



Relationships of excessive internet use with depression, anxiety, and sleep quality among high school students in northern Vietnam

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ABSTRACT

Purpose: To examine the associations of excessive internet use with depression, anxiety, and sleep quality among high school students in northern Vietnam, a country experiencing rapid economic growth.

Design and methods: A cross-sectional study was conducted in a high school in northern Vietnam from July to September 2019. Symptoms of depression and anxiety were respectively assessed using the Center for Epidemiological Studies Depression Scale and the Vietnamese Anxiety Scale. Sleep quality was measured using the Pittsburgh Sleep Quality Index. Internet use and demographic characteristics were obtained using structured questionnaires. A multiple logistic regression was performed.

Results: In total, 678 participants with an average age of 16.1 (standard deviation 0.9) years were included. Nearly one-third of the adolescents (30.7%) exhibited excessive internet use (> 4 h/day), 19.6% experienced depressive symptoms, 14.5% presented anxiety symptoms, and 58.8% reported poor sleep quality. Compared to non-excessive internet users, excessive internet users (> 4 h/day) experienced significantly higher levels of depressive symptoms ($p = .001$), anxiety ($p = .008$), and poorer sleep quality ($p < .001$). Students who were female and with fair/poor self-rated health experienced higher depression, anxiety, and poor sleep quality ($p < .05$). After adjusting for demographic and health-related factors, students with excessive internet use were 58% more likely to experience poor sleep quality (odds ratio, 1.58, 95% confidence interval [1.06, 2.35]).

Conclusions: Excessive internet use in Vietnamese high school students was significantly associated with poor sleep quality, but not with depression or anxiety.

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Introduction

Internet use is rapidly increasing worldwide, and it has become an important means of social connection and communication (Nowland et al., 2018) as well as a source of entertainment in our daily lives (Zhang & Ho, 2016). With technological advances, internet accessibility and digital learning devices have become more convenient for the younger generation and might be linked to the rise in excessive internet use (Lenhart et al., 2010). Excessive internet use is now recognized as a global public health challenge; in particular, Asian populations present more extreme use than Europeans, Americans, or Africans (Baloğlu et al., 2020). An epidemiological study of 5366 adolescents from six Asian countries found that smartphone ownership was 62%, and

internet addiction was estimated to range between 6.2% and 21% in those countries (Mak et al., 2014). In Vietnam, there were an estimated 55.9 million internet users in 2018, and 72.5 million users in 2021 (Degenhard, 2021). Nowadays, adolescents in Vietnam are experiencing dramatic changes in their society, with new lifestyles emerging from the rapid economic development (Vuong et al., 2019). Thus, investigating the relationship between internet use and mental health in adolescents will help in developing intervention programs for prevention and clinical practice.

Existing studies show that the links between internet use and mental health in adolescents are complex, with various affecting factors (Anderson et al., 2017). An analysis of Australian adolescents found that excessive internet use was associated with depression in female but not male adolescents (Hoare et al., 2017). In comparison, a Japanese study found that the duration of mobile phone use was not related to depression among adolescents (Tamura et al., 2017). However, an extensive survey of 8067 youths in Asia and the United States indicated that excessive internet use was associated with a higher risk of

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depression in Asian students than in U.S. students (Tang et al., 2018). These mixed findings may be partially explained by social and cultural factors (Baloglu et al., 2020). In Asian cultures, youth often face conflicts between social and personal identity formation (Tran et al., 2017). For example, high school students in Vietnam often use the internet to cope with stress due to their academic burdens (Nguyen et al., 2013). In addition to mental health, evidence suggests that poor sleep quality or short sleep duration is common in children and adolescents who exhibit excessive internet use (Cain & Gradisar, 2010). However, most existing studies were conducted in developed areas or countries where internet access is widely available. Little is known about the relationships between hours of internet use and health-related problems among adolescents in developing countries.

Access to digital media by adolescents has drastically increased in developing countries in recent years. Notably, adolescents in developing countries face different health challenges and resources compared to those who grow up in developed countries, as the socio-economic context varies (Fatusi & Hindin, 2010; World Health Organization, 2017). Research of high school students in developing countries would provide an ecological understanding of individuals within particular school, family, and peer environments and thus contribute to effective adolescent interventions in these locations (Fatusi & Hindin, 2010). It is therefore a priority to examine internet use and adolescents' health in economically growing countries, such as this study proposes to do for Vietnamese youth.

Depression, anxiety, and sleep problems are recognized as common issues among Vietnamese adolescents. However, their relationships with internet use are much less well understood. In Vietnam, high rates of depression (25.9%–26.3%) and anxiety (16.2%–22.8%) symptoms were reported in middle and high school students in Ho Chi Minh City (Thai, 2010) and Can Tho City (Nguyen et al., 2013). Moreover, a study by Zhang et al. (2017) found that nearly 80% of Vietnam adolescents and young adults have visited healthcare facilities due to sleep problems, but they found no association between internet use and sleep problems (Zhang et al., 2017). Conversely, another study indicated that excessive internet use was associated with a poor health-related quality of life among Vietnamese youth (Tran et al., 2017). A recent study in Vietnam found that 64.7% of Vietnamese youth reported regularly using the internet every day, and over 40% spent more than 3 h/day online (Do et al., 2020). Vietnamese youth also reported a higher rate of excessive internet use than other Asian countries, including the Philippines, Korea, Taiwan, Singapore, and Japan (Tran et al., 2017). A recent study suggested that screen time for adolescents should be limited to 4 h/day (Berchtold et al., 2018) instead of the criterion of 2 h/day (AAP, 2001), which was found to be difficult to achieve in real life. However, whether the time spent on internet use is associated with depression, anxiety, and sleep quality in Vietnamese adolescents remains to be investigated.

To better understand the relationships between the amount of internet use and depression, anxiety, and sleep quality in Vietnamese adolescents, the current study aimed to (1) investigate the distributions of depressive symptoms, anxiety symptoms, sleep quality, and internet use among high school students in northern Vietnam, and (2) examine the relationships of internet use with depression, anxiety, and sleep quality among these students.

Methods

Study design and participants

A cross-sectional study was conducted in a public high school in Yen Phong District, Bac Ninh Province, Vietnam, from July to September 2019. There are two public schools and one private school in Yen Phong District (Pham, 2019). Approximately 92% of high school students in Vietnam attend public high schools (Vietnam Ministry of Education and Training, 2020). We collected our data when students were

attending summer courses at the school. The Ethical Review Board of Biomedical Research of Hanoi University of Public Health, Vietnam (no. 331/2019/YTCC-HD3) and the Joint Institutional Review Board of Taipei Medical University Taiwan (no. N201906014) approved this study. Written informed consent was obtained from the participants and their parents or guardians prior to participation.

The inclusion criterion of this study was that the student had to be a registered high school student. Students were excluded if they had any chronic medical condition (e.g., asthma, congenital heart defects, diabetes, or cancer), were receiving psychiatric care, or were taking antidepressants or antipsychotic medications. Clustered random sampling was conducted using a class as a randomization unit. In total, 15 classes were selected from 45 classes at the studied school, including five classes each from grades 10, 11, and 12. A list of randomization numbers was prepared using a simple randomized sampling method by an off-site research assistant who was not involved in student recruitment.

A sample size of 404 was estimated based on a previous study, which reported an odds ratio (OR) of 1.9 between internet use and depression (Wu et al., 2015) to achieve 80% power at a 0.05 significance level. Considering an incompleteness rate of 20%, the final sample size was set to at least 485.

Measurements

Depressive symptoms

Depressive symptoms were measured using the Vietnamese version of the Center for Epidemiological Studies Depression Scale (CES-D) (Nguyen et al., 2007). The CES-D was originally developed by Radloff (1977) to measure depressive symptoms in the general population in the past week; it has also been widely used for adolescents (Stockings et al., 2015). This 20-item self-reported questionnaire measures depressed mood, feelings of guilt/worthlessness, helplessness, psychomotor retardation, loss of appetite, and sleep disturbances using a 4-point scale from "rarely or none of the time" (less than 1 day) to "most or all of the time" (5–7 days). The participants completed the CES-D according to their depressive symptoms in the past week. Each item was scored from 0 to 3, with the total score ranging between 0 and 60, and a higher score reflecting a higher level of symptoms. A suggested cutoff of 21, commonly adopted for Asian adolescents (Kim et al., 2007), was used to identify adolescents for further evaluation, with a sensitivity of 0.86 and specificity of 0.86 (Stockings et al., 2015). The Vietnamese version of the CES-D had satisfactory internal reliability ($\alpha = 0.87$) (Nguyen et al., 2007). In this study, Cronbach's alpha was 0.87.

Anxiety symptoms

The Vietnamese Anxiety Scale (VAS) (Nguyen et al., 2007), a 13-item self-reported anxiety scale widely used in Vietnam, was used to assess anxiety symptoms. The participants completed each item based on their anxiety symptoms in the past 30 days using a 3-point scale: 1 (never), 2 (sometimes), or 3 (often). The total score range was 13–39, with a higher score indicating greater anxiety (Nguyen et al., 2007). A suggested cutoff of 26 was used to identify adolescents for further evaluation of clinical anxiety, with a sensitivity of 31.3% and specificity of 92.2% (Thai, 2010). This scale had a similar sensitivity of 0.36 and specificity of 0.96 with a non-specific distress scale—a common screening tool for serious mental illness (Kessler et al., 2003). The VAS showed good construct validity and good internal reliability ($\alpha = 0.82$) among Vietnamese adolescents (Nguyen et al., 2007). In this study, Cronbach's alpha was 0.79.

Sleep quality

Sleep quality was assessed using the Vietnamese version of the Pittsburgh Sleep Quality Index (PSQI) (To & Nguyen, 2015), which was originally developed by a group of experts from the University of Pittsburgh (Buysse et al., 1989). The PSQI is a self-rated questionnaire measuring sleep quality over a 1-month interval, including 19 items in seven

components: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, sleep medication use, and daytime dysfunction. Each component was scored from 0 to 3, with the total score ranging between 0 and 21, and a higher score indicating lower sleep quality. A cutoff score of 5 was used for “poor” sleep quality (Woods & Scott, 2016). The Vietnamese version of the PSQI was shown to be acceptable for use in the Vietnamese general population, with a Cronbach's alpha of 0.79 and a test-retest reliability coefficient of 0.79 (To & Nguyen, 2015). A suggested cutoff score of 5 was used to identify adolescents with poor sleep quality, with a respective sensitivity and specificity of 88% and 75% (To & Nguyen, 2015). In this study, Cronbach's alpha was 0.62.

Internet use

Participants were asked how many hours per day on average they had used the internet in the past 30 days, using a five-choice answer (almost none; < 1 h/day; 1–2 h/day; 3–4 h/day; > 4 h/day). Internet use was then categorized as >4 h/day, 3–4 h/day, and < 3 h/day, based on the prior literature (Berchtold et al., 2018), for subsequent analysis.

Demographic and health characteristics

Demographic information including age, gender, grade, and religion was collected. Health-related information was measured, including smoking, alcohol consumption, physical exercise, and the self-rated general health status using a structured questionnaire developed by the research team.

Data collection procedure

Demographic and health characteristics, as well as data on internet use, sleep quality, and symptoms of depression and anxiety were collected at the school. All students completed the self-reported questionnaires during class recess at school, which took about 15 min.

Data analysis

Data were checked and assessed for completeness before the principal data analysis. For participants with only one item missing in the questionnaire, an item was substituted with the mean of the gender-specific subgroup. Among the included subjects, there was one participant with one CESD item missing and another with one VAS item missing. The number of participants with a mean substitution was 1 (0.1%) in the CESD and 1 (0.1%) in the VAS. Descriptive statistics, including the mean and standard deviation (SD) for continuous variables and the frequency and percentage for categorical variables, were conducted. Pearson correlation coefficients were used to assess the correlations among depression, anxiety, and sleep quality. We used the aforementioned cutoff scores to identify elevated levels of depression, anxiety, and sleep quality. To examine bivariate relations, Chi-squared tests and an analysis of variance (ANOVA) were used with Bonferroni post-hoc comparisons. Bonferroni corrections were used to determine the significance levels of comparisons between groups.

To examine the associations of depression, anxiety, and sleep quality with internet use, we started with multilevel logistic regressions that considered the interdependence of students in the same class (Merlo et al., 2005). We used the unconditional model (intercept only model) to obtain intra-class correlation coefficient (ICC) estimates. The ICC was calculated using $[\text{var}(u_{0j})/[\text{var}(u_{0j}) + (\pi^2/3)]]$, where $\text{var}(u_{0j})$ is the random intercept variance and $(\pi^2/3) \approx 3.29$. ICC values of <0.2 were not significant and suggested a small proportion of the total variance between classes, and therefore the use of a multilevel approach was not warranted (Merlo et al., 2005). A single-level analysis was then suggested to use in subsequent analyses. A multiple logistic regression was adopted to examine the associations of depression, anxiety, and sleep quality with internet use, after adjusting for demographic and health characteristics. All data analyses were performed using IBM

SPSS software (Version 25.0). All analyses with a p value of ≤ 0.05 were regarded as statistically significant.

Results

Characteristics of participants

Of the 700 students recruited, 678 students completed the study (completion rate = 96.9%), with 16 not returning the informed consent form and six being absent on the survey date.

In total, 678 students completed the study, and their mean age was 16.1 ± 0.9 years, including 395 (59.3%) females and 283 (41.7%) males (Table 1). Most participants had no religion (92.9%); 118 students (17.4%) reported drinking alcohol during the past month; 45% reported doing less than 1 h/day of physical exercise, and around one-fifth (21.4%) of the sample almost never exercised. The majority of participants rated their general health as “good to excellent” (75.8%). Only three students (0.4%) reported smoking, which is consistent with a prior finding of 0.2%–3.7% of smoking among students from eight high schools in Vietnam (Pham, 2015), and this factor was not included in further analyses due to the small percentage of individuals who reported smoking (Table 1).

Distributions of depressive symptoms, anxiety symptoms, sleep quality, and internet use

The average scores for depressive symptoms and anxiety were 14.5 ± 8.4 and 20.8 ± 4.3 , respectively. Almost 20% of the students had a high level of depression (19.6%), and 14.5% reported high levels of anxiety (Table 2). The mean score of sleep quality was 5.2 ± 2.5 , with 58.8% of students reporting poor sleep quality. In total, 30.7% reported excessive use of the internet (> 4 h/day), and 63.1% used the internet at least 3 h/day. We found significant correlations between depression and anxiety ($r = 0.47$), depression and sleep quality ($r = 0.50$), and anxiety and sleep quality ($r = 0.41$) ($p < .001$) (Table 2).

Table 1
Descriptive characteristics of participants ($n = 678$).

Variable	<i>n</i>	%
Age, $\bar{x} \pm SD$	16.1 \pm 0.9	
Gender		
Male	283	41.7
Female	395	59.3
Grade		
10	227	33.5
11	225	33.2
12	226	33.3
Religion		
No religion	630	92.9
Buddhist/Catholic	48	7.1
Smoking		
No	675	99.6
Yes	3	0.4
Alcohol consumption		
No	560	82.6
Yes	118	17.4
Physical exercise		
Almost never	145	21.4
< 1 h/day	305	45.0
\geq 1 h/day	228	33.6
Self-rated general health		
Excellent/very good/good	514	75.8
Fair/poor	164	24.2

Note: \bar{x} , mean; SD, standard deviation.

Table 2
Distributions of depressive symptoms, anxiety symptoms, sleep quality, and internet use ($n = 678$).

	Distribution			Pearson's correlation		
	n	%	$\bar{x} \pm SD$	Depressive symptoms	Anxiety symptoms	Sleep quality
Depressive symptoms (CES-D)			14.5 \pm 8.4	1.00		
Low (< 21)	545	80.4				
High (\geq 21)	133	19.6				
Anxiety symptoms (VAS)			20.8 \pm 4.3	–	1.00	0.41**
Low (< 26)	580	85.5				
High (\geq 26)	98	14.5				
Sleep quality (PSQI)			5.2 \pm 2.5	–	–	1.00
Good (< 5)	279	41.2				
Poor (\geq 5)	399	58.8				
Internet use						
< 3 h/day	250	36.9				
3–4 h/day	220	32.4				
> 4 h/day	208	30.7				

Note: \bar{x} , mean; SD , standard deviation; CES-D, Center for Epidemiological Studies Depression Scale; VAS, Vietnamese Anxiety Scale; PSQI, Pittsburgh Sleep Quality Index; * $p < .05$; ** $p < .001$.

Depression, anxiety, and sleep quality with different levels of internet use

The ANOVA results showed significant differences in the mean scores of depression ($p = .001$), anxiety ($p = .008$), and sleep quality ($p < .001$) among the different levels of internet use. The Bonferroni post-hoc test indicated that participants had higher symptoms scores among excessive internet users (> 4 h/day) than among low internet users (< 3 h/day) ($p < .05$). The differences between users of 3–4 h/day and < 3 h/day were not significant. We also found a significant association between excessive internet use and poor sleep quality ($p = .014$), but not for depression ($p = .07$) or anxiety ($p = .17$) using χ^2 (Table 3). The results of internet use and sleep quality remained significant after using the Bonferroni corrections ($p = .017$).

Associations of internet use with depressive symptoms, anxiety symptoms, and sleep quality

The analysis of multilevel unconditional models found small estimates of ICCs for depressive symptoms (ICC = 0.019), anxiety symptoms (ICC = 0.008), and poor sleep quality (ICC = 0.041). The results indicated that very small and non-significant values of total individual differences in depression, anxiety, and sleep quality occurred at the class level ($p > .05$). We then used multiple logistic regression models to examine the associations of internet use with depressive symptoms, anxiety symptoms, and sleep quality (Table 4).

The unadjusted models indicated that excessive internet use (> 4 h/day) was associated with an increased risk of depression (OR: 1.71, 95%

CI: 1.07, 2.71) and poor sleep quality (OR: 1.76, 95% CI [1.21, 2.58]) compared to low internet users (< 3 h/day) ($p < .05$). Meanwhile, female students and those who reported fair or poor health had increased odds of being in the high-depression, high-anxiety, and poor-sleep groups ($p < .05$). Students in grade 11 (OR: 2.05, 95% CI [1.26, 3.33]) or 12 (OR: 1.66, 95% CI [1.01, 2.73]), and those with religion (OR: 2.69, 95% CI [1.45, 4.99]) were more likely to experience high depression levels ($p < .05$), while students who exercised > 1 h/day (OR: 0.39, 95% CI [0.21, 0.71]) reported less anxiety ($p < .05$). As to sleep quality, students in grade 12 (OR: 1.93, 95% CI [1.32, 2.82]) and those who consumed alcohol (OR: 1.59, 95% CI [1.04, 2.42]) had increased odds of poor sleep quality ($p < .05$).

In the multivariate analyses, the adjusted ORs remained significant for gender, grade, religion, and self-rated general health. Neither alcohol consumption nor physical exercise was associated with depression, anxiety, or sleep quality. Excessive internet use was associated with sleep quality, but not with depression or anxiety (Table 4).

The relationship between excessive internet use and sleep quality was further examined by including depression or anxiety as a covariate variable as well as adding an interaction term of gender and depression/anxiety subsequently. Students with excessive internet use (adjusted OR 1.53, 95% CI [1.02–2.30], $p = .04$), high anxiety levels (aOR: 2.51, 95% CI [1.36, 4.62], $p = .03$), or the interaction term (anxiety by gender) (aOR: 7.30, 95% CI [0.87, 61.12], $p = .07$) were more likely to experience poor sleep quality. Interestingly, the association of excessive internet use with sleep quality became insignificant (aOR: 1.46, 95% CI [0.97, 2.21]) ($p = .07$) when adding depression (aOR: 5.36, 95% CI [2.64,

Table 3
Distributions of depressive symptoms (CES-D), anxiety symptoms (VAS), and sleep quality (PSQI) with different levels of internet use ($n = 678$).

	Internet use			χ^2	$F (df)$	Post-hoc comparison between groups ^a
	Group I < 3 h/day ($n = 250$)	Group II 3–4 h/day ($n = 220$)	Group III > 4 h/day ($n = 208$)			
	n (%)	n (%)	n (%)			
Depressive symptoms, $\bar{x} \pm SD$	13.35 \pm 7.80	14.29 \pm 8.01	16.21 \pm 9.34		6.79 (2, 675)**	III > I**
Low (< 21)	210 (84.0)	178 (80.9)	157 (75.5)	5.28		
High (\geq 21)	40 (16.0)	42 (19.1)	51 (24.5)			
Anxiety symptoms, $\bar{x} \pm SD$	20.34 \pm 4.5	20.63 \pm 4.01	21.56 \pm 4.40		4.82 (2, 675)*	III > I*
Low (< 26)	218 (87.2)	192 (87.3)	170 (81.7)	3.53		
High (\geq 26)	32 (12.8)	28 (12.7)	38 (18.3)			
Sleep quality, $\bar{x} \pm SD$	4.78 \pm 2.08	5.07 \pm 2.25	5.89 \pm 2.93		12.52 (2, 675)**	III > I**, III > II*
Good (< 5)	118 (47.2)	91 (41.4)	70 (33.7)	8.61*		
Poor (\geq 5)	132 (52.8)	129 (58.6)	138 (66.3)			

Note: \bar{x} , mean; SD , standard deviation; df , degrees of freedom; CES-D, Center for Epidemiological Studies Depression Scale; VAS, Vietnamese Anxiety Scale; PSQI, Pittsburgh Sleep Quality Index; ^a According to Bonferroni post-hoc tests; * $p < .05$; ** $p < .001$.

Table 4
Relationships of internet use with depression, anxiety, and sleep quality in multiple logistic regression models ($n = 678$).

	Depression		Anxiety		Poor sleep quality	
	OR (95% CI)	aOR (95% CI) ^a	OR (95% CI)	aOR (95% CI) ^a	OR (95% CI)	aOR (95% CI) ^a
Internet use						
< 3 h/day	1.00	1.00	1.00	1.00	1.00	1.00
3–4 h/day	1.24 [0.77, 2.00]	1.35 [0.81, 2.24]	0.99 [0.58, 1.71]	0.97 [0.55, 1.71]	1.27 [0.88, 1.83]	1.20 [0.82, 1.76]
> 4 h/day	1.71 [1.07, 2.71]*	1.63 [0.99, 2.68]	1.52 [0.91, 2.54]	1.36 [0.79, 2.32]	1.76 [1.21, 2.58]*	1.58 [1.06, 2.35]*
Gender						
Male	1.00	1.00	1.00	1.00	1.00	1.00
Female	1.58 [1.06, 2.35]*	1.64 [1.03, 2.60]*	3.24 [1.93, 5.43]**	2.99 [1.70, 5.27]**	1.59 [1.17, 2.17]*	1.66 [1.16, 2.38]*
Grade						
10	1.00	1.00	1.00	1.00	1.00	1.00
11	2.05 [1.26, 3.33]*	2.27 [1.35, 3.82]*	0.91 [0.54, 1.53]	0.94 [0.54, 1.63]	1.36 [0.94, 1.97]	1.43 [0.96, 2.12]
12	1.66 [1.01, 2.73]*	1.41 [0.83, 2.39]	0.87 [0.52, 1.47]	0.73 [0.42, 1.28]	1.93 [1.32, 2.82]**	1.65 [1.11, 2.46]*
Religion						
No religion	1.00	1.00	1.00	1.00	1.00	1.00
Buddhist/Catholic	2.69 [1.45, 4.99]*	2.65 [1.37, 5.14]*	1.20 [0.54, 2.65]	1.41 [0.61, 3.25]	1.18 [0.64, 2.16]	1.13 [0.60, 2.13]
Alcohol consumption						
No	1.00	1.00	1.00	1.00	1.00	1.00
Yes	1.20 [0.74, 1.94]	1.09 [0.64, 1.85]	1.17 [0.68, 2.02]	1.63 [0.90, 2.96]	1.59 [1.04, 2.42]*	1.55 [0.98, 2.44]
Physical exercise						
Almost never	1.00	1.00	1.00	1.00	1.00	1.00
< 1 h/day	0.90 [0.56, 1.46]	1.09 [0.65, 1.82]	0.77 [0.46, 1.27]	0.95 [0.56, 1.61]	1.15 [0.77, 1.72]	1.36 [0.89, 2.09]
≥ 1 h/day	0.73 [0.43, 1.23]	1.19 [0.65, 2.15]	0.39 [0.21, 0.71]*	0.68 [0.35, 1.33]	0.93 [0.61, 1.42]	1.33 [0.83, 2.16]
Self-rated general health						
Good/very good/excellent	1.00	1.00	1.00	1.00	1.00	1.00
Fair/poor	3.34 [2.23, 5.00]**	3.30 [2.15, 5.08]**	2.16 [1.38, 3.41]**	1.79 [1.11, 2.88]*	2.21 [1.51, 3.25]**	2.08 [1.39, 3.12]**

Note: OR, odds ratio; aOR, adjusted odds ratio; CI, confidence interval.

^a aORs and their 95% CIs were obtained after adjusting for all variables listed in this table.

* $p < .05$.

** $p < .001$.

10.88]) ($p < .001$) or the interaction term (depression by gender) as covariates (aOR: 0.85, 95% CI [0.29, 2.51]) ($p = .76$).

Discussion

This study provides the first evidence of relationships between excessive internet use and mental health and sleep quality in high school students in Vietnam, one of the most rapidly developing countries in Asia. Our study found a significant proportion of excessive internet use (30.7%), depressive symptoms (19.6%), anxiety symptoms (14.5%), and poor sleep quality (58.8%) in these adolescents. Significant differences in all outcome measures of depression, anxiety, and sleep scores were detected among adolescents with long internet use (> 4 h/day) compared to those who used the internet <3 h/day. Even after adjusting for demographic and health characteristics, excessive internet use remained significant in students with poor sleep quality, but not in those with high depression or high anxiety levels defined by the cutoff scores. Our study adds to the existing literature by showing a significant association of internet use and sleep quality among adolescents when they spent more than 4 h/day on the internet, which is consistent with the results reported by Berchtold et al. (2018). Additionally, our findings extend the previous research conducted in developed countries (Carli et al., 2013) by confirming that excessive internet use was significantly associated with poor sleep quality among adolescents in a developing country. This study's strengths lie in the relatively large number of high school students included and the use of universally valid tools as measurements for depression, anxiety, and sleep quality in order to allow comparisons with other studies. Our study results highlight the need to prioritize health measures to address internet use and its impacts on youth health.

In this study, the proportions of high school students who experienced elevated depression, anxiety, or poor sleep quality were similar to prior findings in Vietnam (Nguyen et al., 2013; Thai, 2010) and China (Li et al., 2019). Most high school students in Asian countries, such as Vietnam and China, need to complete a college entrance

examination, which induces strong academic pressures on adolescents (Nguyen et al., 2013; Tang et al., 2020). In addition, family-related factors, such as parental high expectations or over-involvement, may partially explain the high levels of depression and anxiety found in high school students in Asian cultures (Tang et al., 2020). Recently, a school-based program highlighting sleep hygiene and relaxation showed beneficial results in improving adolescents' sleep problems in Australia, Brazil, Hong Kong, and New Zealand (Chung et al., 2017). Whether such a school-based intervention or other effective programs are suitable for Vietnamese youth is worth exploring.

In the present study, we found that almost two-thirds (60.3%) of high school students reported using the internet for at least 3 h/day, and half of those used it for more than 4 h/day (30.7%), which is higher than the duration of screen time reported by previous studies in Vietnam (Do et al., 2020) and Japan (Tamura et al., 2017). Our results are consistent with an earlier study which suggested that the proportion of excessive internet use among Vietnamese youths was comparable or higher than that in other Asian countries, including the Philippines, Korea, Taiwan, Singapore, Hong Kong, Malaysia, South Korea, and Japan (Tran et al., 2017). Different perceptions of internet use may explain the high use of the internet by Vietnamese adolescents. For example, most Vietnamese youth believe that frequent use of the internet does not affect their health and that only online games can be addictive. They think that their real lives cannot be affected by internet content, even when they feel anxious or uncomfortable after only one day of not using the internet (Do et al., 2020). However, our understanding of internet use behaviors in Vietnam is still in its infancy, and further longitudinal studies on excessive internet use are warranted to develop appropriate interventions in order to reduce screen time among adolescents.

Associations of internet use with depression and anxiety

In this study, excessive internet use was not associated with high levels of depression or anxiety after adjusting for demographic and

health factors. To this date, cross-sectional studies examining internet use and depression or anxiety symptoms have shown inconclusive results. Studies of Australian adolescents (Hoare et al., 2017) and Chinese college students (Wu et al., 2015) indicated positive associations between internet use and depressive symptoms. However, another study based on Japanese adolescents did not find an association between mobile phone use and depression ($p > .05$) (Tamura et al., 2017). The mixed findings might be because of the differences in sample sizes, the characteristics of participants (high school or college students), or the covariates considered (physical activity or the body-mass index) among these studies. Notably, a female gender and self-rated health status as fair/poor were significantly associated with all outcomes in the current study, which is consistent with previous studies in Vietnam and the United States (Bazargan-Hejazi et al., 2010; Nguyen et al., 2013). The association between internet use and youth mental health is inconclusive among different regions with various associated factors, highlighting the importance of incorporating these factors into interventions targeting depression, anxiety, and sleep problems in adolescent populations, especially in developing countries such as Vietnam.

Association of internet use with sleep quality

Our study supports the argument that internet use might negatively influence youth sleep quality, especially with students using the internet for more than 4 h/day. These findings are consistent with a prior study of adolescents in China (Tan et al., 2016). Also, Japanese adolescents who used a mobile phone for ≥ 5 h/day had greater odds of insomnia than those who used one for < 1 h/day (aOR: 3.89, 95% CI: 1.21–12.49) (Tamura et al., 2017). However, our results contrasted with the findings from a previous study of Vietnamese youth reporting that internet use was not associated with sleep problems (aOR: 1.02, 95% CI: 0.99, 1.05) ($p = .12$) (Zhang et al., 2017). The mechanisms underlying the association between internet use and sleep are complex, but the literature has pointed out some potential explanations. For example, long exposure to bright lights from electronic screens may delay melatonin secretion, probably influencing brain activity and affecting cerebral blood flow and brain electrical activity, resulting in delayed sleep onset (Huber et al., 2002). Internet use might also change sleep processes, such as reducing rapid eye movement (REM) sleep, slow-wave sleep, and sleep efficiency (Dworak et al., 2007). Further, prolonged use of electronic devices might cause physical discomfort, such as muscle pain and headaches, which may impair users' sleep patterns (Thomé et al., 2011). Currently, excessive internet use is quite common among youth and can negatively influence youth sleep quality. Schools should therefore pay attention to managing appropriate durations of internet use, which might help prevent sleep problems among youth.

Practice implications

As excessive internet use increases in high school students who are at a vulnerable stage for developing depression, anxiety, and addiction, it is crucial to promptly identify at-risk adolescents and their internet use patterns in order to prevent the effects of prolonged screen time (Carli et al., 2013). Pediatric nurses in primary care settings, in particular, should assess the time youth spend using the internet and provide measures to raise their awareness of proper internet use. In addition, recent evidence has indicated that school-based interventions that address suitable and limited time on the internet, as well as its associations with youth mental health, showed potential effectiveness in preventing excessive internet use among adolescents (Vondráčková & Gabrhelík, 2016). For example, a video-based intervention effectively improved internet use attitudes with concomitant reduced screen time (Turel et al., 2015). School nurses are in an ideal position to provide educational programs for the prevention and detection of students' excessive internet use. Future studies should also evaluate the efficacies of educational interventions targeting students' parents, teachers, and peers, who

positively influence adolescents' values and beliefs. It is suggested that educational programs incorporate the cultural importance of family bonding and teacher and parental involvement to maximize positive outcomes for adolescents (Tang et al., 2020). The diffusion of internet use is rising as the internet becomes affordable and accessible for most adolescents in Vietnam (Do et al., 2020). Therefore, a longitudinal study on changes in internet use over time and its impact on adolescents' health outcomes is warranted for future research. Developing and evaluating intervention programs for preventing excessive or problematic use are urgently needed to protect adolescent health in Vietnam.

Limitations

This study has some limitations that should be considered. First, due to the nature of the cross-sectional methodology, causal relationships were difficult to establish. Longitudinal studies are required to explore the changes of internet use over time. Second, our study recruited participants from a single high school in northern Vietnam. Therefore, the ability to generalize our findings to out-of-school adolescents or the entire country is limited. Future studies that include multiple regions and schools are thus warranted. Third, this study only examined the duration of internet use without differentiating the reasons (studying, gaming, or using social media) and timing (daytime or nighttime) of internet use. It would be worthwhile to explore in future studies whether the reasons and timing of internet use are related to mental health and sleep quality. Fourth, the low sensitivity of the Vietnamese Anxiety Scale (31.3%) might have caused an underestimation of the proportion of high anxiety symptoms. Finally, comprehensive analyses of risk and the protective factors of mental health and sleep quality were not conducted in our study, such as teacher and peer relationships, caffeine intake, coping strategies, and social support. These variables should be included in future studies.

Conclusions

Our study highlights that excessive internet use, depression, anxiety, and poor sleep quality were common among high school students in northern Vietnam. Students with more than 4 h of internet use per day reported more depression and anxiety symptoms and poorer sleep quality. After taking into account the covariates, high school students who used the internet for more than 4 h/day were only associated with higher odds of experiencing poor sleep quality. Interventions that aim to reduce the duration of internet use may therefore be beneficial for improving youth sleep quality.

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Declaration of Competing Interest

None.

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References

- AAP (2001). *American Academy of Pediatrics: Children, adolescents, and television. Pediatrics, 107*, 423–426.

- Anderson, E. L., Steen, E., & Stavropoulos, V. (2017). Internet use and problematic internet use: A systematic review of longitudinal research trends in adolescence and emergent adulthood. *International Journal of Adolescence and Youth*, 22(4), 430–454.
- Baloğlu, M., Şahin, R., & Arpacı, I. (2020). A review of recent research in problematic internet use: Gender and cultural differences. *Current Opinion in Psychology*, 36, 124–129 <https://doi.org/10.1016/j.copsyc.2020.05.008>.
- Bazargan-Hejazi, S., Alvarez, G., Teklehaimanot, S., Nikakhtar, N., & Bazargan, M. (2010). Prevalence of depression symptoms among adolescents aged 12–17 years in California and the role of overweight as a risk factor. *Ethnicity and Disease*, 20(1 Suppl 1), S11–107.
- Berchtold, A., Akre, C., Barrense-Dias, Y., Zimmermann, G., & Suris, J. -C. (2018). Daily internet time: Towards an evidence-based recommendation? *The European Journal of Public Health*, 28(4), 647–651.
- Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research*, 28(2), 193–213 [https://doi.org/10.1016/0165-1781\(89\)90047-4](https://doi.org/10.1016/0165-1781(89)90047-4).
- Cain, N., & Gradisar, M. (2010). Electronic media use and sleep in school-aged children and adolescents: A review. *Sleep Medicine*, 11(8), 735–742 <https://doi.org/10.1016/j.sleep.2010.02.006>.
- Carli, V., Durkee, T., Wasserman, D., Hadlaczky, G., Despalins, R., Kramarz, E., ... Brunner, R. (2013). The association between pathological internet use and comorbid psychopathology: A systematic review. *Psychopathology*, 46(1), 1–13.
- Chung, K. F., Chan, M. S., Lam, Y. Y., Lai, C. S. Y., & Yeung, W. F. (2017). School-based sleep education programs for short sleep duration in adolescents: A systematic review and meta-analysis. *Journal of School Health*, 87(6), 401–408.
- Degenhard, J. (2021). Forecast of the number of internet users in Vietnam from 2010 to 2025. Retrieved July 19, 2021 from <https://www.statista.com/forecasts/1147008/internet-users-in-vietnam>.
- Do, H. N., Onyango, B., Prakash, R., Tran, B. X., Nguyen, Q. N., Nguyen, L. H., ... Ho, R. C. M. (2020). Susceptibility and perceptions of excessive internet use impact on health among Vietnamese youths. *Addictive Behaviors*, 101, 105898 <https://doi.org/10.1016/j.addbeh.2019.01.043>.
- Dworak, M., Schierl, T., Bruns, T., & Strüder, H. K. (2007). Impact of singular excessive computer game and television exposure on sleep patterns and memory performance of school-aged children. *Pediatrics*, 120(5), 978–985.
- Fatusi, A. O., & Hindin, M. J. (2010). Adolescents and youth in developing countries: Health and development issues in context. *Journal of Adolescence*, 33(4), 499–508.
- Hoare, E., Milton, K., Foster, C., & Allender, S. (2017). Depression, psychological distress and internet use among community-based Australian adolescents: A cross-sectional study. *BMC Public Health*, 17(1), 365 <https://doi.org/10.1186/s12889-017-4272-1>.
- Huber, R., Treyer, V., Borbely, A., Schuderer, J., Gottselig, J., Landolt, H. P., ... Buck, A. (2002). Electromagnetic fields, such as those from mobile phones, alter regional cerebral blood flow and sleep and waking EEG. *Journal of Sleep Research*, 11(4), 289–295.
- Kessler, R. C., Barker, P. R., Colpe, L. J., Epstein, J. F., Gfroerer, J. C., Hiripi, E., ... Walters, E. E. (2003). Screening for serious mental illness in the general population. *Archives of General Psychiatry*, 60(2), 184–189.
- Kim, M. -D., Hong, S. -C., Lee, C. -I., Kwak, Y. -S., Shin, T. -K., Jang, Y. -H., Oh, E. -H., Lee, J. -W., Jeon, B. -H., & Hwang, S. -E. (2007). Prevalence of depression and correlates of depressive symptoms for residents in the urban part of Jeju island, Korea. *International Journal of Social Psychiatry*, 53(2), 123–134 <https://doi.org/10.1177/0020764006075022>.
- Lenhart, A., Purcell, K., Smith, A., & Zickuhr, K. (2010). *Social media & mobile internet use among teens and young adults*. Millennials. Pew Internet & American Life Project <http://samaritanbehavioralhealth.net/files/social-media-young-adults.pdf>.
- Li, J. -Y., Li, J., Liang, J. -H., Qian, S., Jia, R. -X., Wang, Y. -Q., & Xu, Y. (2019). Depressive symptoms among children and adolescents in China: A systematic review and meta-analysis. *Medical Science Monitor: International Medical Journal of Experimental and Clinical Research*, 25, 7459.
- Mak, K. -K., Lai, C. -M., Watanabe, H., Kim, D. -I., Bahar, N., Ramos, M., ... Cheng, C. (2014). Epidemiology of internet behaviors and addiction among adolescents in six Asian countries. *Cyberpsychology, Behavior and Social Networking*, 17(11), 720–728.
- Merlo, J., Chaix, B., Yang, M., Lynch, J., & Rastam, L. (2005). A brief conceptual tutorial of multilevel analysis in social epidemiology: Linking the statistical concept of clustering to the idea of contextual phenomenon. *Journal of Epidemiology and Community Health*, 59(6), 443–449 <https://doi.org/10.1136/jech.2004.023473>.
- Nguyen, D. T., Dedding, C., Pham, T. T., Wright, P., & Bunders, J. (2013). Depression, anxiety, and suicidal ideation among Vietnamese secondary school students and proposed solutions: A cross-sectional study. *BMC Public Health*, 13(1), 1195 <https://doi.org/10.1186/1471-2458-13-1195>.
- Nguyen, H. T., Le, A. V., & Dunne, M. P. (2007). Value and reliability of depression and anxiety measuring – Scales used in community-based research among adolescents. *Vietnam Journal of Public Health (Vietnamese)*, 7, 25–31 <http://www.vjph.vn/index.php/tapchitytc/article/view/217>.
- Nowland, R., Necka, E. A., & Cacioppo, J. T. (2018). Loneliness and social internet use: Pathways to reconnection in a digital world? *Perspectives on Psychological Science*, 13(1), 70–87 <https://doi.org/10.1177/1745691617713052>.
- Pham, B. (2019). Bac Ninh - List of preschool, elementary, junior and senior high schools [Vietnamese website]. Retrieved July 19, 2021 from <https://schoolsbox.org/bac-ninh-danh-sach-truong-mam-non-tieu-hoc-thcs-thpt>.
- Pham, T. T. B. (2015). *Study burden, academic stress and mental health among high school students in Vietnam*. Doctoral thesis Queensland, Australia: Queensland University of Technology http://eprints.qut.edu.au/82291/1/Thi%20Thu%20Ba_Pham_Thesis.pdf.
- Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, 1(3), 385–401 <https://doi.org/10.1177/014662167700100306>.
- Stockings, E., Degenhardt, L., Lee, Y. Y., Mihalopoulos, C., Liu, A., Hobbs, M., & Patton, G. (2015). Symptom screening scales for detecting major depressive disorder in children and adolescents: A systematic review and meta-analysis of reliability, validity and diagnostic utility. *Journal of Affective Disorders*, 174, 447–463 <https://doi.org/10.1016/j.jad.2014.11.061>.
- Tamura, H., Nishida, T., Tsuji, A., & Sakakibara, H. (2017). Association between excessive use of mobile phone and insomnia and depression among Japanese adolescents. *International Journal of Environmental Research and Public Health*, 14(7), 701.
- Tan, Y., Chen, Y., Lu, Y., & Li, L. (2016). Exploring associations between problematic internet use, depressive symptoms and sleep disturbance among southern Chinese adolescents. *International Journal of Environmental Research and Public Health*, 13(3), 313 <http://www.mdpi.com/1660-4601/13/3/313>.
- Tang, C., Wu, A., Yan, E., Ko, J., Kwon, J., Yogo, M., ... Koh, Y. (2018). Relative risks of internet-related addictions and mood disturbances among college students: A 7-country/region comparison. *Public Health*, 165, 16–25.
- Tang, X., Tang, S., Ren, Z., & Wong, D. F. K. (2020). Psychosocial risk factors associated with depressive symptoms among adolescents in secondary schools in mainland China: A systematic review and meta-analysis. *Journal of Affective Disorders*, 263, 155–165 <https://doi.org/10.1016/j.jad.2019.11.118>.
- Thai, T. (2010). *Educational stress and mental health among secondary and high school students in Ho Chi Minh City, Vietnam*. Thesis for Masters of Public Health Queensland, Australia: Queensland University of Technology.
- Thomé, S., Härenstam, A., & Hagberg, M. (2011). Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults – A prospective cohort study. *BMC Public Health*, 11(1), 66.
- To, N., & Nguyen, N. (2015). Validity of the Vietnamese version of the Pittsburgh sleep quality index. *Sleep Medicine*, 16, S52 <https://doi.org/10.1016/j.sleep.2015.02.128>.
- Tran, B. X., Huong, L. T., Hinh, N. D., Nguyen, L. H., Le, B. N., Nong, V. M., ... Ho, R. C. M. (2017). A study on the influence of internet addiction and online interpersonal influences on health-related quality of life in young Vietnamese. *BMC Public Health*, 17(1), 138 <https://doi.org/10.1186/s12889-016-3983-z>.
- Turel, O., Mouttapa, M., & Donato, E. (2015). Preventing problematic internet use through video-based interventions: A theoretical model and empirical test. *Behaviour & Information Technology*, 34(4), 349–362.
- Vietnam Ministry of Education and Training (2020). Secondary and high school education statistics for the school year 2018–2019. Retrieved March 19, 2021 from <https://moet.gov.vn/thong-ke/Pages/Thong-ke-giao-duc-trung-hoc.aspx?ItemID=6635>.
- Vondráčková, P., & Gabrhelík, R. (2016). Prevention of internet addiction: A systematic review. *Journal of Behavioral Addictions*, 5(4), 568–579.
- Vuong, T. T., Semerák, V., & Vuong, Q. H. (2019). The Vietnamese economy at the crossroads. *Southeast Asia and the ASEAN economic community* (pp. 91–143). Springer.
- Woods, H. C., & Scott, H. (2016). #Sleepyteens: Social media use in adolescence is associated with poor sleep quality, anxiety, depression and low self-esteem. *Journal of Adolescence*, 51, 41–49 <https://doi.org/10.1016/j.adolescence.2016.05.008>.
- World Health Organization (2017). Global accelerated action for the health of adolescents (AA-HA!): Guidance to support country implementation. <https://apps.who.int/iris/bitstream/handle/10665/255418/WHO-FWC-MCA-17.05-eng.pdf?sequence=1>.
- Wu, X., Tao, S., Zhang, Y., Zhang, S., & Tao, F. (2015). Low physical activity and high screen time can increase the risks of mental health problems and poor sleep quality among Chinese college students. *PLoS One*, 10(3), Article e0119607 <https://doi.org/10.1371/journal.pone.0119607>.
- Zhang, M. W., & Ho, R. (2016). Rapid cross platform healthcare gaming design and implementation: The cost effective methodology. *Technology and Health Care*, 24(6), 973–976.
- Zhang, M. W. B., Tran, B. X., Huong, L. T., Hinh, N. D., Nguyen, H. L. T., Tho, T. D., ... Ho, R. C. M. (2017). Internet addiction and sleep quality among Vietnamese youths. *Asian Journal of Psychiatry*, 28, 15–20 <https://doi.org/10.1016/j.ajp.2017.03.025>.