

Online social networking addiction and depression: The results from a large-scale prospective cohort study in Chinese adolescents

Ji-Bin Li^{1,2*}, Phoenix K. H. Mo^{2,3}, Joseph T. F. Lau^{2,3}, Xue-Fen Su^{2,3}, Xi Zhang⁴, Anise M. S. Wu⁵, Jin-Cheng Mai⁶ and Yu-Xia Chen⁶

¹Department of Clinical Research, State Key Laboratory of Oncology in South China, Collaborative Innovation Center for Cancer Medicine, Sun Yat-sen University Cancer Center, Guangzhou, China

²Centre for Health Behaviours Research, The Jockey Club School of Public Health and Primary Care, The Chinese University of Hong Kong, Hong Kong, China

³Shenzhen Research Institute, The Chinese University of Hong Kong, Shenzhen, China

⁴Clinical Research Unit, Xin Hua Hospital – Shanghai Jiao Tong University School of Medicine, Shanghai, China

⁵Faculty of Social Sciences, Department of Psychology, University of Macau, Macao, China

⁶Department of Psychological Health Research, Center for Health Promotion of Primary and Secondary School of Guangzhou, Guangzhou, China

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Background and aims: The aim of this study is to estimate the longitudinal associations between online social networking addiction (OSNA) and depression, whether OSNA predicts development of depression, and reversely, whether depression predicts development of OSNA. **Methods:** A total of 5,365 students from nine secondary schools in Guangzhou, Southern China were surveyed at baseline in March 2014, and followed up 9 months later. Level of OSNA and depression were measured using the validated OSNA scale and CES-D, respectively. Multilevel logistic regression models were applied to estimate the longitudinal associations between OSNA and depression. **Results:** Adolescents who were depressed but free of OSNA at baseline had 1.48 times more likely to develop OSNA at follow-up compared with those non-depressed at baseline [adjusted OR (AOR): 1.48, 95% confidence interval (CI): 1.14–1.93]. In addition, compared with those who were not depressed during the follow-up period, adolescents who were persistently depressed or emerging depressed during the follow-up period had increased risk of developing OSNA at follow-up (AOR: 3.45, 95% CI: 2.51–4.75 for persistent depression; AOR: 4.47, 95% CI: 3.33–5.99 for emerging depression). Reversely, among those without depression at baseline, adolescents who were classified as persistent OSNA or emerging OSNA had higher risk of developing depression compared with those who were no OSNA (AOR: 1.65, 95% CI: 1.01–2.69 for persistent OSNA; AOR: 4.29; 95% CI: 3.17–5.81 for emerging OSNA). **Conclusion:** The findings indicate a bidirectional association between OSNA and depression, meaning that addictive online social networking use is accompanied by increased level of depressive symptoms.

Keywords: online social networking addiction, depression, longitudinal association, adolescents

INTRODUCTION

Depression, the most widely reported psychiatric disorder (Knopf, Park, & Mulye, 2008; Thapar, Collishaw, Potter, & Thapar, 2010), is an important public health issue among adolescents. Over 9% of adolescents reported moderate to severe levels of depression, and its 1-year incidence rate was estimated at 3% in the United States (Rushton, Forcier, & Schectman, 2002). In Southern China, our previous study reported a 1-week depression prevalence of 23.5% among secondary school students (Li et al., 2017).

A positive association between Internet addiction and depression among adolescents has been reported in both cross-sectional (Moreno, Jelenchick, & Breland, 2015; Yoo, Cho, & Cha, 2014) and longitudinal studies (Cho, Sung, Shin, Lim, & Shin, 2013; Ko, Yen, Chen, Yeh, & Yen,

2009; Lam, 2014). However, these studies assessed Internet addiction in general rather than specific types of online activities. Adolescents could conduct multiple types of online activities on the Internet. Several studies have highlighted the significance and necessity for distinguishing

* Corresponding authors: Ji-Bin Li, MD, PhD; Department of Clinical Research, State Key Laboratory of Oncology in South China, Collaborative Innovation Center for Cancer Medicine, Sun Yat-sen University Cancer Center, No. 651, Dong Feng East Road, Guangzhou 510060, China; Phone: +86 20 8734 3553; Fax: +86 20 8734 3535; E-mail: lijib@sysucc.org.cn; Joseph T. F. Lau, PhD, Professor; Centre for Health Behaviours Research, The Jockey Club School of Public Health and Primary Care, Prince of Wales Hospital, Shatin, Hong Kong, China; Phone: +852 2637 6606; Fax: +852 2645 3098; E-mail: jlau@cuhk.edu.hk

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addiction to specific Internet-related activities from Internet addiction in general (Davis, 2001; Laconi, Tricard, & Chabrol, 2015; Pontes, Szabo, & Griffiths, 2015). Online social networking is a relatively new phenomenon, and high prevalence of depression has been observed among the population who are online social networking users (Lin et al., 2016; Tang & Koh, 2017). Compared to the general population, teenagers and students are the most frequent users of online social networking (Griths, Kuss, & Demetrovics, 2014). Online social networking addiction (OSNA) is a relatively new addictive behavior among adolescents along with compulsive involvement in online social networking activities. As a specific type of Internet-related behavioral addictions, OSNA incorporates core classic symptoms of addiction (Griffiths, 2013; Kuss & Griffiths, 2011), and is defined as “being overly concerned about online social networking use, to be driven by a strong motivation to log on to or use online social networking that impairs other social activities, studies/jobs, interpersonal relationships, and/or psychological health and well-being” (Andreassen, 2015). OSNA has risen noticeably among adolescents. Around 9.78% of the US college students self-perceived to have Facebook addiction (Pemppek, Yermolayeva, & Calvert, 2009), and 29.5% of Singaporean college students possess OSNA (Tang & Koh, 2017). A study in 2010 reported that the OSNA prevalence was even higher than 30% in Chinese college students (Zhou & Leung, 2010). Evidences have suggested that excessive and compulsive online social networking is seldom beneficial, rather having potentially detrimental effects on adolescents’ psychosocial well-being, including emotional, relational, and other health-related outcomes (Andreassen, 2015).

A few of cross-sectional surveys reported a positive association between OSNA and depression among adolescents (Hong, Huang, Lin, & Chiu, 2014; Koc & Gulyagci, 2013). However, due to the inherent limitation of the cross-sectional study design, it is still unclear whether OSNA is a cause or consequence of depression or bidirectional. Online social networking could provide adolescents with social convenience and capital, selective self-disclosure, and potential social support (Ellison, Steinfield, & Lampe, 2007; Steinfield, Ellison, & Lampe, 2008). Individuals who experience psychiatric disorders (i.e., depression and anxiety) might view online social networking as a safe and important virtual community (Gámez-Guadix, 2014), where they could escape from emotional problems experienced in the real world (Andreassen, 2015; Griths et al., 2014), and further lead to potential addictive involvement (Oberst, Wegmann, Stodt, Brand, & Chamarro, 2017). Meanwhile, excessive exposure to virtual community would result in negative emotions (McDougall et al., 2016). Adolescents with maladjustment to their depressive moods may experience more detrimental effects of excessive online social networking (Selfhout, Branje, Delsing, Ter Bogt, & Meeus, 2009). Therefore, a bidirectional association between OSNA and depression is theoretically reasonable. However, to our knowledge, there is no prospective study that focused on exploring the longitudinal relationships between OSNA and depression among adolescents and other populations.

Therefore, we designed a prospective study to comprehensively estimate the longitudinal association between

depression and OSNA over time, such as whether OSNA predicts development of depression, and whether depression predicts development of OSNA, by considering changes in OSNA and depression status (e.g., remission from disorder) during a 9-month follow-up period.

METHODS

Study design

This prospective cohort study was conducted in Guangzhou, Southern China. The baseline survey was conducted from March to April 2014, and the subsequent follow-up survey was conducted at a 9-month interval, using the same procedure.

Participants and sampling

Participants were recruited using a stratified cluster sampling method. One district/county was conveniently selected from each of three regions (i.e., core, suburb, and outer suburb regions) in Guangzhou, respectively (red dots in Figure 1). Three public secondary schools were then conveniently selected from each selected district/county, and a total of nine schools were thus selected. All the seventh- and the eighth-grade students within the selected schools were voluntarily invited to participate in the study. Anonymous questionnaire was self-administrated by participants in the classroom settings with the absence of any teacher, under the supervision of well-trained research assistants.

A total of 5,365 (response rate = 98.04%) students completed the baseline survey. The two questionnaires of the same students were matched using last four digits of home telephone number, last four digits of parents’ mobile phone number, last four digits of participants’ identity card number, participants’ date of birth, last letter of self and parents’ spell name. Finally, 4,871 of 5,365 participants provided complete questionnaires at follow-up (follow-up rate = 90.8%). After excluding those who did not use online social networking ($n = 643$), a total of 4,237 participants were involved in our longitudinal study.

Measures

Depression. Level of depressive symptoms was measured using the 20-item Chinese version of the Center for Epidemiology Scale for Depression (CES-D). Its psychometric properties have been validated among Chinese adolescents (Chen, Yang, & Li, 2009; Cheng, Yen, Ko, & Yen, 2012; Lee et al., 2008; Wang et al., 2013). Higher scores indicate more severe level of depressive symptoms, with a total score ranging from 0 to 60 (Radloff, 1977). The Cronbach’s α coefficients in this study were .86 at baseline and .87 at follow-up, showing a good internal reliability. Individual reporting a CES-D score ≥ 21 is defined as a depressed case (Stockings et al., 2015). Following the previous studies (Penninx, Deeg, van Eijk, Beekman, & Guralnik, 2000; Van Gool et al., 2003), change in depression status during follow-up period in this study was

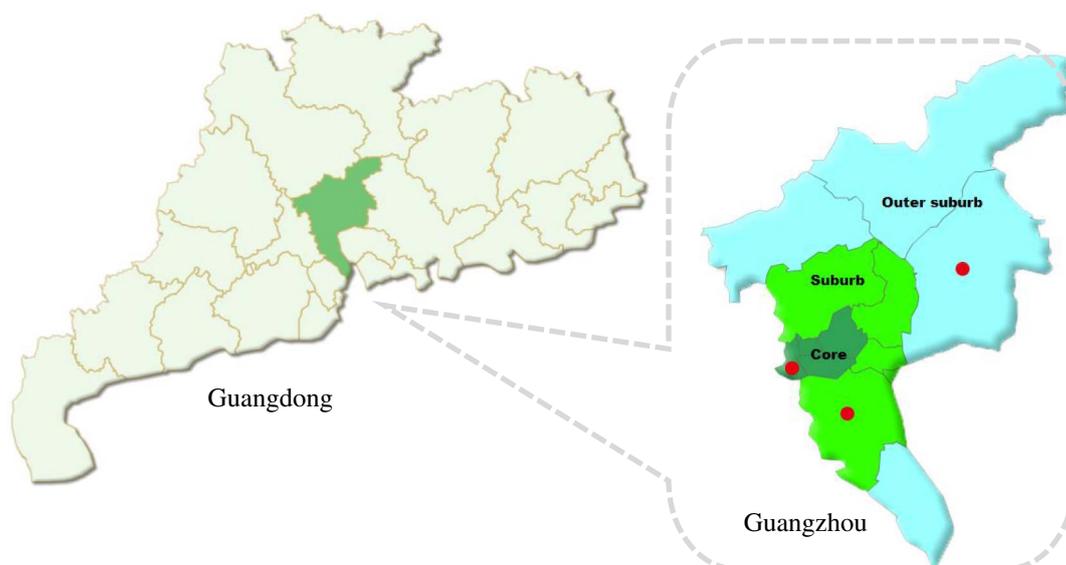


Figure 1. The location of the study sites

categorized as follows: no depression (participants without depression both at baseline and follow-up), remission from depression (participants with depression at baseline but transitioned to without depression at follow-up), persistent depression (participants with depression both at baseline and follow-up), and emerging depression (participants without depression at baseline but transitioned to with depression at follow-up).

Online social networking addiction (OSNA). Addictive level to online social networking was measured using an OSNA scale, which includes eight items measuring core addictive symptoms of cognitive and behavioral salience, conflict with other activities, euphoria, loss of control, withdrawal, relapse, and reinstatement. Higher scores of OSNA scale indicate higher levels of addictive tendency to online social networking, with a maximum score of 40. Its psychometric properties have been thoroughly assessed in our previous study (Li et al., 2016). There is no established cut-off value for the OSNA scale to identify OSNA cases: participants who scored in the 10th decile of scores (i.e., OSNA score ≥ 24) were classified as OSNA cases at baseline, and the same cut-off value was used to classify cases at follow-up. The similar classification strategy has been applied in the previous study (Verkuil et al., 2014). The Cronbach's α coefficients of OSNA scale in this study were .86 at baseline and .89 at follow-up. Similarly, change in OSNA status from baseline to follow-up was categorized as follows: no OSNA (participants without OSNA both at baseline and follow-up), remission from OSNA (participants with OSNA at baseline but transitioned to without OSNA at follow-up), persistent OSNA (participants with OSNA both at baseline and follow-up), and emerging OSNA (participants without OSNA at baseline but transitioned to with OSNA at follow-up).

Covariates. Covariates included sex, grade, parental education levels, perceived family financial situation, living arrangement (with both parents or not), self-reported academic performance, and perceived study pressure at baseline.

Statistical analyses

Descriptive statistics (e.g., means, standard deviation, and percentages) were presented when appropriate. Intraclass correlation coefficients for clustering across schools were 1.56% ($p = .002$) for incident depression and 1.42% ($p = .042$) for incident OSNA, indicating significant variances across schools (Wang, Xie, & Fisher, 2009). Multi-level logistic regression models (Level 1: student; Level 2: school) were therefore applied to evaluate the longitudinal associations between OSNA and depression over time, accounting for the cluster sampling effect from school. Background covariates associated with incident depression/OSNA with $p < .05$ in univariate analysis or widely reported in the literature (i.e., sex and grade) were adjusted for in the multivariable logistic regression models.

For prediction of OSNA on new incidence of depression among participants who were non-depressed at baseline ($n = 3,196$), we first estimated the odds ratio (OR) of baseline OSNA, both binary variable (i.e., OSNA or not) and continuous variable (OSNA scale scores), on new incidence of depression after adjusting of significant covariates, and then further adjusting of baseline CES-D scale score (Hinkley et al., 2014). We then estimated the prediction of change in OSNA status over time on new incidence of depression, including a model adjusted of significant covariates and a model additionally adjusted of baseline CES-D scale score.

Reversely, the prediction of depression on new incidence of OSNA among participants without OSNA at baseline ($n = 3,657$) was estimated in a similar manner to that described above with new incidence of OSNA as outcome and depression as an exposure. The prediction of baseline depression (both continuous and categorical version) on new incidence of OSNA and prediction of change in depression status over time on new incidence of OSNA were estimated, respectively.

Statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC, USA). A two-sided p value $< .05$ was considered statistically significant.

Ethics

The study procedures were carried out in accordance with the Declaration of Helsinki. School consent and permission for the in-school survey were obtained from school principals before the survey had administered. Verbal consent was obtained from students before their participation. This study and the consent procedure were approved by the Survey and Behavioral Research Ethics Committee of the Chinese University of Hong Kong.

RESULTS

Participants' characteristics and attrition analysis

Attrition analysis showed that there were no significant differences in terms of parental education levels and self-reported academic performance between adolescents who were involved in the longitudinal analysis ($n = 4,237$) and who were excluded from longitudinal analysis ($n = 1,128$). Adolescents, who were involved in the longitudinal sample were more likely to be females, were from the eighth grade, have good family financial situation, lived with both parents, and perceive nil/light study pressure (Table 1).

Among 4,237 adolescents (mean age: 13.9, standard deviation: 0.7) in the longitudinal sample, 49.7% (2,105 of 4,237) were female and 47.5% (2,011 of 4,237) were the seventh grade students. Most of adolescents (88.4%; 3,747 of 4,237) were living with their parents. In the longitudinal sample, the prevalence of depression significantly increased from 24.6% (1,041 of 4,237) at baseline to 26.6% at follow-up (McNemar's test = 7.459, $p = .006$). There was no significant difference for the prevalence of OSNA between baseline and follow-up (13.7% at baseline vs. 13.6% at follow-up; McNemar's test = 0.053, $p = .818$). A total of 3,196 students were non-depressed at baseline, and 3,657 students were free of OSNA at baseline (Table 1).

Potential confounders associated with new incidence of depression or OSNA

Table 2 shows that perceived poor family financial situation, self-reported poor academic performance, and perceived heavy study pressure were significantly associated with both higher incidence of depression (range of univariate OR: 1.32–1.98) and higher incidence of OSNA (range of univariate OR: 1.61–2.76). Living with their parents was a significantly protective factor for incidence of OSNA only [univariate OR: 0.65, 95% confidence interval (CI): 0.48–0.89].

OSNA predict new incidence of depression

Among 3,196 adolescents who were non-depressed at baseline, univariate model showed that baseline OSNA was significantly associated with higher incidence of depression during the follow-up period (univariate OR: 1.65, 95% CI: 1.22–2.22). After adjustment of sex, grade, family financial situation, academic performance, and perceived study pressure, the association remained significant [adjusted OR

(AOR): 1.48, 95% CI: 1.09–2.01]. When further adjusting of baseline CES-D score, the association becomes statistically non-significant (AOR: 1.16, 95% CI: 0.85–1.60). The similar results were observed when using OSNA score (continuous variable) as a predictor of new incident depression (Table 3).

We found a significant association between change in OSNA status and higher incidence of depression. Compared with adolescents who were classified as no OSNA, the risk of developing depression was 1.65 times (95% CI: 1.01–2.69) higher among those with persistent OSNA, and 4.29 times (95% CI: 3.17–5.81) higher among those with emerging OSNA, after adjustment of sex, grade, family financial situation, academic performance, perceived study pressure, and baseline CES-D scores (Table 3).

Depression predict new incidence of OSNA

Among 3,657 adolescents who were free of OSNA at baseline, univariate results demonstrated a significant positive association between baseline depression and higher incidence of OSNA (univariate OR: 2.02, 95% CI: 1.58–2.58). After adjusting of sex, grade, family financial situation, living arrangement with parents, academic performance, and perceived study pressure, the association slightly attenuated but remained significant (AOR: 1.78, 95% CI: 1.38–2.31). The association between baseline depression status and incidence of OSNA was still statistically significant when further adjustment of baseline OSNA scores (AOR: 1.48, 95% CI: 1.14–1.93). The results were still significant when using CES-D score (continuous variable) as a predictor of new incident OSNA (Table 3).

A significant association between change in depression status and incidence of OSNA was observed in multivariable analysis. After adjusting of sex, grade, family financial situation, living arrangement with parents, academic performance, perceived study pressure, and baseline OSNA score, as compared to adolescents without depression, the odds of developing OSNA was 3.45 times (95% CI: 2.51–4.75) higher among those who were persistently depressed, and 4.47 times (95% CI: 3.33–5.99) higher among those who were emerging depressed (Table 3).

DISCUSSION

In this large-scale longitudinal study, we found that adolescents who were depressed but free of OSNA at baseline had a 48% higher risk of developing OSNA within 9-month follow-up period compared with those without depression at baseline, but the prediction of baseline OSNA on new incidence of depression was not supported in this study. Moreover, when the effects of changes in status over time (i.e., remission from depression/OSNA at baseline to non-depression/non-OSNA at follow-up) were considered in the models, the results revealed a bidirectional association between OSNA and depression. Adolescents who were persistently depressed or emerging depressed had a higher risk of developing OSNA compared with those who were not depressed during the 9-month follow-up period. Reversely, adolescents who were persistent OSNA or emerging OSNA

Table 1. Attrition analysis and participants' characteristics in the longitudinal sample

	Baseline	Participants in the longitudinal sample			Participants without depression at baseline			Participants without OSNA at baseline			p*
		Yes	No	p*	Non-OSNA	OSNA	p*	Non-depressed	Depressed		
Total	5,365	4,237	1,128	-	2,922	274	-	2,922	735	-	
Sex											
Male	2,533 (47.2)	2,105 (49.7)	727 (64.4)	<.001	1,464 (50.1)	164 (59.8)	.002	1,464 (50.1)	309 (42.0)	<.001	
Female	2,832 (52.8)	2,132 (50.3)	401 (35.6)		1,458 (49.9)	110 (40.2)		1,458 (49.9)	426 (58.0)		
Grade											
Seven	2,592 (48.3)	2,011 (47.5)	581 (51.5)	.016	1,418 (48.5)	131 (47.8)	.820	1,418 (48.5)	337 (45.9)	.194	
Eight	2,773 (51.7)	2,226 (52.5)	547 (48.5)		1,504 (51.5)	143 (52.2)		1,504 (51.5)	398 (54.2)		
Father's education level											
Primary school or below	356 (6.6)	273 (6.4)	83 (7.4)	.376	165 (5.7)	21 (7.7)	.049	165 (5.7)	61 (8.3)	.010	
Junior secondary school	1,816 (33.9)	1,425 (33.6)	391 (34.7)		958 (32.8)	108 (39.4)		958 (32.8)	259 (35.2)		
Senior secondary school	1,646 (30.7)	1,312 (31.0)	334 (29.6)		911 (31.2)	79 (28.8)		911 (31.2)	230 (31.3)		
College or above	1,317 (24.5)	1,053 (24.9)	264 (23.4)		763 (26.1)	54 (6.6)		763 (26.1)	159 (21.6)		
Don't know	230 (4.3)	174 (4.1)	56 (5.0)		125 (4.3)	12 (4.4)		125 (4.3)	26 (3.5)		
Mother's education level											
Primary school or below	588 (11.0)	445 (10.5)	143 (12.7)	.144	267 (9.1)	35 (12.8)	.108	267 (9.1)	103 (14.0)	<.001	
Junior secondary school	1,909 (35.6)	1,507 (35.6)	402 (35.6)		1,030 (35.3)	108 (39.4)		1,030 (35.3)	274 (37.3)		
Senior secondary school	1,497 (27.9)	1,199 (28.3)	298 (26.4)		860 (29.4)	71 (25.9)		860 (29.4)	180 (24.5)		
College or above	1,143 (21.3)	913 (21.6)	230 (20.4)		634 (21.7)	50 (18.3)		634 (21.7)	156 (21.2)		
Don't know	228 (4.3)	173 (4.1)	55 (4.9)		131 (4.5)	10 (3.6)		131 (4.5)	22 (3.0)		
Family financial situation											
Very good/good	2,519 (47.0)	2,047 (48.3)	472 (41.8)	<.001	1,495 (51.2)	123 (44.9)	.115	1,495 (51.2)	300 (40.8)	<.001	
Average	2,664 (49.6)	2,072 (48.9)	592 (52.5)		1,366 (46.7)	143 (52.2)		1,366 (46.8)	405 (55.1)		
Poor/very poor	182 (3.4)	118 (2.8)	64 (5.7)		61 (2.1)	8 (8.6)		61 (2.1)	30 (4.1)		
Lives with both parents											
No	4,712 (87.8)	490 (11.6)	163 (14.4)	.008	312 (10.7)	30 (11.0)	.890	312 (10.7)	107 (14.6)	.003	
Yes	653 (12.2)	3,747 (88.4)	965 (85.6)		2,610 (89.3)	244 (89.0)		2,610 (89.3)	628 (85.4)		
Academic performance											
Upper	1,817 (33.9)	1,465 (34.6)	223 (19.8)	.276	1,142 (39.1)	51 (18.6)	<.001	1,142 (39.1)	205 (27.9)	<.001	
Medium	2,396 (44.6)	1,920 (45.3)	619 (54.9)		1,306 (44.7)	134 (48.9)		1,306 (44.7)	347 (47.2)		
Lower	1,152 (21.5)	490 (20.1)	286 (25.4)		474 (16.2)	89 (32.5)		474 (16.2)	183 (24.9)		
Perceived study pressure											
Nil/light	1,034 (19.3)	811 (19.1)	352 (31.2)	<.001	667 (22.8)	31 (11.3)	<.001	667 (22.8)	78 (10.6)	<.001	
General	3,052 (56.9)	2,433 (57.4)	476 (42.2)		1,769 (60.5)	172 (62.8)		1,769 (60.5)	359 (48.8)		
Heavy/very heavy	1,279 (23.8)	993 (23.4)	300 (26.6)		486 (16.6)	71 (25.9)		486 (16.6)	298 (40.5)		

Note. Data are shown as n (%). OSNA: online social networking addiction; CES-D: Center for Epidemiology Scale for Depression; -: not applicable. *p values were obtained using χ^2 test.

Table 2. Univariate associations between background covariates and incidence of depression/OSNA

	Incidence of depression			Incidence of OSNA		
	<i>n</i> (%) (<i>n</i> = 515)	ORu (95% CI)	<i>p</i>	<i>n</i> (%) (<i>n</i> = 335)	ORu (95% CI)	<i>p</i>
Sex						
Male	249 (15.9)	1		168 (8.9)	1	
Female	266 (16.3)	0.96 (0.79, 1.16)	.641	167 (9.4)	0.94 (0.75, 1.17)	.573
Grade						
Seven	250 (16.1)	1		160 (9.1)	1	
Eight	265 (16.1)	1.00 (0.83, 1.21)	.977	175 (9.2)	1.00 (0.80, 1.26)	.977
Father's education level						
Primary school or below	32 (17.2)	1		26 (11.5)	1	
Secondary middle school	190 (17.8)	1.04 (0.69, 1.59)	.827	116 (9.5)	0.81 (0.52, 1.28)	.377
High middle school	139 (14.0)	0.80 (0.52, 1.23)	.317	93 (8.2)	0.67 (0.42, 1.07)	.090
University or above	129 (15.8)	0.92 (0.60, 1.42)	.705	86 (9.3)	0.78 (0.49, 1.26)	.310
Don't know	25 (18.3)	1.14 (0.63, 2.04)	.666	14 (9.3)	0.79 (0.40, 1.59)	.516
Mother's education level						
Primary school or below	47 (15.6)	1		31 (8.4)	1	
Secondary middle school	196 (17.2)	1.15 (0.81, 1.63)	.424	118 (9.1)	1.11 (0.73, 1.69)	.621
High middle school	141 (15.2)	1.01 (0.70, 1.46)	.939	109 (10.5)	1.28 (0.84, 1.96)	.257
University or above	105 (15.4)	1.03 (0.70, 1.52)	.861	64 (8.1)	0.97 (0.61, 1.53)	.891
Don't know	26 (18.4)	1.32 (0.77, 2.25)	.310	13 (8.5)	1.03 (0.52, 2.03)	.940
Family financial situation						
Very good/good	229 (14.2)	1		145 (8.1)	1	
Average	269 (17.8)	1.32 (1.08, 1.60)	.006	172 (9.7)	1.21 (0.96, 1.53)	.105
Poor/very poor	17 (24.6)	1.98 (1.12, 3.49)	.019	18 (19.8)	2.76 (1.60, 4.76)	<.001
Lives with both parents						
No	64 (18.7)	1		54 (12.9)	1	
Yes	451 (15.8)	0.80 (0.60, 1.07)	.135	281 (8.7)	0.65 (0.48, 0.89)	.008
Academic performance						
Upper	169 (14.2)	1		109 (8.1)	1	
Medium	226 (15.7)	1.13 (0.91, 1.41)	.254	145 (8.8)	1.10 (0.85, 1.42)	.488
Lower	120 (21.3)	1.66 (1.28, 2.16)	<.001	81 (12.3)	1.61 (1.19, 2.19)	.002
Perceived study pressure						
Nil/light	96 (13.8)	1		59 (7.9)	1	
Average	305 (15.7)	1.16 (0.90, 1.48)	.253	178 (8.4)	1.05 (0.77, 1.44)	.735
Heavy/very heavy	114 (20.5)	1.63 (1.20, 2.20)	.002	96 (12.5)	1.65 (1.17, 2.32)	.004

Note. OSNA: online social networking addiction; ORu: univariate odds ratio; 95% CI: 95% confidence interval, obtained by the univariate logistic regression models.

also have an increased risk of developing depression compared with those who were no OSNA at both baseline and follow-up.

The difference in results obtained using baseline measures (i.e., baseline OSNA) and changes in status (i.e., change in OSNA status) to predict an incidence outcome (i.e., new incidence of depression) could be explained by the high remission rates from OSNA and depression during the follow-up period. The high natural remission rate of Internet addictive behaviors (49.5%–51.5%) has been observed in two previous longitudinal studies in Taiwan (Ko, Yen, Yen, Lin, & Yang, 2007; Ko et al., 2015). The results from our previous survey in Hong Kong also consistently observed a high incidence of remission from Internet addiction behavior during a 12-month period (59.29 per 100 person-years; Lau, Wu, Gross, Cheng, & Lau, 2017). Similarly, in this study, a large proportion of remission cases from depression (41.4%) and OSNA (58.8%) were observed during the study period. These results indicated that OSNA and depression status in

baseline assessment could not be treated as unchangeable conditions over time and hence ignoring the remission effect over time would potentially underestimate the effect of OSNA on depression. Thus, we speculated that the modeling approach involving dynamic changes in OSNA and depression status over time could provide more convincing and robust estimation by ruling out the potential offset effects from remission cases.

The findings in this study suggest a bidirectional association between OSNA and depression among adolescents, indicating that depression renders an individual vulnerability to develop OSNA, and in turn, the negative consequence of OSNA further exacerbates the symptoms of depression. Maladaptive cognitions (i.e., rumination, self-doubt, low self-efficacy, and negative self-appraisal) and dysfunctional behaviors (i.e., using Internet to escape from emotional problems) are critical in the development of Internet-related addictive behaviors (Davis, 2001). Depressed individuals usually present cognitive symptoms and possess positive expectancies for their Internet use that Internet could distract

Table 3. Longitudinal associations between OSNA and depression: multilevel logistic regression models

	n	No. of new incident cases	Univariate models		Multivariable models		p	
			ORu (95% CI)	p	AOR (95% CI)	p		
OSNA predict new incident depression (n = 3,196)								
Baseline OSNA score (continuous)	–	–	1.05 (1.03, 1.07)	<.001	1.04 (1.02, 1.06) ^a	<.001	1.01 (0.99, 1.03) ^b	.242
Baseline OSNA								
No	2,922	451	1		1 ^a		1 ^b	
Yes	274	64	1.65 (1.22, 2.22)	.001	1.48 (1.09, 2.01)	.012	1.16 (0.85, 1.60)	.342
Change in OSNA status over time								
No OSNA	2,694	354	1		1 ^a		1 ^b	
Remission from OSNA	179	38	1.77 (1.21, 2.58)	.003	1.61 (1.10, 2.37)	.015	1.29 (0.87, 1.91)	.202
Persistent OSNA	95	26	2.46 (1.54, 3.93)	<.001	2.23 (1.39, 3.58)	<.001	1.65 (1.01, 2.69)	.044
Emerging OSNA	228	97	4.89 (3.67, 6.52)	<.001	4.67 (3.49, 6.24)	<.001	4.29 (3.17, 5.81)	<.001
Depression predict new incident OSNA (n = 3,657)								
Baseline CES-D score (continuous)	–	–	1.05 (1.03, 1.06)	<.001	1.04 (1.03, 1.05) ^c	<.001	1.03 (1.01, 1.04) ^d	<.001
Baseline depression								
No	2,922	228	1		1 ^c		1 ^d	
Yes	735	107	2.02 (1.58, 2.58)	<.001	1.78 (1.38, 2.31)	<.001	1.48 (1.14, 1.93)	.004
Change in depression status over time								
No depression	2,471	131	1		1 ^c		1 ^d	
Remission from depression	315	21	1.28 (0.80, 2.07)	.307	1.19 (0.73, 1.93)	.486	0.97 (0.60, 1.59)	.918
Persistent depression	420	86	4.62 (3.43, 6.21)	<.001	4.17 (3.05, 5.69)	<.001	3.45 (2.51, 4.75)	<.001
Emerging depression	451	97	4.88 (3.67, 6.50)	<.001	4.70 (3.53, 6.28)	<.001	4.47 (3.33, 5.99)	<.001

Li et al.

Note. OSNA: online social networking addiction; CES-D: Center for Epidemiology Scale for Depression; ORu: univariable odds ratio; AOR: adjusted odds ratio; 95% CI: 95% confidence interval. ^aModels were adjusted for sex, grade, family financial situation, academic performance, and perceived study pressure. ^bModels were adjusted for sex, grade, family financial situation, academic performance, perceived study pressure, and baseline CES-D score (continuous variable). ^cModels were adjusted for sex, grade, family financial situation, living arrangement with parents, academic performance, and perceived study pressure. ^dModels were adjusted for sex, grade, family financial situation, living arrangement with parents, academic performance, perceived study pressure, and baseline OSNA score (continuous variable).

them from negative moods and personal problems (e.g., depression and loneliness; Brand, Laier, & Young, 2014; Wu, Cheung, Ku, & Hung, 2013). In particular, online social networking is attractive to people with mood problems because of its anonymity and absence of social cues (i.e., facial expression, voice inflection, and eye contact) compared to face-to-face communications (Young & Rogers, 1998). Depressed individuals might prefer online social networking as a more secure and less threatening means of communication, as well as a means for regulating their negative moods (i.e., alleviating negative emotions, anxiety, and personal problems). These maladaptive cognition and avoidance coping strategies accelerate the development of OSNA. Excessive online social networking involvement displaces the time spent with family and peers in the real world, and causes withdrawal from interpersonal offline activities, which intensifies the negative moods (e.g., depressive symptoms and loneliness; Kraut et al., 1998), thereby presenting a reciprocal relation.

The findings in this study entail several implications in designing prevention and intervention programs. First, the positive prediction of baseline depression on new incidence of OSNA implies that depressed adolescents are at high risk of developing OSNA later. Intervention strategies of reducing depressive symptoms, that is, reducing maladaptive belief of positive outcome expectancies of Internet use, training social skills, and planning offline leisure activities (Chou et al., 2015), might effectively prevent the development of OSNA. Second, it is meaningful to assess the levels of depressive symptoms as a marker of the vulnerability for OSNA. Interventions and preventions targeting adolescents at high risk with identified depressive symptoms might reduce the odds of experiencing OSNA among school adolescents. Third, for the strong prediction of change in OSNA status (i.e., persistent OSNA and emerging OSNA) on incidence of depression and the prediction of change in depression status (i.e., persistent depression and emerging depression) on incidence of OSNA, it implies that OSNA is highly comorbid with depression, indicating a negative reinforcement mechanism.

There are some implications for future research. First, our results along with previous studies indicated that the level of OSNA and depressive symptoms are dynamic and reversible during the study period rather than random fluctuation in chance (Lau et al., 2017). Future studies involving measures of depression or OSNA are suggested to measure these disorders repeatedly rather than just one time point by assuming them unchangeable over time. In addition, the statistical methodology should consider such status change in modeling specifications, such as using change in pathological status over time rather than baseline status as a predictor of mental health outcomes. Second, it raised a concern whether these disorders (i.e., depressive symptoms and Internet-related behaviors) are long-lasting or short-term. Further longitudinal studies involving latent-class trajectory modeling approach are alternative to estimate the natural developmental course of these disorders.

To our knowledge, our cohort study is the first to estimate a bidirectional association between OSNA and depression among the adolescents. The main strength of this study is a prospective large-scale study design with repeated measures

for OSNA and depression. Another major advantage is that a bidirectional association, including the longitudinal prediction of OSNA on development of depression and the longitudinal prediction of depression on development of OSNA, was tested in the same sample.

However, several limitations should be noted when interpreting the findings. First, due to self-reported data collection method, reporting bias may consequentially exist (e.g., social desirable bias and recall bias). Second, this study focused on specific demographic population (i.e., non-clinical, school-based students), and the generalizability of the results to other population should be cautious. Studies in other demographic population (i.e., psychiatric clinical population) are necessary to further confirm such longitudinal associations found in this study. Third, there may exist misclassification for depression as a source of measurement error considering that depression was measured by a self-administered epidemiological screening scale rather than clinical diagnosis to assess depression. Fourth, this study was restricted to two time points with 9-month interval. As we defined change in OSNA/depression (i.e., persistent OSNA/depression and remission from OSNA/depression) by comparing results of baseline and follow-up surveys that were conducted 9 months apart, we do not know whether OSNA/depression status changed or fluctuated during the 9-month period. Longitudinal studies with multiple observations and short time interval are necessary to capture the dynamic picture of these negative conditions. Fifth, considering that there is no available golden standard instrument and diagnostic criteria for OSNA, we used 10th decile of the OSNA scores at baseline to define OSNA cases following similar published study (Verkuyl et al., 2014). The sensitivity and specificity of such criterion for OSNA status is unclear and need to be evaluated in future research. However, the OSNA scale showed acceptable psychometric properties in this study and our previous studies. Sixth, the longitudinal associations between OSNA and depression were estimated separately using two subsamples. We believe that using pathological status as outcome rather than continuous scores could provide more meaningful explanation in epidemiological study. Cross-lagged structural equation modeling could be an alternative approach to explore causal directions in future longitudinal studies with three or more observations. In addition, our findings provide strong evidences of temporal associations (one important criterion for causal inference) between OSNA and depression. However, we could not rule out the possibility that a third variable not included in this study linked the longitudinal associations between OSNA and depression.

CONCLUSIONS

This study revealed a bidirectional association between OSNA and depression among adolescents, meaning that depression significantly contributes to the development of OSNA, and in turn, depressed individuals experience more deleterious effects from addictive online social networking use. More longitudinal studies with multiple observational time points and short-time interval are warranted for further confirmation of the findings from this study.

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Authors' contribution: J-BL, JTFL, PKHM, and X-FS conceived and designed the study. J-BL, J-CM, and Y-XC acquired the data. J-BL, JTFL, and PKHM performed the statistical analyses. J-BL, JTFL, PKHM, XZ, and AMSW drafted and revised the manuscript. All authors contributed to the interpretation of the results and critical revision of the manuscript for important intellectual content and approved the final version of the manuscript.

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