockdown levels (level 1: mean [SD]: 20.7 [18]; Cohen's D: 0.22; level 2: mean [SD]: 17.9 [16.8]; Cohen's D: 0.39); level 4: mean [SD]: 19.7 [15]; Cohen's D: 0.3) and level 5: mean [SD]: 22.5 [16.4]; Cohen's D: 0.13) (all $p < 0.05$), respectively. Similarly, the level of compulsive symptoms/traits also differed significantly amongst the various lockdown levels ($F(4, 2105) = 4.7$, p=<0.01), with the level at lockdown level 3 (mean [SD]: 27.2 [6]) significantly higher than that of participants at lockdown level 1 (mean [SD]: 25.5 [6.3]; Cohen's D: 0.29), level 4 (mean [SD]: 25.9 [5.7]; Cohen's D: 0.22), and level 5 (mean [SD]: 26.4 [6]; Cohen's D: 0.14) (all $p \leq 0.01$), respectively. The level of impulsive symptoms did not differ amongst the various lockdown levels ($F(4, 2105) = 1.5$, $p = 0.2$).

4. Discussion

Using a cross-sectional design, this study investigated PUI level during the COVID-19 pandemic in South Africa. We aimed to explore whether contextual variables of age, impulsive-compulsive symptoms/traits, and pandemic-related stress were significantly related to PUI. Analyses of data from a diverse sample, with age ranging broadly and from different backgrounds (supplementary materials: Table 1 for ethnicity, Fig. 1 for histogram of participants' ages) confirmed our *a priori* hypotheses. Investigated variables were correlated with medium effect size, and cumulatively explained approximately 29% of variance in PUI in multivariate modelling. Path modelling also indicated that all variables except age were associated with higher PUI.

This study contributes to the paucity of publications on PUI in Africa. While one should not assign 'clinical' thresholds to PUI scores due to absence of rigorous validation studies, our findings suggested that almost a quarter of the study sample had total JEG-IAT-10 scores indicative of a putatively medium to high level of internet use problems. This appears to be a higher percentage of the study population as compared to other studies in adults, especially those published before COVID-19 (e.g., Bakken et al., 2009; Zadra et al., 2016), and may be consistent with the suggestion that this pandemic has increased the tendency to excessively engage in internet-related activities as a coping strategy (Király et al., 2020), albeit the study design cannot address causality or whether such effects would be sustained throughout the pandemic, or might habituate with time.

Our finding of higher levels of COVID-19-related stress statistically predicting increased PUI, in a cross-sectional fashion, is key. Indeed, this pandemic represents a major stressful event. Several investigations of the potential harmful impact thereof on mental health exist (Rajkumar, 2020), with some highlighting unpredictability, uncertainty, seriousness of the disease, misinformation and social isolation as contributors to stress and mental morbidity, amongst others (Zandifar and Badrfam, 2020). The economic impact of COVID-19 and its effects on well-being, as well as high levels of fear and panic-driven behaviour such as stockpiling resources, have also been emphasized (Shigemura et al., 2020). Some have labelled anxiety as the dominant emotional response to the outbreak (Lima et al., 2020). Anecdotally, extreme stress during, and emotional response to this pandemic have also been noted among South Africans (Spotlight, 2021). Here and elsewhere, some patients with pre-existing mental disorders or problematic/addictive behaviours (Sinha, 2008) such as PUI may be at higher risk of relapse or new episodes of their disorder due to pandemic-stress (Yao et al., 2020; Zhu et al., 2020). The psychological stress related to COVID-19 may contribute to a mindset that rationalizes new unhealthy habits (e.g., engaging in poorly controlled internet use or excessive screen time) as necessary for coping, thus potentially posing a longer-lasting threat (Király et al., 2020). Notably, the link reported here between COVID-19 related stress and PUI may be bi-directional. Excessive worries about COVID-19 would be expected to fuel internet use (e.g., increased reading of health pages and COVID-related news); in parallel, reading such materials in turn can fuel greater stress. Future directions include disentangling directions of effect, requiring a longitudinal research design.

Compared to all variables investigated here, symptoms of impulsive and compulsive disorders (indicated by the comorbid symptom domains on a screening tool capturing a range of disorders often overlooked in psychiatric practice) had the strongest association with PUI. This is partially consistent with work that argued that PUI can be considered as an impulse-control spectrum problem (Mazhari, 2012). Trans-diagnostic levels of compulsivity also contributed to the statistical model. Compulsivity refers to the tendency to engage in repetitive, habitual behaviours that are difficult to control, and which interfere with goals (e.g., Figee et al., 2016). Higher levels of trait compulsivity have been associated with addictive and compulsive behaviours, including PUI (e.

g., Albertella et al., 2020a). In terms of its latent structure, there are strong theoretical and clinical grounds suggesting that compulsivity is a core PUI construct (e.g., Chamberlain et al., 2018; Dong and Potenza, 2014; Fineberg et al., 2014; Ho et al., 2014; Ioannidis et al., 2016), in keeping with our findings. A previous separate study, also including a South African cohort, provided evidence for two subtypes of PUI that differed in severity: a lower severity "impulsive" subtype (linked with attention-deficit hyperactivity disorder symptoms), and a higher severity "compulsive" subtype (linked with obsessive-compulsive personality traits) (Tiego et al., 2019a).

Like adults, children and adolescents use the internet for various purposes, such as entertainment, learning, communication, and learning. Here, we focused on PUI across a wide age range allowing assessment of potential differences between individuals from different age groups in terms of PUI. Regression findings suggested a significant role for age in PUI albeit statistically less significant compared to the other variables. The path loading of age was negative, suggesting that younger age was associated with increased PUI. Mediation effects were also noted, with the association between age and PUI being statistically cross-sectionally mediated by impulsivity, COVID-19-related stress, and compulsivity. Young individuals are generally considered most vulnerable for PUI (e.g., Mellouli et al., 2018). Of note however is that PUI is likely a *multifaceted* age-related problem (Ioannidis et al., 2018). There may be age-related differences in PUI in general, or in terms of different problematic online behaviours (Ioannidis et al., 2018). Youth might be more at risk of developing PUI with a propensity for viewing pornography or to be involved in online gaming, a vulnerability that may be less in middle age and wane with increasing age. With most parents being at home during lockdown, with increased supervision over their children's online activities, the relatively weaker link between age and PUI is thus not so surprising. PUI in older populations have not yet been comprehensively investigated, and it should be considered that the current study had relatively high representation from younger individuals between 18 and 25 years (supplementary materials: Fig. 1).

PUI may differ as a function of sex. Our findings suggested however that males and females were similar in terms of their PUI rates and in terms of the associations found between the independent variables and PUI level under COVID-19. This is in line with work suggesting that both sexes are at risk for PUI or similarly affected by COVID-19 (Ioannidis et al., 2018; Király et al., 2014; Shen et al., 2021).

Our finding that PUI level differed according to the level of restriction, is interesting, but in the opposite direction than expected. Caution is needed when interpreting this result, as changes to lockdown level could impact who took part, i.e., the groups may not be comparable, as possibly indicated by the large differences in cell sizes across restriction groups. However, if this finding does reflect underlying differences as a function of lockdown status, potential explanations for our finding that levels of PUI, COVID-19-related stress, and compulsivity at Alert Level 3 were higher than at more stringent levels, include the fact that level 3 was implemented mid-winter (June–August), a season associated with adverse effects on mental health, and with most people spending the majority of their days indoors. Perhaps more important is that the number of COVID-19 cases in South Africa peaked during this period (particularly July 5–11, 2020, with 13 000+ cases daily) (NICD, 2020). South Africans would have been more stressed under these circumstances, potentially sparking increased engagement in all available coping mechanisms – including the internet. Another possible explanation involves 'habituation': i.e., the acute impact of the pandemic leading to changes in mental health (such as PUI) that may then ameliorate as people adapt to the pandemic. Intriguingly, a meta-analysis of longitudinal studies is suggestive of population level habituation for other areas of mental health (anxiety/depression) (Robinson et al., 2021). Another possibility is that PUI requires some *gestational* time before it manifests, i.e., latency between the extreme stress and establishment of PUI symptoms. Therefore, while more stringent lockdown existed in March/April 2020, it may be that the problematic routines did not establish until later on, when restrictions were less. To our knowledge, ours is the first study that has investigated the impact of various lockdown levels on problematic or addictive behaviour, warranting further exploration.

Our study has several limitations. Participants were recruited through social media and on four university campuses and may therefore not be representative of the whole general population of South Africa. The survey also likely rendered a *self-selected* sample introducing limitations to the generalizability of findings, though we were careful to try to minimise participation bias by using neutral text. In addition, data collection was conducted via an online survey which has inherent limitations. Nevertheless, online reporting may render more accurate information, with increasing evidence for the validity of this methodology, especially in populations where individuals engage in high-risk behaviours such as gambling (Barratt et al., 2015). It was also particularly useful in the context where movement and in-person contact were restricted. In addition, we focused on PUI in general, not specifying the different manifestations of PUI, an avenue that needs to be explored in future. The current study also did not control for other potentially confounding variables such as depression, illicit drug use, IQ, or ADHD, which have all been associated with problematic or addictive behaviours (e.g., (Ostinelli et al., 2021; Sjölund et al., 2015), and which deserve further study. Future studies should also investigate the interaction between impulsivity and compulsivity, as individuals with high levels of both may potentially be at greatest risk of developing, or increasing, such problematic behaviours (Albertella et al., 2020b, 2021; Prochazkova et al., 2018; Tiego et al., 2019b). Lastly, while we used an extensively validated trans-diagnostic scale for compulsivity, we used a relatively new tool for impulsivity: as such it would be important for future work to extend the range of measures used to examine links with PUI, as well as to explore the properties of the new instrument in more detail and at larger scale, in a variety of populations for cross-validation.

Despite these limitations, our study contributes to the paucity of work on PUI in the context of COVID-19, suggesting a significant association between pandemic-related stress and levels of PUI in a South African sample. The study findings suggest that managing pandemic-related stress should be a public health consideration. It may be argued that PUI may not even be an actual disorder within this context but simply a symptom of drastically increased stress and abnormal circumstances. Managing the impact of COVID-19-related stress will require concerted efforts (Király et al., 2020). Enhancing resilience to stress, particularly in vulnerable populations including children and adolescents, through lifestyle changes and use of adaptive or healthy coping strategies, may reduce the risk for PUI and its negative sequalae during the COVID-19 pandemic and beyond. Moreover, intervening early, possibly before impulsive-compulsive behaviours and traits become entrenched, is critical to prevent progression to problematic or addictive disorders (Gillan et al., 2016) such as PUI. These cross-sectional data draw attention to the need for future studies to address PUI in general and its different manifestations, longitudinally where possible, taking into consideration any pre-existing conditions. Whether our findings hold for higher income, developed countries, should also be investigated.

Funding source

National Research Foundation of South Africa (CSRU180501325167)

Disclosures and declaration of interest

MY is supported by a National Health and Medical Research Council (NHMRC) of Australia Fellowship (APP1117188) and the David Winston Turner Endowment Fund. DJS has received research grants and/or consultancy honoraria from Johnson & Johnson, Lundbeck, Servier, Takeda and VistaGen. JEG has received research grants from the TLC

Foundation for Body-Focused Repetitive Behaviors, Biohaven, Promentis, and Avanir Pharmaceuticals. SRC's role in this study was funded by a Wellcome Trust Clinical Fellowship. He receives and honorarium from Elsevier for journal editorial work, and previously consulted for Promentis. This research was funded in whole, or in part, by Wellcome [110049/Z/15/Z and 110049/Z/15/A]. For the purpose of open access, the author has applied for a CC BY public copyright licence to any Author Accepted Manuscript version arising from this submission. The other authors do not have any disclosures to report.

CRediT authorship contribution statement

Christine Lochner: Conceptualization, Funding acquisition, Project administration, Formal analysis, Writing – original draft. **Lucy Albertella:** Data curation, Software, Writing – review & editing, Writing - editing. **Martin Kidd:** Data curation, Formal analysis, Writing – review & editing, Writing - editing. **Zelal Kilic:** Data curation, Software, Writing – review & editing, Writing - editing. **Konstantinos Ioannidis:** Formal analysis, Assistance with analyses, Validation, Writing – original draft. **Jon E. Grant:** Validation, Writing – review & editing, Writing - editing. **Murat Yücel:** Conceptualization, Writing – review & editing, Writing - editing. **Dan J. Stein:** Conceptualization, Writing – review & editing, Writing - editing. **Samuel R. Chamberlain:** Conceptualization, Investigation, Methodology, Formal analysis, Writing – review & editing, Writing - editing.

Acknowledgements

National Research Foundation of South Africa (CSRU180501325167); European Network for Problematic Usage of the Internet (COST Action 16207)

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2022.06.035.

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