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# Psychological Compensation or Drinking Poison to Quench Thirst: The Dual Effects of Smartphone Use Habits on Depression in Chinese Left-Behind Adolescents

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**ABSTRACT**

With the popularity of smartphones, their impact on the physical and mental health of left-behind adolescents has become the focus of social attention. Some believe that smartphone use will provide emotional compensation for left-behind adolescents, while others believe that the lack of supervision of smartphone use among left-behind adolescents will exacerbate their psychological problems. To explore the mechanisms of the dual effects, we conducted a field survey of 848 left-behind adolescents (male = 446, age between 12 and 19) in Shicheng County in Gannan Region of China. It was found that social smartphone use, recreational smartphone use, frequency, and duration of smartphone use, mediated by smartphone dependence, were positively associated with social anxiety, stress perception, and sleep disorder, and further with depression of left-behind adolescents. Although social uses of smartphones were positively associated with online social support, they were not related to loneliness and depression. Based on our results, left-behind adolescents' smartphone use habits have shown more harmful than good effects on their psychological well-being.

In 2022, the suicide of a teenager in Jiangxi Province of China reignited social attention and discussion on adolescent depression (China Central Television, 2023). Adolescence is a period of rapid physiological and psychological changes, accompanied by an increase in health-risk behaviors (Alderman et al., 2019). For this reason, adolescents face high incidences of depression, which harm their academic performance, social skills, and physical and mental health, hindering their healthy growth (Cortés-Denia et al., 2020). Among factors affecting adolescent depression, family factors show important direct impacts (e.g., Hollis, 1996). Due to the lack of complete parental companionship, mental health problems of left-behind adolescents have drawn social concerns. Left-behind adolescents refer to teenagers aged 12–18 who are left behind at their hometown with one or both of their migrant parents working away from home (Zhao et al., 2008). According to the latest census data in 2020, there are a total of 17.24 million left-behind adolescents in China, including 10.93 million residing in rural areas and 6.31 million living in urban areas (National Bureau of Statistics et al, 2023). A survey showed that about 60% of Chinese left-behind adolescents suffered from psychological problems due to the absence of their parents (Zhang et al., 2017).

With the popularity of smartphones, left-behind adolescents have begun to use them widely. A research report released by the Center for Rural Governance at Wuhan University showed that 90% of left-behind adolescents played with smartphones (China Youth Daily, 2023). Long-term unhealthy mental state and lack of supervision may make them more likely to addict to smartphones. Previous studies have shown mixed results regarding the impact of smartphones on adolescents' mental health. Some believed that smartphone use can aggravate adolescent depression by increasing smartphone dependence and addiction (e.g., Twenge et al., 2018). However, such research targeted adolescents in general. Other scholars argued that adolescents' smartphone uses can provide emotional support and a sense of digital compensation, which can promote socialization and alleviate adolescents' mental health problems (e.g., Chen & Guo, 2022). In terms of left-behind adolescents, some studies have found that smartphones can help build remote families and provide emotional compensation (e.g., Lü et al., 2022; Wang & Zheng, 2022).

From this perspective, the relationship between adolescents' smartphone uses and their mental health problems is yet inconclusive, and the impact of smartphones on the mental health of left-behind adolescents remains unclear. Therefore, research concerning the influence of smartphones on left-behind adolescents who rely on smartphones to build connections with their migrant parents should be conducted separately to explore the impact of smartphone use on their emotions, distinguishing both positive influences that bring emotional support to left-behind adolescents and negative influences that aggravate their psychological problems. For such purpose, we conducted a field survey of left-behind adolescents in Shicheng County, which is well-known as the main connection between Guangdong Province and Fujian Province in China. Convenient transportation prompts adults in Shicheng County to work away from their hometown, leaving their adolescent children at home without supervision. This study aims to explore the influencing mechanisms of smartphone uses on left-behind adolescents' depression and provide

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suggestions to guide proper smartphone use and maintain good mental health of left-behind adolescents.

## Theoretical background and hypotheses

### Smartphone use and depression in adolescents

Previous studies on smartphone use and adolescent depression have often regarded smartphone use as a direct cause of adolescent depression. In fact, some studies have found that smartphone use is essentially an avoidance strategy, with which people try to divert negative emotions such as depression and anxiety through smartphone use (e.g., Wei et al., 2023). In other words, smartphone use is not necessarily a direct cause of adolescent depression, but a mediating variable of adolescents' own negative emotions and their depressive tendencies. For example, Elhai et al. (2018) found that more anxious and depressed individuals were more likely to experience problems with smartphone addiction.

Left-behind adolescents, a marginalized group with insufficient family care, may experience heightened vulnerability to exhibit mental health problems such as anxiety, loneliness, depression, and somatization (Fellmeth et al., 2018; Wang et al., 2019). Therefore, they were more likely to be attracted by smartphones and use smartphone to avoid pressure and loneliness (Zhen et al., 2020), causing problematic smartphone use, e.g., a recurrent failure to control smartphone use (Alageel et al., 2021). According to the report by a research group at Wuhan University, the problem of Chinese left-behind adolescents indulging in smartphones was serious, as 67.3% of parents reported that their children were addicted to smartphones and 21.3% reported that their children were seriously addicted (China Youth Daily, 2023). However, is such excessive use of smartphones a kind of "drinking poison to quench thirst," which will trigger more serious psychological problems? Or can it provide psychological compensation for left-behind adolescents, alleviating their depression and distress in the real world? On this point, research conclusions have diverged.

### Smartphone use may exacerbate depression among left-behind adolescents

Most studies that hold a negative view on smartphone use posit that adolescents' smartphone use is likely to trigger smartphone dependence, which may cause many mental problems and aggravate adolescents' existing mental health problems in real life, leading to depression.

#### From smartphone use to smartphone dependence

Smartphone use is thought to be more likely to lead to smartphone dependence among adolescents than among adults. Phone dependence is also known as "problematic phone use" or "phone addiction" (e.g., De Sola Gutiérrez et al., 2016). Yen et al. (2009) defined smartphone dependence as a strong and persistent sense of craving and dependence on smartphone use due to excessive indulgence in various activities mediated by smartphones. Compared with adults, adolescents are more likely to be attracted by smartphones and become dependent on them due to their unstable state of physiological and psychological conditions during adolescence (Mak et al., 2014).

Habit formation theory (HFT) posits that the development of habits involves the integration of cues, routine behaviors, and rewards, culminating in the cultivation of a need that drives this cycle (Neal et al., 2006; Wood & Neal, 2007). Stronger habits may manifest as dependency or addictive responses, wherein the initial "need" evolves into a compelling "craving," causing individuals to overlook negative physical consequences. HFT has been applied to explain habitual smartphone behavior (e.g., van Deursen et al., 2015), where repeated usage and associated rewards gradually form a psychological cue that triggers a continuous urge to use smartphones. According to this theory, smartphone dependence may be positively correlated with repetitive behavioral factors such as the frequency and duration of smartphone use. For instance, Yang et al. (2021) found that the frequency of smartphone uses significantly influenced problematic smartphone use. Similarly, Park et al. (2021) identified the duration of smartphone use as a significant predictor of addictive smartphone behavior.

Additionally, smartphone dependence may also be associated with social and recreational smartphone activities, which function as rewards reinforcing the repeated actions. Recreational smartphone use has been found to be closely linked to smartphone dependence. Bae (2017) found that game use was significantly related to phone dependence in Korean adolescents. Liu et al. (2022) research suggests that short video addiction among Chinese left-behind adolescents has become a prominent phenomenon. Meanwhile, social smartphone use has also been suggested to link to smartphone dependence (e.g., Jeong et al., 2016). A survey of South Korean teens by Cha and Seo (2018) found that social media use was a key predictor of teen's phone dependence.

Therefore, the following hypotheses were proposed:

**H1:** (a) Frequency of smartphone use, (b) Duration of smartphone use, and Purposes of smartphone usage, including (c) recreational and (d) social purpose, of left-behind adolescents are positively associated with smartphone dependence.

#### Smartphone dependence may lead to mental health problems

Smartphone dependence is seen as a threat to the physical and mental health of adolescents, as well as the trigger and catalyst of depression in adolescents. First, dependence on smartphones can lead to communication barriers, thereby triggering depressive emotions (Kim et al., 2019). The underlying mechanism is that when individuals overuse smartphones, it may lead to a significant decline in time and quality of interpersonal interactions, damaging their intimate relationship and bringing about consequences such as a reduction of social resources and a decline in self-confidence, thus increasing negative emotions such as social anxiety (Kim et al., 2018). Social anxiety can then increase the risk of developing depression by lowering an individual's self-esteem (Lee et al., 2023).

Second, smartphone dependence can enhance an individual's perception of pressure (Samaha & Hawi, 2016; Sohn

et al., 2019), resulting in the exacerbation of individual's own depressive tendency (P. Zhao & Lapierre, 2020). For one thing, individuals may feel stressed due to information and communication overload on the internet (Thomée et al., 2011). For another, social comparisons amplified by social media may bring stress to those who feel disadvantaged (Chou & Edge, 2012). Perceived stress can then affect the body's stress response system, leading to an increased secretion of stress hormones such as cortisol, which are associated with a higher risk of developing depression (Nikkheslat et al., 2020).

Finally, dependence on smartphones can also affect the activity of the pineal gland of the brain, resulting in continuous excitation of brain blood flow and brain electrical activity, causing sleep disorders (Lemola et al., 2015). Sleep disorders may also lead to elevated cortisol levels, impairing individuals' emotional regulation abilities and increasing the risk of experiencing depressive emotions (Asarnow, 2020; Pandi-Perumal et al., 2020; Tomaso et al., 2021).

Thus, the following hypotheses were proposed:

**H2:** (a) Smartphone dependence of left-behind adolescents is positively associated with depression.

**H2:** (b) Social anxiety, (c) Stress perception, and (d) Sleep disorder play a mediating role in the relationship between smartphone dependence and depression among left-behind adolescents.

### *Smartphone use may alleviate depression among left-behind adolescents through "digital compensation"*

Some studies have drawn positive conclusions about the relationship between smartphone use and mental health of left-behind adolescents. For example, Hu and Mao (2019) found that left-behind children and adolescents (6–20 years old) achieved ritual co-occurrence and the construction of virtual home with the help of smart media, and media technology provided a breakthrough for creating a stronger parent-child relationship. Wang and Zheng (2022) found that smartphones provided indirect, alternative, and displaced emotional compensation for left-behind children and adolescents, and the "digital compensation" mechanism made emotional socialization in virtual situations possible.

Most of the above-mentioned research went deep into the rural fields conducting interviews and making observations, and found that the use of smartphones provided a sense of social support and family compensation for left-behind children, alleviating negative psychological problems triggered by the absence of their parents. According to the details of these studies, social support provided by smartphone use generally came from the social use of smartphones of left-behind adolescents (Liu et al., 2018). For example, Chen and Guo (2022) found that rural adolescents can maintain strong relationships with their parents and relatives, and establish instrumental weak relations with the help of smart communication devices and the internet. Gan (2023) observed video calls between left-behind children and their migrant parents and revealed the mechanism of remote media parenting. Previous studies have also found that the recreational use of smartphones can play a "bridging role," expanding adolescents' social networks and enhancing their sense of social support (Trepte et al., 2012).

In addition, social support was regarded as a "prescription" for alleviating depression among left-behind adolescents (Fan & Lu, 2020). For example, He et al. (2012) found that left-behind adolescents with high levels of social support showed significantly lower levels of loneliness and depression. Meanwhile, loneliness is a mediating variable between social support and depression. The cause lies in the fact that social support can meet individuals' social interaction needs, thereby alleviating feelings of loneliness (Zhang & Dong, 2022). There is also a close association between loneliness and depression, as a lack of social connections and dysfunctional interpersonal relationships are considered significant factors that may increase the likelihood of developing depression (Dunn & Sicouri, 2022).

Hence, the following hypotheses were proposed:

**H3:** (a) Social smartphone use and (b) Recreational smartphone use of left-behind adolescents is positively associated with online social support.

**H3:** (c) Online social support of left-behind adolescents is negatively associated with depression.

**H3:** (d) Loneliness plays a mediating role between social support and depression.

In sum, smartphone uses showed complex effects on the emotional state of left-behind adolescents. Due to the lack of family functions, on the one hand, left-behind adolescents may be more likely to be attracted to smartphones and become addicted to them, thus laying potential dangers of psychological problems. On the other hand, the use of smartphones by left-behind adolescents may provide a sense of "family compensation" and "online emotional support," providing a potential outlet for solving their psychological problems and alleviating loneliness and depression. Taking these diverging views as a starting point, we constructed a theoretical framework to explore the dual effects of smartphone use habits on depression of left-behind adolescents, in hoping to provide suggestions for more effective regulation of smartphone uses among left-behind adolescents (Figure 1).

## Methods

### *Data*

In May 2023, a field survey on left-behind adolescents was conducted in Shicheng County of China. In this study, left-behind adolescents were defined as junior high school or high school students, aged between 12 and 19 years old (we found that some students in high school were over 18 years old, so this study extended the age range of left-behind adolescents to 12–19 years old), with both or one of their parents working away from home.

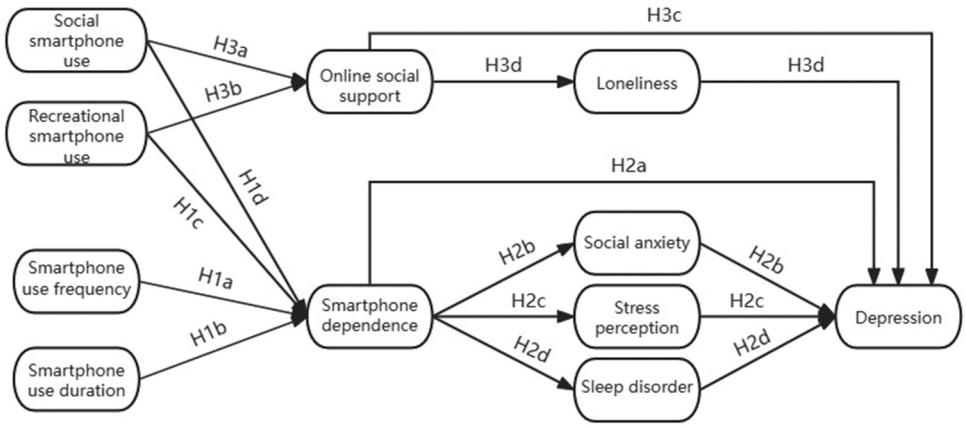


**Figure 1.** Theoretical framework of the influence of smartphone use on depression.

According to an earlier investigation, Shicheng County has one key high school, one ordinary high school, one county junior high school, and 12 township junior high schools. This study employed the stratified sampling method and selected one key high school, one ordinary high school, one county junior high school, and one township junior high school in each of the south, north and middle of the town, resulting in six schools in total. In China, schools categorize students into different classes based on their academic performance. In an effort to enhance teaching efficiency, high-performing students are placed in advanced classes, those with average performance are placed in balanced classes, and those with lower performance are placed in regular classes. After entering each school, one advanced class, one balanced class, and one regular class were selected in the first, second, and third grades of junior high schools (if the school only has advanced and balanced classes, one class was selected from each category), while one advanced class, one balanced class, and one regular class were selected in the first and second grades of high schools. Due to the high pressure of study in the third grade of high school, we expect that stress factors may interfere with the relationship between smartphone use and depression. In addition, the third graders of high school are too stressful preparing the college entrance exam and their time to use smartphones is limited, therefore they were excluded from the sample selection.

A total of 2,000 paper questionnaires were distributed. Students who answered "yes" to the question "are one or both of your parents working outside your hometown in another city" were selected for further analysis, resulting in a total of 868 left-behind adolescents. Excluding 20 questionnaires that failed the attention check, 848 valid questionnaires remained. The sample consists of 53.1% males and 50.7% living in rural areas (Table 1).

**Table 1.** Sample distribution.

| Variable | Frequency | Percentage |
|---|---|---|
| Gender | | |
| Male | 446 | 53.1% |
| Female | 394 | 46.9% |
| Year in school | | |
| 7th grade | 208 | 24.6% |
| 8th grade | 198 | 23.4% |
| 9th grade | 218 | 25.8% |
| 10th grade | 149 | 17.6% |
| 11th grade | 73 | 8.6% |
| Home location | | |
| Town | 413 | 49.3% |
| Rural | 425 | 50.7% |
| Age | | |
| 12–14 | 297 | 37.7% |
| 15–16 | 359 | 45.6% |
| 17–19 | 131 | 16.7% |
| Academic performance | | |
| Excellent | 33 | 4.0% |
| Good | 186 | 22.3% |
| Fair | 366 | 43.9% |
| Pass | 151 | 18.1% |
| Fail | 98 | 11.7% |

## Measurements

Depression, smartphone dependence, social anxiety, stress perception, sleep disorder, social support (both online and offline), and loneliness were all measured on 5-point Likert scales from "*Strongly disagree*" to "*Strongly agree*" (see Table 2 for more details). The higher the scores on depression, smartphone dependence, social anxiety, stress perception, sleep disorder and loneliness, the more serious the problem was. Higher scores of online or offline social supports indicate more supports adolescents received either via smartphones or from real life.

Table 2 also shows the reliability and validity test results of the latent variables. Cronbach's α coefficients and component reliability (CR) are both within the eligibility criteria, indicating good reliability. The factor loadings from Confirmatory Factor Analysis (CFA) were mostly between 0.5 and 0.95. In addition, the Average Variance Extraction (AVE) is greater than 0.36, indicating that the scale has good convergence validity. Finally, by checking the cross-loads, comparing the correlation coefficient between the square root of AVE and each dimension, and applying the HTMT.85 standard proposed by Henseler et al. (2015), the model also showed good discriminative validity.

According to HFT, the rewards associated with smartphone use were captured by the different purposes of smartphone uses by left-behind adolescents. Social smartphone use was measured by averaging the "frequency of using social applications such as QQ, WeChat, Weibo, etc." and the "frequency of

**Table 2.** Question items of latent variables and results of reliability and validity tests.

| Latent variables | Question items | Reference | α | CR | AVE |
|---|---|---|---|---|---|
| Depression | (1) I often feel sad or down; (2) I get upset over minor matters; (3) I feel restless and agitated; (4) My appetite has changed – I eat more/less than I used to.; etc. | Adapted from the Self-Rating Depression Scale SDS (Zung, 1965) | 0.918 | 0.89 | 0.36 |
| Smartphone dependence | (1) I use my smartphone late at night instead of sleeping; (2) I cannot go a while without using my smartphone; (3) If I go a day without using my phone, I feel disconnected from my surroundings; and (4) I feel anxious or uneasy when I'm without my smartphone. | Adapted from the Smartphone Dependence Scale SAS (Kwon et al., 2013) | 0.783 | 0.77 | 0.46 |
| Social anxiety | (1) It takes me a lot of time to overcome shyness in a new environment; (2) I struggle with my work when someone is watching me; and (3) I worry about not knowing what to say in a group. | Adapted from the Interaction Anxiety Scale (Leary & Kowalski, 1993) | 0.669 | 0.66 | 0.40 |
| Stress perception | (1) I felt upset because of something that happened unexpectedly; (2) I felt I were unable to control the important things in my life; (3) I felt that things were not going my way; (4) I found that I could not cope with all the things that I had to do. | Adapted from the Perceived Stress Scale (Cohen et al., 1983) | 0.702 | 0.69 | 0.37 |
| Sleep disorder | (1) I have difficulty falling asleep; (2) I have difficulty staying asleep; (3) my sleep problem impairs the quality of your life; (4) I am worried/distressed about my current sleep problem. | Adapted from the Insomnia Severity Scale (Bastien et al., 2001) | 0.724 | 0.68 | 0.36 |
| Online social support | (1) There is a special person (e.g., teachers, family members, classmates) who is around when I am in need on my phone; (2) there is a special person (e.g., teachers, family members, classmates) with whom I can share my joys and sorrows on my phone; (3) my family is willing to help me make decisions on my phone. (4) I can talk about my problems with my family. | Adapted from the Perceived Social Support Scale (Wang et al., 1999) | 0.775 | 0.78 | 0.46 |
| Offline social support | (1) There is a special person (e.g., teachers, family members, classmates) who is around when I am in need; (2) there is a special person (e.g., teachers, family members, classmates) with whom I can share my joys and sorrows; (3) my family is willing to help me make decisions. (4) I can talk about my problems with my family. | Adapted from the Perceived Social Support Scale (Wang et al., 1999) | 0.883 | 0.83 | 0.46 |
| Loneliness | (1) I lack companionship; (2) I feel in tune with the people around me; (3) I feel left out; (4) I am isolated from others; (5) I feel not a part in a group of friends; (6) I feel lonely. | Adapted from UCLA Loneliness Scale Brief Edition (Russell, 1996) | 0.881 | 0.87 | 0.54 |

using virtual community applications such as Zhihu, Douban, Baidu Tieba, etc." Recreational smartphone use was measured by averaging the "frequency of using smartphone game applications such as Honor of Kings and Game for Peace" and the "frequency of using video applications such as Douyin, Kuaishou, iQIYI, and YOUKU." Educational or learning-oriented usages are also important purposes for adolescents to use smartphones in assisting school work and improving academic performance. However, educational smartphone uses are not the focus of this study since such purposes are unlikely to lead to addictive behaviors or provide emotional support. Therefore, we included educational use only as a control variable in the current study. The educational use of smartphones was measured by the "frequency of using educational applications such as Yuansouti." These items were measured on Likert scales, with 1–5 representing "*never*" to "*very frequently*."

Based on HFT, the repetitiveness of smartphone uses was captured by the frequency of smartphone use and the duration of uses each time. Frequency of smartphone use was measured by how often adolescents used smartphones in the past week on a scale of 1–7 from "*rarely*" to "*very often*." Since left-behind adolescents' smartphone uses were fragmented due to strict prohibition of smartphone use at school in accordance to school policies, calculating the total amount of usage time per day would be difficult and subjected to recall errors. Therefore, the duration of smartphone use was measured by the average amount of time they use smartphones each time (rather than each day), with 1 representing never, 2 representing <30 minutes, 3 representing 30 ≤ use time <60 minutes, 4 representing 60 ≤ use time <120 minutes, 5 representing 120 ≤ use time <180 minutes, 6 representing 180 ≤ use time <240 minutes, and 7 representing ≥240 minutes. Table 3 shows the means and standard deviations of the key variables in the study.

**Table 3.** Mean and standard deviation of key variables.

| Variable | Mean | S.D. |
|---|---|---|
| 1. Social smartphone use | 2.31 | 0.74 |
| 2. Recreational smartphone use | 2.71 | 0.99 |
| 3. Educational smartphone use | 1.95 | 0.92 |
| 4. Duration of smartphone use | 2.39 | 1.12 |
| 5. Frequency of smartphone use | 3.48 | 1.90 |
| 6. Smartphone dependence | 2.45 | 0.89 |
| 7. Social anxiety | 3.10 | 0.89 |
| 8. Stress perception | 3.21 | 0.75 |
| 9. Sleep disorder | 2.38 | 0.81 |
| 10. Online social support | 2.94 | 0.81 |
| 11. Offline social support | 3.58 | 0.68 |
| 12. Loneliness | 2.36 | 0.75 |
| 13. Depression | 2.53 | 0.65 |

Covariates include adolescents' year in school (1 = 7$^{th}$ grade, 2 = 8$^{th}$ grade, 3 = 9$^{th}$ grade, 4 = 10$^{th}$ grade, 5 = 11$^{th}$ grade), gender (0 = male, 1 = female), family location (0 = urban, 1 = rural), academic performance (1 = *excellent*, 2 = *good*, 3 = *medium*, 4 = *pass*, 5 = *fail*), the frequency of contact with their parents (how often do you contact your migrant parents by phone? 1 = *never*, 2 = *occasionally*, 3 = *sometimes*, 4 = *often*, 5 = *very frequently*) and the relationship with their father/mother (1 = *very good*, 2 = *good*, 3 = *average*, 4 = *bad*, 5 = *very bad*).

## Analytic plan

Since depression, smartphone dependence, sleep disorder, stress perception, social anxiety, and loneliness are all latent variables, structural equation models were established to examine multiple causal pathways. SPSS26.0 and AMOS23.0 were used. In the mediation analysis, 5000 bootstrapped samples were drawn to test the significance of the paths.

## Results

As can be seen in Table 3, left-behind adolescents used smartphones for recreational purposes ($M = 2.71$, $SD = 0.99$) most often, followed by social uses ($M = 2.31$, $SD = 0.74$), and least often for educational purposes ($M = 1.95$, $SD = 0.92$). They used smartphones moderately frequently ($M = 3.48$, $SD = 1.90$), and the average duration of smartphone use was less than an hour each time ($M = 2.39$, $SD = 1.12$). To assess the depression tendency, we added the score of each depression item to get a raw score, multiplied the raw score by 1.25, and rounded it up to the whole number to get a standard score (Zhao & Liu, 2021; Zung, 1965). The cutoff value of depression assessment is 53 points, with 53–62 indicating mild depression, 63–72 indicating moderate depression, and above 72 points indicating severe depression. According to the depression scores, about 17.9% of left-behind adolescents had a depressive tendency, of which 11.2% showed a mild tendency, 4.7% showed a moderate tendency, and 1.8% showed a severe tendency.

Figure 2 shows the standardized path coefficients of the structural model. The model fits well ($\chi^2/df = 3.29 < 5$, $p < .001$, RMSEA = 0.052, GFI = 0.839, AGFI = 0.820, NFI = 0.796, IFI = 0.848, TLI = 0.836). Model fit criteria suggest that a lower chi-square value indicates better fit; RMSEA varies between 0 and 1, with lower values (typically less than 0.05 or 0.08) indicating better fit; CFI or IFI values closer to 1 represent good model fit; and TLI values closer to 1 indicate better fit (Hu & Bentler, 1999).

In terms of the relationship between smartphone uses and smartphone dependence, it was found that the frequency ($\beta = 0.314$, $p < .001$) and the duration ($\beta = 0.091$, $p = .015$) of smartphone use of left-behind adolescents were significantly positively associated with smartphone dependence, supporting H1(a) and H1(b). In addition, recreational smartphone use ($\beta = 0.196$, $p < .001$) and social smartphone use ($\beta = 0.198$, $p < .001$) of left-behind adolescents were both significantly positively associated with smartphone dependence, supporting H1(c) and H1(d).

In terms of the impact of smartphone dependence on the mental health of left-behind adolescents, smartphone dependence was found significantly positively associated with social anxiety ($\beta = 0.275$, $p < .001$), stress perception ($\beta = 0.298$, $p < .001$) and sleep disorder ($\beta = 0.217$, $p < .001$). Furthermore, social anxiety ($\beta = 0.077$, $p = .046$), stress perception ($\beta = 0.254$, $p < .001$) and sleep disorder ($\beta = 0.229$, $p < .001$) were significantly positively associated with depression among left-behind adolescents.

In terms of the influence of smartphone use purposes on social support of left-behind adolescents, it was found that social smartphone use was significantly positively associated with online social support ($\beta = 0.203$, $p < .001$), supporting H3(a). However, recreational smartphone use was not significantly related to online social support ($p = .100$), not supporting H3 (b). Online social support was not significantly associated with the loneliness of left-behind adolescents ($p = .188$), but loneliness was significantly positively associated with depression ($\beta = 0.542$, $p < .001$).

Among the covariates, adolescents' year in school, family location, and frequency of contact with their parents were unrelated to depression, while gender, academic performance, and relationship with parents showed certain effects on depression of left-behind adolescents, but these effects were only marginally significant except for gender. Females were more prone to depression than males ($\beta = 0.083$, $p < .001$). The worse the academic performance, the more serious was depression ($\beta = 0.041$, $p = .090$). The worse the relationship with mother ($\beta = 0.051$, $p = .055$) or father ($\beta = 0.052$, $p = .089$), the more severe was depression. Lastly, educational smartphone use was not significantly associated with depression of left-behind adolescents ($p = .118$). However, offline social support was significantly negatively associated with the loneliness of left-behind adolescents ($\beta = -0.371$, $p < .001$), and depression accordingly.

Table 4 shows the results of the mediation effects. First, the total effect of smartphone dependence on depression

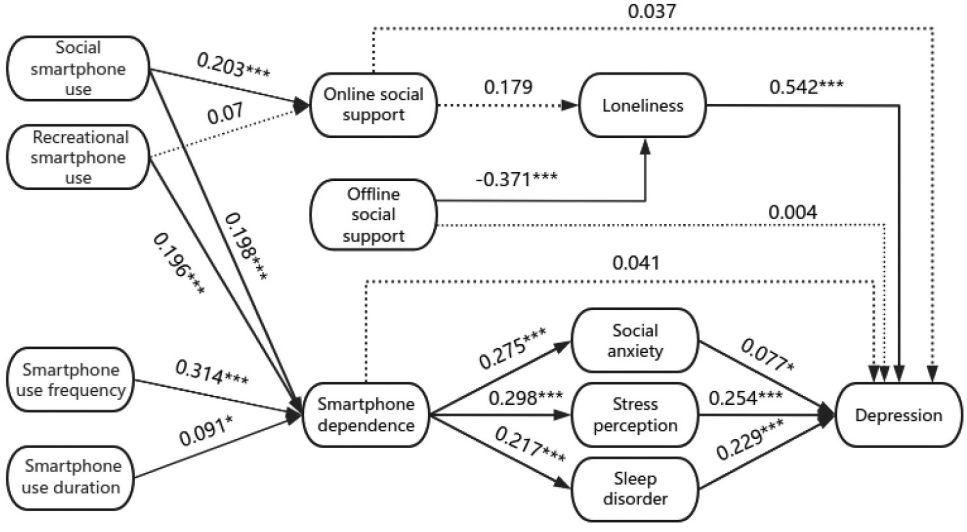


**Figure 2.** Path coefficients of the structural model. The coefficients presented are standardized regression coefficients; solid lines indicate significant paths, and dashed lines indicate non-significant paths; *$p < .05$, ***$p < .001$.

**Table 4.** Results of the mediation effects.

| Paths | Coefficient | 95% Bootstrapped CI | *p* |
|---|---|---|---|
| Smartphone dependence → social anxiety → depression | 0.025 | (0.001, 0.063) | .040 |
| Smartphone dependence → stress perception → depression | 0.084 | (0.038, 0.164) | <.001 |
| Smartphone dependence → sleep disorder → depression | 0.056 | (0.028, 0.104) | <.001 |
| Online social support → loneliness → depression | 0.095 | (−0.056, 0.312) | .200 |
| Offline social support → loneliness → depression | 0.219 | (−0.307, −0.148) | <.001 |

was significant ($\beta = 0.210$, $p < .001$), supporting H2(a). Social anxiety played a partial mediating role in the relationship between smartphone dependence and depression of left-behind adolescents ($\beta = 0.025$, $p = .040$), with the mediating effect accounting for 11.9%, supporting H2(b). Stress perception played a partial mediating role between smartphone dependence and depression ($\beta = 0.084$, $p < .001$), with the mediating effect accounting for 40.0%, supporting H2(c). Sleep disorder also played a partial mediating role in the relationship between smartphone dependence and depression ($\beta = 0.056$, $p < .001$), with the mediating effect accounting for 26.7%, supporting H2(d). Social anxiety, stress perception, and sleep disorder all together explained the relationship between smartphone dependence and depression.

Second, the overall effect of smartphone (online) social support on depression was not significant ($p = .116$), rejecting H3(c). Loneliness did not mediate the relationship between smartphone social support and depression ($p = .200$), rejecting H3(d). However, further investigation revealed that loneliness mediated the relationship between real life (offline) social support and depression ($\beta = -0.219$, $p < .001$).

## Discussion

### Interpretation of results

#### Excessive and improper uses of smartphone were positively associated with phone dependence and negatively associated with the psychological well-being of left-behind adolescents

The current study found that frequent and prolonged use of smartphone, as well as recreational use of smartphone, e.g., playing games and watching short videos, and social use, e.g., surfing on social media platforms, was positively correlated with smartphone dependence among left-behind adolescents. When comparing the magnitudes of these associations, it was suggested that the frequency of smartphone use was a more important indicator of smartphone dependence (three times greater) than the duration of smartphone use. These findings supported the habit formation theory in explaining how repeated smartphone behaviors and the associated rewards from entertainment and social interaction gratifications may form habitual or problematic smartphone uses (e.g., van Deursen et al., 2015).

Smartphone dependence was then positively related to social anxiety, stress perception, and sleep disorders of left-behind adolescents, and consequently depressive moods. With low media literacy (Zheng, 2012), left-behind adolescents were unable to distinguish the authenticity of online information. Interviews with left-behind adolescents revealed that they often felt stressed when browsing negative information online, such as news regarding the difficulty of college entrance examination and future employment. Moreover, many left-behind adolescents exhibited introverted personalities (Kharel et al., 2021) and lacked sufficient offline social support networks. Turning to smartphones may further affect their real-world social interaction, leading to increased social anxiety (Yang & Lu, 2022). Finally, because school policies strictly prohibited the use of smartphones at school (Ministry of Education of China, 2021), adolescents' desire for smartphone use was severely suppressed, leading to excessive use after school and even during late night which may impair their quality sleep. This is particularly pronounced among left-behind adolescents with inadequate family supervision.

The habit formation theory also predicts that as habitual or addictive smartphone behaviors become more frequent, the initial gratification and rewards may diminish over time due to increased physical tolerance and the activation of the anti-reward system (e.g., Koob & Le Moal, 2005). In an attempt to relieve such discomforts and restore high levels of dopamine (e.g., Wise & Koob, 2014), adolescents may increase their frequency or intensity of addictive smartphone behaviors, further entrenching this vicious cycle and leading to the consequence of "drinking poison to quench thirst."

#### Remote communication via smartphones may weaken the feeling of being cared for and offer insufficient emotional support for alleviating loneliness and depression of left-behind adolescents

Consistent with previous research findings (e.g., Chen & Guo, 2022), social uses of smartphones were positively correlated with online social support. However, more online social support obtained from social smartphone uses was not related to less loneliness or less depressive moods, which contradicted most previous qualitative research findings about left-behind adolescents arguing that the emotional compensation offered by remote parenting on smartphones can alleviate their loneliness and depression (e.g., Wang & Zheng, 2022).

Smartphone use did not play a positive role in providing emotional support for left-behind adolescents, because they used smartphones mainly to watch short videos, play online games or communicate with their peers, but rarely communicate with their parents, making it hard to accomplish the role of emotional compensation. In left-behind families, prolonged parent-child separation makes it difficult to fulfill parenting roles, leading to mental health issues among adolescents (Karhina et al., 2023). Communication in distant families often focused on physical health and academic performance of left-behind adolescents rather than their emotions, therefore, remote parents were not fully aware of the emotional

need of left-behind adolescents, nor did they intervene timely. In addition, the intimate signals conveyed by parents to left-behind adolescents may be damaged in long-distance communication, making it impossible for left-behind adolescents to form a strong emotional connection with their "virtual parents" in smartphones (Hu & Mao, 2019). Due to lack of context and communication barriers, remote communication may also lead to more parent-child conflicts. For example, excessive control over mobile phone use has also led to rebellious behavior among left-behind adolescents (e.g., Lee & Ogbolu, 2018), which is common in distant family relationships (Xiao, 2022). For these reasons, the emotional support intended by parents via smartphones failed to mitigate the loneliness and depressive feelings of left-behind adolescents.

Meanwhile, the current study suggested that offline social support played a significant role in alleviating left-behind adolescents' feelings of loneliness and depression, which is consistent with prior research findings (e.g., Twenge et al., 2018). This means that social support from the real world is essential in maintaining good mental health of left-behind adolescents and cannot be easily substituted by virtual companionship.

## Implications

### Theoretical implications

The theoretical implications of this study are manifested two-fold. First, this study attempted to construct a dual-effects model of smartphone use based on the habit formation theory to examine smartphone use habits and their effects on the psychological well-being of left-behind adolescents. A promising effort has been made to integrate two important dimensions in the habit formation process – repetitiveness, conceptualized and measured by the frequency and duration of smartphone uses, and rewards associated with smartphone usage behaviors, operationalized by different usage purposes (e.g., social, recreational, and educational smartphone uses). This new explanatory framework can help better understand how adolescents' smartphone use habits can affect their mental health either positively or negatively.

Second, the current study implies that the positive effects of smartphones in providing digital companionship to left-behind adolescents in remote families as reported in previous qualitative studies (e.g., Hu & Mao, 2019; Q. Wang & Zheng, 2022) may be overstated. In contrast, social supports from the real world (e.g., high levels of face-to-face socializing or contact; Kim, 2017; Shensa et al., 2020) were found much more important in protecting left-behind adolescents against negative consequences of too much time using smartphones. The evidence revealed in the current study warrants further investigation. Future research, both qualitative and quantitative, should pay more attention to differentiate the effects of online and offline social support for left-behind adolescents.

### Practical implications

As advocated by UNICEF (2020), parents, guardians, teachers, communities, policy makers, and service providers should coordinate and collaborate to ensure the well-being of children "left behind." First, it is important to help left-behind adolescents develop healthy smartphone use habits. With insufficient parental supervision, guardians, schools, and communities should take more responsibilities to supervise smartphone use of left-behind adolescents. In terms of time management, non-educational smartphone usage for left-behind adolescents should be limited to less than 2 hours based on recommendations in previous studies (Abi-Jaoude et al., 2020; Twenge et al., 2018). Meanwhile, considering that imposing prohibition on adolescents' smartphone use may trigger psychological reactance, schools and guardians should establish a mutually acceptable phone management strategy by seeking input and engaging in discussions with adolescents. Soft policies regarding smartphone use at school can be implemented to protect adolescents from potential harm of smartphone use while not hindering the benefit of digital connectivity. For those who are not fully aware of the risks of excessive smartphone use for socializing and entertainment, schools can introduce media literacy courses to help them identify beneficial and harmful applications and learn how to manage their usage time effectively. Concrete steps may include encouraging students to create their usage schedules, plan screen-free time, reflect on any overuse behaviors in the past week, and hold classroom discussions on the benefit and harm of different smartphone apps (Gui et al., 2023; Walther et al., 2014). Service providers should continue to optimize the "adolescent mode" function of entertainment and social media platforms to prevent excessive and improper uses by adolescents.

Second, social supports, both online and offline, should be strengthened to satisfy the emotional needs of left-behind adolescents and safeguard them from the negative effects of improper smartphone use. Remote parents should make more visits to their children and spend more time with them to provide emotional support through more face-to-face communication. When they are away from home, they should interact with their left-behind children more frequently through phone and video calls, focusing more on the effectiveness of emotional connection during this media-based nurturing process to reduce the feelings of separation and loneliness of their left-behind children. Research has shown that rural adolescents face more psychological problems than urban ones, but mental health and psychiatric resources are far fewer in rural regions than in cities (Wang et al., 2019). Schools like those in Shicheng county over-emphasized the academic performance of students and neglected their psychological well-being, which sadly led to multiple tragic incidents of self-harm and even suicides in recent years. Therefore, psychological counseling centers should be established in schools or communities where left-behind adolescents gather, especially in rural areas, regularly monitoring the mental health of left-behind adolescents, and inviting mental health experts or community volunteers to provide regular counseling seminars. Media literacy courses can also integrate curriculums to help adolescents master the skills of getting access to massive online psychological resources.

## Limitations and future research directions

As a field survey, this study has the following limitations. First, only one region where left-behind adolescents gather was

selected, resulting in a lack of representativeness of the sample. Second, the variable of social support is a compound measure, which did not distinguish the supporting roles of teachers, classmates, and parents. In fact, what left-behind adolescents lack most is the support from their parents, which is also the key to alleviate their loneliness and depression. The lack of distinctions may be the reason that online social support did not show a significant impact on depression. Third, self-reported smartphone usage may be subject to measurement errors. Fourth, individual differences in terms of the effects of smartphone uses have not been thoroughly explored besides basic demographic variables. Fifth, causal interpretations of the effects are insufficient relying on cross-sectional data. Finally, smartphone use patterns and how they may evolve into addictive behaviors are more complex than what have been explored in the current study. Our measures of smartphone use habits were only one feasible attempt to capture the nature of repetitiveness and rewards associated with smartphone use.

For future research, we first suggest that the sources of social support can be measured separately to further explore the social support function of smartphone use among left-behind adolescents. Second, automatic record of smartphone use can be considered as an alternative to self-reported questionnaires for more precise data collection. Third, more individual characteristic variables, e.g., adolescents' personality, self-esteem, etc., can be considered and measured in future study. Fourth, short-term and long-term effects of smartphone use can be explored through regular follow-up visits to reveal the causal mechanisms and provide a more powerful explanation for the conclusions of the current study.

Finally, other methods to better conceptualize and operationalize smartphone use habits can be implemented to improve both validity and reliability of the relevant measures. A potential approach to better capture smartphone use habits, as reported in Yoon and Yun's recent work (Yoon & Yun, 2023), was to classify adolescents into distinct smartphone usage profiles based on how much time they spent on different smartphone activities, such as learning (those who used smartphone mainly for watching online lectures), recreational use (those who spent much more time on social networking sites, recreational multimedia, and mobile games than learning), and minimal use groups (those with minimal smartphone uses across all activities). Another approach was to capture smartphone use behaviors by measuring total usage time and the fragmentation of smartphone usage and non-usage time intervals using smartphone sensing data as proposed by große Deters and Schoedel (2024). More comprehensive classifications of smartphone use patterns can be explored in the future to extend the applicability of HFT in explaining habitual smartphone behaviors.

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