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# Predictors of problematic smartphone use among young adult lesbian, gay and bisexual individuals during the COVID-19 pandemic: a four-year follow-up study

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## Abstract

**Background** This 4-year follow-up study was conducted to evaluate the predictive effects of prepandemic individual and environmental factors on problematic smartphone use (PSU) among young adult lesbian, gay, and bisexual (LGB) individuals during the COVID-19 pandemic.

**Methods** Data on prepandemic PSU, demographics, sexual stigma (e.g., perceived sexual stigma from family members, internalized sexual stigma, and sexual microaggression), self-identity confusion (e.g., disturbed identity, unconsolidated identity, and lack of identity), anxiety, depression, and family support were collected from 1,000 LGB individuals between August 2018 and June 2019. The participants' PSU was surveyed again after 4 years (between August 2022 and June 2023). The associations of prepandemic individual and environmental factors with PSU at follow-up were analyzed through linear regression.

**Results** In total, 673 (67.3%) participants completed the follow-up assessment. The severity of PSU significantly decreased after 4 years ( $p = .001$ ). Before the incorporation of PSU at baseline into the analysis model, the results of the model revealed that high levels depressive symptoms ( $p < .001$ ), disturbed identity ( $p < .001$ ), and perceived sexual stigma from family members ( $p = .025$ ) at baseline were significantly associated with PSU at follow-up. After the incorporation of PSU at baseline into the analysis model, the results of the model revealed that high levels PSU ( $p < .001$ ) and depressive symptoms ( $p = .002$ ) at baseline were significantly associated with PSU at follow-up.

**Conclusion** Interventions aimed at reducing the severity of PSU among LGB individuals should be designed considering the predictors identified in our study.

**Keywords** Smartphone, Gay, Lesbian, Bisexual, Sexual stigma, Psychological well-being

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## Background

Smartphones have become an indispensable tool in modern life. People use smartphones to connect with others, get messages, have fun, learn, and go about their daily lives. However, smartphones have the ability to provide quick fun and close social interaction, which has led to an increasing dependence on smartphones. Individuals who have problematic smartphone use (PSU) experience compulsive smartphone use, tolerance to smartphone use, withdrawal symptoms if smartphones are unavailable, and functional impairment due to PSU [1]. A meta-analysis found that the global pooled prevalence estimate of PSU was 26.99% for PSU [2]. Another meta-analysis on 27 published studies demonstrated that PSU was associated with mental health problems (e.g., anxiety, sleep problems, and depression), physical problems (e.g., musculoskeletal problems), sedative lifestyles, and accidents [3]. Brand et al. proposed a Person-Affect-Cognition-Execution (I-PACE) model to illustrate the development and maintenance of problematic digital devices use [4]. The I-PACE model hypothesizes that problematic digital devices use is the consequence of interactions between predisposing factors (e.g., neurobiological and psychological constitutions), moderators (e.g., coping styles and Internet-related cognitive biases), and mediators (e.g., affective and cognitive responses to situational triggers in combination with reduced executive functioning); conditioning processes may strengthen these associations within an addiction process [4, 5]. Tan (2023) also proposed a stimulusorganismresponse–cognitiveadaptive–normative model to examine the drivers of habitual smartphone behavior and PSU [6].

Problematic digital devices use dramatically worsened during the coronavirus disease 2019 (COVID-19) pandemic [2]. People discontinued pre-pandemic socializing and recreational activities due to the lockdown or restriction of living areas in the COVID-19 pandemic; smartphones become the convenient tool for accessing information, entertainment and interaction with others. A systematic review and meta-analysis on 94 published studies revealed that the prevalence rate of PSU during the COVID-19 pandemic was 30.7%; in the lockdown periods, prevalence of problematic gaming and social media use were higher compared to non-lockdown periods [7]. Schoolchildren with a high level of problematic digital devices use had greater fear of COVID-19 [8] and psychological distress [9, 10] compared with those with a low level of problematic digital devices use, especially during COVID-19 school suspension [11]. Therefore, PSU is an emerging health issue during the COVID-19 pandemic that needs to be explored in depth.

Lesbian, gay, and bisexual (LGB) individuals are one of the populations at risk for PSU. LGB individuals experience public discrimination and prejudice due to their

sexual orientation [12]. LGB individuals may conceal their sexual orientation and restrict their social interaction to avoid sexual stigma and bullying. Compared to the real world, the online world offers them a safer and more private place for obtaining entertainment and social interaction. Social media and dating applications on smartphone also provide the LGB individuals with a quick way to meet LGB friends and find sexual partners [13, 14]. However, a study in the United States found that problematic social media use among LGB young adults is associated with depression and low social support [15]. Two studies in Taiwan have also demonstrated that PSU among LGB individuals was associated with depressive and anxiety symptoms [16, 17]. A literature review evidenced that problematic Internet use is associated with health issues among the youth minority population [18]. The findings of previous studies highlight the significance of prevention and intervention of PSU in young adult LGB individuals.

LGB individuals were disproportionately affected by the COVID-19 pandemic in terms of psychological well-being compared with heterosexual individuals [19–21]. Disconnection with LGB communities can further worsen LGB individuals' mental health. LGB individuals may rely more on smartphones to obtain social connection and entertainment and thus have a higher risk of PSU compared with heterosexual individuals. Furthermore, PSU can compromise LGB individuals' ability to cope with the predicaments happened during the pandemic. Examining factors that can predict PSU in LGB individuals during the COVID-19 pandemic may provide a reference for developing intervention strategies to reduce the PSU risk.

According to ecological system theory [22], there may be individual and environmental factors that increase the risk of PSU in LGB individuals. Regarding demographic characteristics, LGB individuals who are male and bisexual have greater PSU than those who are women and gay or lesbian, respectively [16]. Regarding environmental factors, sexual stigma was cross-sectionally associated with PSU severity in LGB individuals [16, 17]. However, no prospective study examined the pre-pandemic individual and environmental predictors of PSU in LGB individuals during the COVID-19 pandemic. In the Taiwanese Study of Sexual Stigma (T-SSS, in 2018 and 2019), the data of PSU, multiple types of sexual stigma (i.e., perceived sexual stigma from family members, sexual orientation microaggression, and internalized sexual stigma), self-identity confusion (i.e., disturbed identity, unconsolidated identity, and lack of identity), emotional problems (i.e., depressive and anxiety symptoms), and perceived family support in 1,000 LGB individuals living in Taiwan were collected [23–29]. Whether these pre-pandemic individual and environmental factors can predict the

level of PSU in LGB individuals during the COVID-19 pandemic warrants study.

This 4-year follow-up study was conducted to investigate the predictive effects of prepandemic individual factors (e.g., demographics, sexual and gender identities, self-identity confusion, anxiety, depression, and PSU) and environmental factors (e.g., sexual stigma and perceived family support) on PSU during the COVID-19 pandemic in young adult LGB individuals. Based on the results of previous cross-sectional studies [16, 17], we hypothesized that greater prepandemic sexual stigma was associated with greater PSU during the pandemic. Moreover, Internet provides young adults who have self-identity confusion with an environment to explore their personal values, beliefs, and goals [30, 31]; therefore, we hypothesized that greater prepandemic self-identity confusion was associated with greater PSU during the pandemic. A prospective study found the predictive effect of depression on PSU in Chinese adolescents [32]. A meta-analysis study also demonstrated a positive correlation between PSU and anxiety symptoms [33]. Therefore, we hypothesized that greater prepandemic depressive and anxiety symptoms were associated with greater PSU during the pandemic. Moreover, a prospective study demonstrated the predictive effect of low family support on problematic Internet use in Taiwanese adolescents [34]; therefore, we hypothesized that lower prepandemic family support was associated with greater PSU during the COVID-19 pandemic.

## Methods

### Participants and procedure

Both the criteria and methodology used in the T-SSS for recruiting participants at baseline have been described in previous studies [23–29]. In brief, a cohort of 1,000 individuals (500 men and 500 women) at baseline were recruited through online advertisements on social media platforms—including Facebook, Twitter, and LINE—and a bulletin board system from August 2018 to June 2019. The inclusion criteria were identifying as an LGB individual, being 20 to 30 years of age, and living in Taiwan. The exclusion criterion was having any form of impaired cognition that might interfere with the ability to complete a questionnaire.

Four years later (between August 2022 and June 2023), the same 1,000 individuals were contacted by text message and were invited to participate in a follow-up study. Those who responded to this message and agreed to participate received a blank consent form, a research questionnaire, and instructions for how to complete the questionnaire; they were also allowed to contact the research assistant for help if they had any problem understanding the questionnaire. Written informed consent was obtained from all participants. A total of three text

messages were sent to the individuals to invite them to participate in the follow-up study, with a 1-month interval between each pair of messages. Those who responded to none of these messages were considered to have been lost to follow-up. This study was approved by the Institutional Review Board of Kaohsiung Medical University Hospital (KMUHIRB-F(1)-20210219).

### Measures

The outcome variable was PSU at follow-up. The predicting variables at baseline included prepandemic PSU, demographics, three types of sexual stigma, self-identity confusion, depression, anxiety, and perceived family support.

### Smartphone addiction inventory (SPAI)

The 26-item SPAI [1] was used to assess the participants' self-reported severity of PSU in the three months prior to the baseline and follow-up assessments. The participants rated each item on a 4-point scale ranging from 1 (*totally disagree*) to 4 (*totally agree*), with a total score ranging from 26 to 104. A higher total score indicated a higher level of PSU. The Cronbach's  $\alpha$  coefficient of the SPAI in the present study was 0.96.

### Demographic characteristics

We collected data on participants' sex, age, educational level (high school or lower vs. college or higher), sexual orientation (lesbian or gay vs. bisexual), and gender orientation (transgender or not).

### Homosexuality-related stigma scale (HRSS)

The 12-item HRSS was used to measure the levels of perceived sexual stigma from family members [35]. Each item was rated on a 4-point Likert scale with endpoints ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). A higher total score indicated that the participant perceived a higher level of sexual stigma from family members [35]. The Cronbach's  $\alpha$  coefficient for this scale was 0.93 in this study.

### Measure of internalized sexual stigma for lesbians and gay men (TC-MISS-LG)

The 17-item traditional Chinese version [29] of the TC-MISS-LG [36] was used to assess each participant's sexuality, identity, and level of social discomfort. Each item was rated on a 5-point Likert scale with endpoints ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). A higher score indicated a greater level of internalized sexual stigma. The Cronbach's  $\alpha$  coefficient for this scale was 0.76 in this study.

### Sexual orientation microaggression inventory (SOMI)

The 19-item traditional Chinese version [25] of the SOMI [37] was used to assess microaggression in the dimensions of anti-gay attitudes and expressions, denial of homosexuality, and societal disapproval over 6 months among LGB individuals. Each item was rated on a 5-point Likert scale with endpoints ranging from 1 (*not at all*) to 5 (*almost every day*). A total higher score indicated a higher level of microaggression. The Cronbach's  $\alpha$  coefficient for this scale was 0.90 in the present study.

### Self-concept and identity measure (SCIM)

The traditional Chinese version [31, 38] of the 27-item SCIM was used to assess the level of current self-identity confusion [39, 40]. The SCIM assesses three dimensions of self-identity confusion, including disturbed identity, unconsolidated identity, and lack of identity. Items are rated on a 7-point rating scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). A higher total score indicates a higher tendency for self-identity confusion. Cronbach's alpha of the SCIM was 0.79 in the present study.

### Center for epidemiologic studies depression scale (CES-D)

The 20-item Mandarin Chinese version [41] of the CES-D [42] was used to assess the frequency of depressive symptoms within the preceding month. Each item was rated on a 4-point Likert scale with endpoints ranging from 1 (*rarely or none of the time*) to 4 (*most or all of the time*). A higher total score indicated more severe depression. The Cronbach's  $\alpha$  coefficient for this scale was 0.91 in this study.

### State-trait anxiety inventory (STAI)

The Mandarin Chinese version [43] of the STAI [44] consists of 20 items embedded in a single factor of anxiety. All the STAI items are assessed on a 4-point Likert scale, where a score of 1 indicates almost never and a score of 4 almost always. A higher STAI score indicates higher levels of anxiety [44]. The Cronbach's  $\alpha$  coefficient for this scale was 0.87 in this study.

### Adaptability, partnership, growth, affection, and resolve (APGAR) index

The Chinese version [45] of the APGAR Index [46] was used to assess the participants' perceived support from their families. Each item was rated on a 4-point Likert-type scale with endpoints ranging from 1 (*never*) to 4 (*always*). The total scores for the Family APGAR Index range from 5 to 20, with higher total scores indicating higher levels of perceived support from family. In our study, the Cronbach's  $\alpha$  values for the Family APGAR Index were 0.94.

### Data analysis

All statistical analyses were conducted using SPSS (version 24.0; SPSS, Chicago, IL, USA). We employed descriptive statistics to summarize and analyze the participants' data. The distributions of continuous variables were further tested for skewness and kurtosis to assess their level of departure from a normal distribution, and the results (i.e., absolute values of  $<3$  for skewness and  $<10$  for kurtosis) did not reveal any severe deviation [47].

This study detected the associations of prepandemic demographic characteristics, sexual stigma, self-identity confusion, depression, anxiety, perceived family support, and PSU with PSU at follow-up in two stages. In the first stage, the bivariate linear regression analysis involved the entry of only one independent variable at baseline for each time to detect their associations with PSU at follow-up. In the second stage, factors that were significantly associated with PSU in the bivariate linear regression analysis models were further included into a multivariate linear regression model to identify their associations with PSU at follow-up. Regarding the level of collinearity, the values of variance inflation factor ranged between 1.241 and 3.286; the values of tolerance ranged between 0.304 and 0.806; all values of eigenvalue were larger than 0.01; and the value of condition index was 29.862. The results indicated no problem of collinearity [48]. In order to understand what prepandemic factors were predictive of PSU severity at follow-up in the absence of the influence of prepandemic PSU, we used two regression analyses (one including and another not including prepandemic PSU as an independent variable) to identify the predictors of PSU at follow-up. Stepwise linear regression was performed to select most significant factors in the model. A  $p$  value of  $<0.05$  was regarded as significant.

### Results

In total, 673 (67.3%) participants responded to the invitation and agreed participating the follow-up study, 167 (16.7%) responded to the invitation but refused participating in the follow-up study, and 160 (16.0%) did not respond to the invitation. No differences in gender ( $\chi^2=0.005$ ,  $p=.946$ ), age ( $t=1.890$ ,  $p=.059$ ), sexual orientation ( $\chi^2=2.087$ ,  $p=.149$ ), and gender orientation ( $\chi^2=15.767$ ,  $p<.001$ ) were found between those received and did not receive the follow-up survey; however, those who did not receive the follow-up survey were more likely to have an education level of high school or below ( $\chi^2=15.767$ ,  $p<.001$ ).

Table 1 shows participants' demographics, sexual stigma, self-identity confusion, depressive and anxiety symptoms, perceived family function, and PSU. The gender distribution was relative similar (50.1% were men and 49.9% were women). The participants had a mean age of 24.8 years (standard deviation [SD]=2.9 years)

**Table 1** Demographics, Sexual Stigma, Self-Identity Confusion, Anxiety, Depression, Family Support, and PSU of Participants (N = 673)

Variable	n (%)	Mean (SD)	Range
Gender			
Women	336 (49.9)		
Men	337 (50.1)		
Age at baseline (year)		24.8 (2.9)	20–30
Education level			
High school or below	55 (8.2)		
College or above	618 (91.8)		
Sexual orientation			
Bisexual	300 (44.6)		
Gay or lesbian	373 (55.4)		
Transgender	19 (2.8)		
Perceived familial sexual stigma on the HRSS		26.8 (6.3)	10–40
Internalized sexual stigma on the MISS		35.6 (11.5)	17–76
Microaggression on the SOMI		42.3 (11.3)	19–78
Disturbed identity on the SCIM		37.5 (9.7)	13–67
Unconsolidated identity on the SCIM		29.4 (8.7)	10–64
Lack of identity on the SCIM		19.2 (7.5)	6–42
Anxiety symptoms on the STAI		41.2 (12.7)	20–79
Depressive symptoms on the CES-D		18.9 (11.3)	0–57
Family support on the APGAR Index		13.6 (3.6)	5–20
PSU on SPAI			
At baseline		61.9 (14.6)	26–101
At follow-up		58.9 (17.4)	26–101

APGAR Index: Adaptability, Partnership, Growth, Affection, and Resolve Index; CES-D: Center for Epidemiologic Studies Depression Scale; HRSS: Homosexuality-Related Stigma Scale; MISS: Measure of Internalized Sexual Stigma for Lesbians and Gay Men; SOMI: Sexual Orientation Microaggression Inventory; STAI: State-Trait Anxiety Inventory; SCIM: Self-Concept and Identity Measure; SPAI: Smartphone Addiction Inventory

at baseline, and most of them had a college degree or higher ( $n=618$ ; 91.8%). More than half of the participants ( $n=373$ ; 55.4%) were gay or lesbian, and 19 participants (2.8%) identified themselves as transgender. The mean perceived sexual stigma from family members on the HRSS was 26.8 (SD=6.3); the mean internalized sexual stigma on the MISS was 35.6 (SD=11.5); and the mean sexual orientation microaggression on the SOMI was 42.3 (SD=11.3). The mean level of disturbed identity on the SCIM was 37.5 (SD=9.7), unconsolidated identity was 29.4 (SD=8.7), and lack of identity was 19.2 (SD=7.5). The mean score of depressive symptoms on the CES-D was 18.9 (SD=11.3). The mean score of anxiety symptoms on the STAI was 41.2 (SD=12.7). The mean perceived family function on the APGAR Index

**Table 2** Associations of Factors with PSU at Follow-Up: Bivariate Linear Regression Analysis

Variable	B (SE)	p
Gender	1.905 (1.340)	0.155
Age	0.347 (0.229)	0.131
Education level <sup>a</sup>	-1.898 (2.448)	0.438
Sexual orientation <sup>b</sup>	-1.008 (1.349)	0.455
Transgender	4.061 (4.047)	0.316
Perceived familial sexual stigma	0.414 (0.106)	<0.001
Internalized sexual stigma	0.274 (0.057)	<0.001
Sexual orientation microaggression	0.266 (0.058)	<0.001
Disturbed identity	0.419 (0.067)	<0.001
Unconsolidated identity	0.396 (0.076)	<0.001
Lack of identity	0.635 (0.086)	<0.001
Anxiety symptoms	0.321 (0.051)	<0.001
Depressive symptoms	0.421 (0.057)	<0.001
Family support	-0.475 (0.185)	0.012
PSU at baseline	0.699 (0.035)	<0.001

<sup>a</sup>: high school or below as the reference; <sup>b</sup>: bisexual as the reference

was 13.6 (SD=3.6). The mean PSU on the SPAI was 61.9 (SD=14.6) at baseline and 58.9 (SD=17.4) at follow-up. The severity of PSU significantly decreased four years later (paired  $t=5.351$ ,  $p<.001$ ).

Table 2 presents the results of bivariate linear regression analysis examining the individual associations of demographic characteristics, sexual stigma, self-identity confusion, depressive and anxiety symptoms, perceived family function, and PSU at baseline with PSU at follow-up. Three types of sexual stigma, three types of self-identity confusion, depressive and anxiety symptoms, and PSU at baseline were significantly associated PSU at follow-up. Lower perceived family function at baseline was significantly associated PSU at follow-up.

Factors that were significantly associated with PSU were further included in a stepwise linear regression model (Table 3). Before the incorporation of PSU at baseline into the analysis model, the results of the model revealed that high levels depressive symptoms ( $p<.001$ ), disturbed identity ( $p<.001$ ), and perceived sexual stigma from family members ( $p=.025$ ) at baseline were significantly associated with PSU at follow-up. After the incorporation of PSU at baseline into the analysis model, the results of the model revealed that high levels PSU ( $p<.001$ ) and depressive symptoms ( $p=.002$ ) at baseline were significantly associated with PSU at follow-up.

### Discussion

The present study found that the severity of PSU at follow-up significantly decreased compared with the pre-pandemic severity among LGB individuals. This finding is inconsistent with the findings of other studies examining the changes of digital devices use [2, 49]. For example, a 6-month follow-up study that the severity of problematic

**Table 3** Predictors of PSU at Follow-up: Stepwise Multivariate Linear Regression Analysis

Variable	Model I		Model II	
	B (SE)	p	B (SE)	p
Depressive symptoms	0.310 (0.062)	< 0.001	0.149 (0.049)	0.002
Disturbed identity	0.254 (0.072)	< 0.001	–	–
Familial sexual stigma	0.235 (0.104)	0.025	–	–
PSU	–	–	0.697 (0.038)	< 0.001
F	25.111		209.566	
p	< 0.001		< 0.001	
Adjusted R <sup>2</sup>	0.097		0.383	

Internet use among children and adolescents significantly increased during the COVID-19 pandemic [49]. The present study examined the changes of the severity of PSU among young adults during a 4-year period; the participants may have significant growth in mental maturity and increase the ability to self-control smartphone use. However, there was a proportion of LGB individuals having a high severity of PSU measured by SPAI. For example, the total score of the SPAI ranged from 26 to 104, and 15.3% of the participants reported a total score of 78 (three-quarters of the total score) or higher on the SPAI. Moreover, the severity of PSU before the pandemic significantly predicted that of PSU after 4 years, indicating that LGB individuals with high prepandemic PSU tend to maintain their pattern of smartphone use during the COVID-19 pandemic. The result shows the need for early prevention of PSU among LGB individuals.

Our findings demonstrated that high levels depressive symptoms, disturbed identity, and perceived sexual stigma from family members at baseline predicted PSU at follow-up. LGB individuals have a higher risk of depressive disorders than do heterosexual individuals [50]. Both sexual minority stress [51] and intraminority LGB community stress [52, 53] result in high depressive symptoms in LGB individuals. LGB individuals with depressive symptoms may overuse smartphones to obtain entertainment and online social support for relieving negative emotion. Depression may also compromise LGB individuals' ability to control their smartphone use. Therefore, depressive symptoms can predict the severity of PSU. Because PSU can worsen the individuals' sleep rhythm, physical health, and the ability to cope with stress in the real world, PSU and depression may form a vicious cycle. This study highlights the necessity of early detection and intervention of depressive symptoms for preventing PSU.

This study demonstrated that prepandemic high disturbed identity predicted PSU four years later among LGB individuals. The individuals with a matured self-identity have clear goals in life, is willing to make commitments, and make efforts to complete developmental tasks [54], whereas the individuals with disturbed identity tend to acquire the thoughts, feelings, and beliefs of others in adulthood [55]. Smartphones provide the

individuals with disturbed identity the opportunities to assess the thoughts, feelings, and beliefs of others in the online world; therefore, the individuals with disturbed identity have a high demand for smartphones use and develop PSU gradually.

Our findings revealed that high prepandemic perceived sexual stigma from family members predicted PSU at follow-up among LGB individuals. Family is the basic and primitive microsystem in which the individuals are nourished [22]. LGB individuals who perceive sexual stigma from family members have the difficulty in recognizing their sexual orientation and conceal it; they may use smartphones to explore the world outside family, connect with LGB communities, and take a break from family discord. However, overuse of smartphones can lead to PSU.

To the best of our knowledge, this study is the first to explore the predictive effects of prepandemic individual and environmental factors on PSU among LGB individuals during the COVID-19 pandemic. Although the severity of PSU was lower at the 4-year follow-up than at baseline, PSU remains a key health concern among LGB individuals and thus warrants attention. The factors significantly associated with PSU should be considered when designing intervention strategies for these individuals. Furthermore, health-care providers should design programs aimed at enabling LGB individuals to develop a mature self-identity and reduce depression. Interventions for the reduction of family and public prejudice toward LGB individuals are also needed.

#### Limitations

Our study has some limitations. First, because we collected data from a single source, our findings may be subject to shared-method variance. Moreover, because of the self-report measures used in the present study, our findings could be biased by social desirability. Second, our participants were interested in the follow-up survey; thus, our results may not be generalizable to all LGB individuals. Third, several factors were not evaluated at baseline, such as the types of smartphone activities (e.g., Internet gaming, social media, and dating) and impulsivity; therefore, the predictive effects of these factors on PSU remain undetermined.

## Conclusions

In this study, higher levels of prepandemic PSU, disturbed identity, depressive symptoms, and perceived sexual stigma from family members were associated with a higher level of PSU at follow-up among LGB individuals during the COVID-19 pandemic. The prevention and cure of PSU are crucial. Health-care providers should design programs to help LGB individuals develop a mature self-identity. Further efforts to modify the family and public attitude and prejudice toward transgender LGB individuals are warranted. Furthermore, mental health problems, such as depressive symptoms, among LGB individuals should be explored as the predictors of PSU.

## Acknowledgements

Not applicable.

## Authors' contributions

The work was conceived and planned by MFH and CFY. CFY carried out the analyses. MFH, YPC, WJC and CFY drafted the paper. The authors read and approved the final manuscript.

## Funding

This study was supported by grants from the Ministry of Science and Technology, Taiwan (MOST 111-2314-B-037-041) and Kaohsiung Medical University Hospital (grants KMUH110-OR70 and KMUH111-1R66).

## Data Availability

The data will be available upon reasonable request to the corresponding authors.

## Declarations

## Competing interests

The authors declare no competing interests.

## Ethics approval and consent to participate

The institutional review boards of Kaohsiung Medical University Hospital (approval number: KMUHIRB-F(I)-20210219) approved this study. Informed consent was obtained from all participants prior to the assessment. This questionnaire-survey study did not apply any experiments on humans or the use of human tissue samples. This paper conforms to the Declaration of Helsinki and Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals.

## Consent for publication

Not applicable.

Received: 20 August 2023 / Accepted: 30 October 2023

Published online: 05 December 2023

## References

1. Lin YH, Chang LR, Lee YH, Tseng HW, Kuo TB, Chen SH. Development and validation of the Smartphone Addiction Inventory (SPAI). *PLoS ONE*. 2014;9(6):e98312.
2. Meng SQ, Cheng JL, Li YY, Yang XQ, Zheng JW, Chang XW, et al. Global prevalence of digital addiction in general population: a systematic review and meta-analysis. *Clin Psychol Rev*. 2022;92:102128.
3. Ratan ZA, Parrish AM, Zaman SB, Alotaibi MS, Hosseinzadeh H. Smartphone addiction and associated health outcomes in adult populations: a systematic review. *Int J Environ Res Public Health*. 2021;18(22):12257.
4. Brand M, Young KS, Laier C, Wöfling K, Potenza MN. Integrating psychological and neurobiological considerations regarding the development and maintenance of specific internet-use disorders: an Interaction of person-affect-cognition-execution (I-PACE) model. *Neurosci Biobehav Rev*. 2016;71:252–66.
5. Chang CW, Chen JS, Huang SW, Potenza MN, Su JA, Chang KC, Pakpour AH, Lin CY. Problematic smartphone use and two types of problematic use of the internet and self-stigma among people with substance use disorders. *Addict Behav*. 2023;147:107807.
6. Tan CN. Toward an integrated framework for examining the addictive use of smartphones among young adults. *Asian J Social Health Behav*. 2023;6:119–25.
7. Alimoradi Z, Lotfi A, Lin CY, Griffiths MD, Pakpour AH. Estimation of behavioral addiction prevalence during COVID-19 pandemic: a systematic review and meta-analysis. *Curr Addict Rep*. 2022;9(4):486–517.
8. Chen IH, Chen CY, Liu CH, Ahorsu DK, Griffiths MD, Chen YP, Kuo YJ, Lin CY, Pakpour AH, Wang SM. Internet addiction and psychological distress among Chinese schoolchildren before and during the COVID-19 outbreak: a latent class analysis. *J Behav Addict*. 2021;10(3):731–46.
9. Chen IH, Chen CY, Pakpour AH, Griffiths MD, Lin CY, Li XD, Tsang HWH. 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. *J Behav Addict*. 2021;10(1):135–48.
10. Chen CY, Chen IH, Hou WL, Potenza MN, O'Brien KS, Lin CY, Latner JD. The relationship between children's problematic internet-related behaviors and psychological distress during the onset of the COVID-19 pandemic: a longitudinal study. *J Addict Med*. 2022;16:e73–80.
11. Chen IH, Chen CY, Pakpour AH, Griffiths MD, Lin CY. Internet-related behaviors and psychological distress among schoolchildren during COVID-19 school suspension. *J Am Acad Child Adolesc Psychiatry*. 2020;159(10):1099–102.
12. Meyer IH. Prejudice, social stress, and mental health in lesbian, gay, and bisexual populations: conceptual issues and research evidence. *Psychol Bull*. 2003;129:674–97.
13. Gudelunas D. There's an app for that: the uses and gratifications of online social networks for gay men. *Sex Cult*. 2012;16(4):347–65.
14. Rosser BS, Wilkerson JM, Smolenski DJ, Oakes JM, Konstan J, Horvath KJ, et al. The future of internet-based HIV prevention: a report on key findings from the men's INternet (MINTS-I, II) sex studies. *AIDS Behav*. 2011;15(1):91–100.
15. Vogel EA, Ramo DE, Prochaska JJ, Meacham MC, Layton JF, Humfleet GL. Problematic social media use in sexual and gender minority young adults: observational study. *JMIR Ment Health*. 2021;8(5):e23688.
16. Huang MF, Chang YP, Lu WH, Yen CF. Problematic smartphone use and its associations with sexual minority stressors, gender nonconformity, and mental health problems among young adult lesbian, gay, and bisexual individuals in Taiwan. *Int J Environ Res Public Health*. 2022;19:5780.
17. Li DJ, Chang YP, Chen YL, Yen CF. Mediating effects of emotional symptoms on the association between homophobic bullying victimization and problematic Internet/smartphone use among gay and bisexual men in Taiwan. *Int J Environ Res Public Health*. 2020;17(10):3386.
18. Ruckwongpatr K, Paratthakonkun C, Ghavifekr S, Gan WY, Tung SEH, Nurmala I, Nadhiroh SR, Pramukti I, Lin CY. Problematic internet use (PIU) in youth: a brief literature review of selected topics. *Curr Opin Behav Sci*. 2022;46:101150.
19. Buspavanich P, Lech S, Lerner E, Fischer M, Berger M, Vilsmaier T, et al. Well-being during COVID-19 pandemic: a comparison of individuals with minoritized sexual and gender identities and cis-heterosexual individuals. *PLoS ONE*. 2021;16:e0252356.
20. Slemmon A, Richardson C, Goodyear T, Salway T, Gadermann A, Oliffe JL, et al. Widening mental health and substance use inequities among sexual and gender minority populations: findings from a repeated cross-sectional monitoring survey during the COVID-19 pandemic in Canada. *Psychiatry Res*. 2022;307:114327.
21. Veldhuis CB, Nesoff ED, McKowen ALW, Rice DR, Ghoneima H, Wootton AR, et al. Addressing the critical need for long-term mental health data during the COVID-19 pandemic: changes in mental health from April to September 2020. *Prev Med*. 2020;146:106465.
22. Bronfenbrenner U. *The ecology of Human Development: experiments by Nature and Design*. Cambridge, Massachusetts: Harvard University Press; 1979.
23. Chen YL, Chang YP, Yen CF. Effects of gender nonconformity and biological sex on the relationship between sexual orientation microaggressions and anxiety and depressive symptoms among lesbian, gay, and bisexual

- Taiwanese young adults: a moderated-moderation study. *J Affect Disord.* 2023;334:129–36.
24. Chen JS, Huang YT, Lin CY, Yen CF, Griffiths MD, Pakpour AH. Relationships of sexual orientation microaggression with anxiety and depression among lesbian, gay, and bisexual Taiwanese youth: self-identity disturbance mediates but gender does not moderate the relationships. *Int J Environ Res Public Health.* 2021;18(24):12981.
  25. Hsieh MT, Chen JS, Lin CY, Yen CF, Griffiths MD, Huang YT. Measurement invariance of the sexual orientation Microaggression Inventory across LGB males and females in Taiwan: Bifactor structure fits the best. *Int J Environ Res Public Health.* 2021;18(24):10668.
  26. Lee JI, Chang YP, Tsai CS, Yen CF. Internalized sexual stigma among lesbian, gay, and bisexual individuals in Taiwan: its related factors and association with mental health problems. *Int J Environ Res Public Health.* 2022;19(25):2427.
  27. Tsai CS, Huang YT, Yen CF. Experience of sexual orientation microaggression among young adult lesbian, gay, and bisexual individuals in Taiwan: its related factors and association with mental health problems. *Int J Environ Res Public Health.* 2021;18(24):11744.
  28. Lin CY, Griffiths MD, Pakpour AH, et al. Relationships of familial sexual stigma and family support with internalized homonegativity among lesbian, gay and bisexual individuals: the mediating effect of self-identity disturbance and moderating effect of gender. *BMC Public Health.* 2022;22(1):1465.
  29. Yen CF, Huang YT, Potenza MN, Tsai TT, Lin CY, Tsang HWH. Measure of internalized sexual stigma for lesbians and Gay men (MISS-LG) in Taiwan: psychometric evidence from Rasch and confirmatory factor analysis. *Int J Environ Res Public Health.* 2021;18(24):13352.
  30. Hsieh KY, Hsiao RC, Yang YH, Lee KH, Yen CF. Relationship between self-identity confusion and internet addiction among college students: the mediating effects of psychological inflexibility and experiential avoidance. *Int J Environ Res Public Health.* 2019;16(17):3225.
  31. Chen TH, Hsiao RC, Liu TL, Yen CF. Predicting effects of borderline personality symptoms and self-concept and identity disturbances on internet addiction, depression, and suicidality in college students: a prospective study. *Kaohsiung J Med Sci.* 2019;35(8):508–14.
  32. Zhou H, Dang L, Lam LW, Zhang MX, Wu AMS. A cross-lagged panel model for testing the bidirectional relationship between depression and smartphone addiction and the influences of maladaptive metacognition on them in Chinese adolescents. *Addict Behav.* 2021;120:106978.
  33. Li Y, Li G, Liu L, Wu H. Correlations between mobile phone addiction and anxiety, depression, impulsivity, and poor sleep quality among college students: a systematic review and meta-analysis. *J Behav Addict.* 2020;9(3):551–71.
  34. Chen YL, Chen SH, Gau SS. ADHD and autistic traits, family function, parenting style, and social adjustment for internet addiction among children and adolescents in Taiwan: a longitudinal study. *Res Dev Disabil.* 2015;39:20–31.
  35. Liu H, Feng T, Rhodes AG. Assessment of the Chinese version of HIV and Homosexuality Related Stigma scales. *Sex Transm Infect.* 2009;85(1):65–9.
  36. Lingardi V, Baiocco R, Nardelli N. Measure of internalized sexual stigma for lesbians and Gay men: a new scale. *J Homosex.* 2012;59(8):1191–210.
  37. Swann G, Minshew R, Newcomb ME, Mustanski B. Validation of the sexual orientation Microaggression Inventory in two diverse samples of LGBTQ youth. *Arch Sex Behav.* 2016;45(6):1289–98.
  38. Wang CC, Chang YP, Yang YH, Hu HF, Yen CF. Relationships between traditional and cyber Harassment and self-identity confusion among Taiwanese gay and bisexual men in emerging adulthood. *Compr Psychiatry.* 2019;90:14–20.
  39. Kaufman EA, Cundiff JM, Crowell SE. The development, factor structure, and validation of the Self-Concept and Identity measure (SCIM): a self-report assessment of clinical identity disturbance. *J Psychopathol Behav Assess.* 2015;37(1):122–33.
  40. Kaufman EA, Puzia ME, Crowell SE, Price CJ. Replication of the Self-Concept and Identity measure (SCIM) among a treatment-seeking sample. *Identity.* 2019;19(1):18–28.
  41. Chin WY, Choi EP, Chan KT, Wong CK. The psychometric properties of the Center for Epidemiologic Studies Depression Scale in Chinese primary care patients: factor structure, construct validity, reliability, sensitivity, and responsiveness. *PLoS ONE.* 2015;10(8):e0135131.
  42. Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. *Appl Psychol Meas.* 1977;1(3):385–401.
  43. Chen YP, Wang SM, Wu Y, Lin HY, Wu CC, Chuang TY, et al. Worsen depression after viscosupplementation treatment for geriatric people with knee osteoarthritis? *Int J Clin Health Psychol.* 2019;19(1):31–40.
  44. Spielberger CD, Gorsuch RL, Lushene R, Vagg PR, Jacobs GA. Manual for the state-trait anxiety inventory. Palo Alto, CA, USA: Consulting Psychologists Press; 1983.
  45. Chen Y, Hsu C, Hsu S, Lin C. A preliminary study of family APGAR index. *Acta Paediatr Sin.* 1980;21:210–7.
  46. Smilkstein G. The family APGAR: a proposal for a family function test and its use by physicians. *J Fam Pract.* 1978;6(6):1231–9.
  47. Lin CY, Luh WM, Cheng CP, Yang AL, Su CT, Ma HI. Measurement equivalence across child self-reports and parent-proxy reports in the Chinese version of the Pediatric Quality of Life Inventory version 4.0. *Child Psychiatry Hum Dev.* 2013;44(5):583–90.
  48. Senaviratna N, Cooray T. Diagnosing multicollinearity of logistic regression model. *Asian J Probab Statist.* 2019;5(2):1–9.
  49. Teng Z, Pontes HM, Nie Q, Griffiths MD, Guo C. Depression and anxiety symptoms associated with internet gaming disorder before and during the COVID-19 pandemic: a longitudinal study. *J Behav Addict.* 2021;10(1):169–80.
  50. Wittgens C, Fischer MM, Buspavanich P, Theobald S, Schweizer K, Trautmann S. 2022. Mental health in people with minority sexual orientations: A meta-analysis of population-based studies. *Acta Psychiatr Scand.* 2022;145:357–72.
  51. Meyer IH. Minority stress and mental health in gay men. *J Health Soc Behav.* 1995;36:38–56.
  52. Pachankis JE, Clark KA, Burton CL, Hughto JMW, Bränström R, Keene DE. Sex, status, competition, and exclusion: intraminority stress from within the gay community and gay and bisexual men's mental health. *J Pers Soc Psychol.* 2020;119:713–40.
  53. Lin CY, Huang YT, Lee CH, Fan CW, Yen CF. Gay Community stress scale with its cultural translation and adaptations in Taiwan. *Int J Environ Res Public Health.* 2022;19:11649.
  54. Erikson E. *Identity. Youth and Crisis.* New York: W. W. Norton & Company; 1968.
  55. Westen D, Heim AK. Disturbances of self and identity in personality disorders. In: Leary MR, Tangney JP, editors. *Handbook of self and identity.* New York, NY, USA: Guilford Press; 2003. pp. 643–64.

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