

Association between smartphone use, smartphone addiction and mental health in teenagers: a structural equation modeling approach

ABSTRACT

This study assessed the interrelationships between smartphone use habits, self-reported dependence and mental health in a cross-sectional study encompassing 1,031 teenagers. The study variables comprised smartphone use/abuse and psychiatric distress signs/symptoms, whose associations were analyzed employing a structural model through structural equation modeling. Early smartphone use by teenagers was negatively and significantly associated to smartphone dependence scores (direct effect) and psychiatric distress symptoms (indirect effect), mediated by cell phone dependence. Furthermore, smartphone addiction led to increased psychiatric distress scores, with a large effect. Thus, it appears that the relationships between smartphone use/abuse and mental health are complex and require further studies to support interventions aimed at teenagers.

KEYWORDS: Smartphone. Mental Disorder. Teenager.

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INTRODUCTION

Smartphones became widely available worldwide from 2011 and since then, their use has increased in all age groups, especially children and teenagers (OECD, 2017). In 2021, Brazil ranked first regarding smartphone use by pre-teenagers and teenagers worldwide (96%), with use becoming increasingly precocious and rising in a dose-dependent manner, increasing with age, reaching up to 99% for 17- and 18-year-olds (MCAFFE, 2022).

Children and teenagers are more vulnerable to excessive smartphone use, since their prefrontal cortical development is not yet complete, which reduces impulse control and hinders substance use control strategies and specific behaviors (BECHARA et al., 2001; BOWDEN-JONES et al., 2005).

Contemporary smartphone use patterns, such as precocity and excessive use, have suggested the existence of a condition termed smartphone addiction, in which daily functioning user interference takes place (DEMIRCI et al., 2015). Also called nomophobia, this condition is considered a technological addiction, characterized by withdrawal symptoms (anxiety, irritability, and impatience), lack of control over smartphone use, longer use times than originally anticipated, tolerance symptoms, interference in daily living activities, positive anticipation and maintenance of smartphone use periods despite negative consequences (KHOURY et al. 2017).

Studies on factors associated with smartphone addiction have focused on eastern countries and university populations (KHOURY et al., 2020; ALVES; ANTONIO; LAUX, 2021). Studies in this regard concerning Brazilian teenagers are scarce and have demonstrated that smartphone dependence is associated with younger teenager age, less sleep hours, more smartphone use during the weekends, complaints of neck pain and suspicions of Common Mental Disorder (CMD) (NUNES et al., 2021). However, a systematic review of longitudinal studies did not find sufficient evidence to support associations between screen time and other mental health symptoms, including anxiety, self-esteem, and general internalizing problems (TANG et al., 2021). On the other hand, an increasing number of studies has detected associations between excessive smartphone use and mental problems, such as depression, anxiety, or stress symptoms (ELHAI et al., 2017; VAHEDI; SAIPHOO, 2018; YANG *et al.*, 2020; SOHN *et al.*, 2019). In this regard, it is noteworthy that mental health during adolescence is a predictive factor for adult life outcomes (HOYT et al., 2012).

The worldwide prevalence of mental disorders in teenagers aged 10 to 19 is 31% (SILVA et al., 2020). In Brazilian teenagers aged 12 to 17, this value has been reported as 30%, increasing with age for both sexes and always higher in girls (LOPES et al., 2016). The world median smartphone addiction prevalence is 23.3% (SOHN et al., 2019), ranging from 4.3% in Iran (MAHMOODI et al., 2018) to 70.3% in Brazil (NUNES et al., 2021). The understanding of potential associations between these two variables has been highlighted in the literature (SOHN et al., 2019).

Based on this theoretical considerations and evidence, the aim of the present study was to investigate associations between smartphone use habits, self-reported smartphone dependence and mental health in teenagers employing structural equation modeling methods.

METHODOLOGY

Participants and procedures

This assessment comprises a cross-sectional study on teenagers, both girls and boys, enrolled in four public state schools in the urban area of São Luís, in the state of Maranhão, Brazil. The study is part of a research project intitled “Use of digital technologies and mental health of teenagers in São Luís, Maranhão”, approved by the Maranhão Federal University Ethics Committee in Research with Human Beings, under no. 5.800.631 and CAAE 58014122.8.0000.5086.

The data sampling took place from November 15 to December 15, 2021. The participants were informed in detail about the study and their assent and/or legal guardian consent was obtained by signing a Free and Informed Assent Term (FIART) and Free and Clarified Assent Term (FLAT), respectively. Students aged between 12 and 19 who self-reported smartphone use for at least one year were included. Participants answered a questionnaire in person in the classroom in the presence of a psychologist. In total, 1,050 participants answered the data collection instrument. Data presenting linear responses, missing values and obvious errors in answers to questions about smartphone use (n=9) were excluded. In addition, 10 non-smartphone users were excluded, resulting in a final sample of 1,031 teenagers, with 539 females (52.28%). No significant difference between boys and girls was noted ($\chi^2=2.05$, $p=0.15$) and the mean age of participants was 15.06 years (standard deviation= ± 1.98 years).

Measurements

A self-administered instrument developed by this study’s researchers containing information on variables associated with smartphone use (addiction and usage patterns) and teenager mental health (occurrence of CMDs) was employed. Items present in the SRQ-20 (Psychiatric distress indicator) and the SPAI-BR (smartphone dependence) were incorporated into the instrument, described below:

(i) The *Smartphone Addiction Inventory (SPAI-BR)* is a public domain questionnaire containing 26 items with yes/no answers that aims to assess smartphone dependence, validated, and adapted to Portuguese for young populations. The sum of positive scores was used as the response variable (KHOURY et al., 2017). Good internal consistency was noted for this measure (Cronbach’s $\alpha=0.87$).

(ii) The *Self Reporting Questionnaire (SRQ-20)* is an instrument validated for the Portuguese language, recognized by the World Health Organization and validated in Brazil (MARI; WILLIAMS, 1986), that identifies psychosomatic symptoms for the screening of CMD. This instrument contains twenty questions with yes/no answers distributed in four symptom groups reported in the last thirty days. The sum of answers marked as “yes” (numerical variable) was used in this assessment (MORAES et al., 2017). Good internal consistency was noted for this measure Cronbach’s $\alpha=0,85$).

Two dependent and two independent variables were considered, namely cell phone dependence and occurrence of CMD and age of onset of smartphone use and time of smartphone use in life, respectively, both measured as self-reports. Variables were continuously analyzed and expressed as means and standard deviations (Table 1).

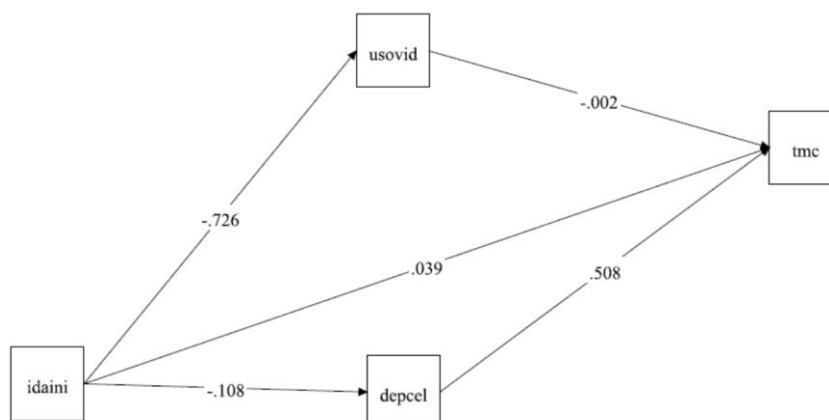
Table 1. Operational definition and descriptive statistics of the variables employed herein.

Variable code	Description	Type	Means ± Standard deviation	Asymmetry	Kurtosis
Usovid	Smartphone use period (years)	Continuous	4.92 ± 2.56	0.711	0.383
idaini	smartphone use onset age (years)	Continuous	10.14 ± 2.19	-0.177	-0.196
Tmc	Self Reporting Questionnaire (SRQ20) Score	Continuous	7.02 ± 4.71	0.561	-0.435
depcel	Smartphone Addiction Inventory (SPAI-BR) Score	Continuous	10.06 ± 5.99	0.238	-0.737

Theoretical model

The theoretical model employed herein is presented in Figure 1. The endogenous variables considered in this study were the presence of CMD, smartphone use during life (usovid) and smartphone dependence (depcel). The variable smartphone use age onset (idaini) was applied as an exogenous variable. Thus, the three endogenous variables would be explained by the exogenous one, either through paths mediated by smartphone use in life or smartphone addiction, or directly.

Figure 1. Final structural theoretical model displaying the standardized interrelation coefficients between smartphone use, smartphone dependence and mental health in teenagers from São Luís, Maranhão, Brazil, 2023.



Theoretical model and respective standardized relationship coefficients; idaini: age of onset of smartphone use; tmc: CMD, depcel: smartphone addiction; usolive: smartphone continuous time the lifetime.

Statistical analyses

Descriptive statistics were calculated using the Stata version 14.0 software (StataCorp LP, College Station, United States). Univariate asymmetry and kurtosis were calculated and the Mardia test for asymmetry and multivariate kurtosis was applied (MARDIA, 1970). A path analysis was performed using the Mplus version 8.7 DEMO software (Muthén & Muthén, Los Angeles, United States). As the data did not present a multivariate normal distribution, the hypothetical model was calculated using the Robust Maximum Likelihood (MLR) estimator, which presents the maximum likelihood estimation with scaled test statistics and standard Huber-White-corrected errors. The fit of the model was evaluated based on Kline (2011) and Wang and Wang (2012), considering (i) p-value less than 0.05 and an upper limit of the 90% confidence interval (CI90%) less than 0.08 for the Root Mean Square Error of Approximation (RMSEA), (ii); and (iii) values lower than 0.05 for the Standardized Root Mean Square Residual Index (SRMR). The model was considered identifiable, as it contains positive degrees of freedom ($gl=1$).

RESULTS

The final model (Figure 1) presented a good data fit for all goodness of fit indicators (RMSEA = 0.07 [90%CI 0.000 – 0.063]; CFI = 0.99; TLI = 0.95; SRMR=0.01).

A significant positive relationship and high effect was observed between smartphone dependence and CMD occurrence (H3) in the path analysis by direct effects. On the other hand, smartphone use onset age was negatively and significantly associated to smartphone dependence (H4) and with teenager device usage time (H5), presenting small and high magnitudes, respectively. Additionally, a small significant negative relationship between smartphone use onset age and CMD occurrence mediated by smartphone dependence (H7) was also noted (Table 2)

Finally, the results revealed that 1.2% of the variation in smartphone dependence, 53% of the variation in lifetime smartphone use, and 26% of the variation in CMD occurrence were explained by their respective models.

Table 2. Standardized coefficient, standard error and p value of direct and indirect effects for the investigated associations between smartphone use, smartphone dependence and mental health in teenagers from São Luís, Maranhão, Brazil, 2023.

Hypotheses	Pathways	Standardized coefficient	Standard error	p
Direct effects				
H1	idaini → tmc	0.039	0.038	0.304
H2	usovida → tmc	-0.002	0.039	0.958
H3	depcel → tmc*	0.508	0.026	0.000
H4	idaini → depcel*	-0.108	0.032	0.001
H5	idaini → usovida*	-0.726	0.012	0.000
Indirect effects				
H6	idaini → usovida → tmc	0.003	0.047	0.958
H7	idaini → depcel → tmc*	-0.092	0.029	0.001

* Significant association; idaini: age of onset of smartphone use; tmc: CMD, depcel: smartphone addiction; uselife: continuous smartphone lifetime use.

DISCUSSION

Main findings

The present study analyzed the structural associations between smartphone use habits and mental health indicators in teenagers employing structural equation modeling (path analysis). The standardized estimates indicate that early smartphone use by teenagers tends to significantly increase smartphone addiction scores (direct effect) and psychiatric distress symptoms (indirect effect). Furthermore, smartphone addiction leads to an increase in the intensity of psychiatric distress scores, with a high effect.

Comparison to previous studies

The findings reported herein are in line with the available literature on the subject, demonstrating that smartphone use time predisposes teenagers to smartphone dependence and negative mental health outcomes.

Sahin et al. (2013) demonstrated that individuals who received their first smartphone before the age of 13 are more likely to be smartphone dependent than those whose age of first use was 16 years or older. Smartphone use age is becoming increasingly precocious, and the younger the age of possession of the first device, the greater the probability of dependence, due to greater smartphone exposure. Teenagers seem to be more vulnerable to addiction compared to other populations, as they use the device for longer periods of time in search for autonomy, interaction with peers and to gain recognition and externalize their identities (GUTIÉRREZ et al., 2016). In addition, they exhibit greater activation of the reward system, resulting in a preference for novelty and a strong interest in risky situations. This activation gradually declines during late adolescence and early adulthood, due to reductions in the pleasure reward system (TELZER, 2016).

In Brazil, a study conducted in the city of Fortaleza on teenagers aged 15 to 19 years demonstrated that the average time spent using a smartphone during the week was 5.8 hours, increasing to 8.8 hours during the weekends. The use of the device on weekends increased the chances of smartphone dependence in the studied sample (NUNES et al., 2021). In another study, time spent on screen media (number of hours per day) by UK 13-15 old teenagers demonstrated a pattern of social device use, with higher social media use observed among girls and online gaming among boys (TWENGE; FARLEY, 2020). Other literature has also demonstrated significant positive correlations between social smartphone use and smartphone addiction. (ROZGONJUK; ELHAI, 2019, ELHAI et al., 2020). Furthermore, Rozgonjuk *et al.* (2019) found that social smartphone use is a predictor of cell phone addiction.

It is noteworthy that the minimum age reported for smartphone use by the study participants was three years old and the average onset use age was ten years old. A study conducted on 300 Indian teenagers concerning screen time and pathological behaviors demonstrated that the number of weekly hours spent on smartphones was positively associated to substance abuse, generalized anxiety, and eating and major depressive disorders (TAYWADE; KHUBALKAR, 2019). It is also important to note that smartphone use habits, such as usage for longer periods of

time, early onset use age and use right after waking up are related to psychoactive substance and game addictions, as well as other addiction syndromes (O'BRIEN, 2011).

Reer et al. (2022) reported significant positive associations between Smartphone Use Disorder severity and high stress, depression, anxiety, and loneliness levels in 938 Germans aged 14 to 64 years old. A meta-analysis quantified the associations between problematic smartphone use and mental health outcomes in 41,871 children and youth and identified increased odds of 3.17 times for depression, 3.05 for anxiety, 1.86 for perceived stress and 2.60 for worse sleep quality (SOHN et al., 2019). In a systematic review that included only longitudinal studies examining young people's screen time and mental health, two studies reported a significant positive association between cell phone use and subsequent depressive symptoms. Furthermore, among the three selected studies, two found a significant positive association between cell phone use and subsequent depressive symptoms (TANG et al., 2021).

The effect of smartphone use onset age mediated by smartphone addiction on the mental health of teenagers has not been reported in the literature to date. However, Kil et al. (2021) reported a similar effect to that described in the present study, in which smartphone dependence comprises a mediating variable in the association between smartphone use and depression, anxiety, and stress symptoms in American undergraduates. As the use of smartphones is ubiquitous today, it is possible to extrapolate the interpretations of that study with the current assessment. Thus, habits related to smartphone use precocity and frequency of use predispose teenagers to the abusive/pathological use of cell phones and, consequently, to psychiatric disorders, as these individuals undergo increased social isolation (YANG et al., 2010) and impair sleep (DEMIRCI; AKGONUL; AKPINAR, 2015)

Strengths and limitations

The use of the maximum likelihood estimation method with robust estimations is a strong point of this study, as the variables were used continuously with all asymmetry and univariate kurtosis indicators indicating normality. No data imputation was performed, as respondents were instructed to clarify their doubts during the data collection and no instrument was received without data completeness certification. In addition, regarding sample size, enough participants were obtained for the estimation process, considering the relationship between the number of parameters and the number of observations (20 observations/parameter). However, as this study assessed a convenience and non-probabilistic sample, the external validity of the findings is limited.

Some limitations are noted, such as the small number of analyzed variables and the absence of measurement errors, as latent variables were not created and the data collection took place during the COVID-19 pandemic period, in which students used this technology a lot, which would tend to increase the Smartphone Addiction Inventory scores, as well as the impossibility of separating the effects of social and non-social smartphone use. Another limitation comprises the use of self-administered instrument items for screening in a non-clinical sample of teenagers, indicating the need for the use of clinical instruments in future studies. As for the cross-sectional design, the existence of reverse causality bias may also be considered, which interferes with the interpretation of variable directionality.

FINAL CONSIDERATIONS

Early smartphone use plays an important role in the etiology of self-reported smartphone dependence (direct effect) and self-reported CMD (indirect effect), the latter, mediated by self-declared smartphone dependence. Thus, the younger the age at which smartphones are used, the greater the risk of developing addictive behaviors and, consequently, psychiatric suffering.

The findings reported herein indicate that the associations between smartphone use behaviors and mental health outcomes are complex and involve mediators, such as device abuse, which in this study mediated the negative relationship between smartphone use onset age and CMD self-reports. In addition, these findings expand the current literature body, demonstrating that the problematic use of smartphones can negatively impact the mental health of teenagers and serve as a warning to parents, educators, and health professionals about the risks of excessive use of screens in adolescence and its impact on later stages of life.

The use of other variables is suggested in future assessments, as well as data collection during non-pandemic periods, time of use measurement standardization, clinical evaluations for outcome variables and hypothesis tests for other possible mediators concerning the studied interrelationships.

Relações entre uso de *smartphone*, dependência de *smartphone* e saúde mental em adolescentes: abordagem com modelagem com equações estruturais

RESUMO

O presente estudo avaliou as relações entre hábitos de uso, dependência autodeclarada de *smartphone* e saúde mental em um estudo transversal com 1.031 adolescentes. O uso/abuso de *smartphone* e sinais/sintomas de sofrimento psiquiátrico foram as variáveis de estudo, cujas conexões foram analisadas em um modelo estrutural, através de modelagem com equações estruturais. Observou-se que o início precoce no uso do *smartphone* pelos adolescentes relacionou-se negativamente e de forma significativa com os escores de dependência de *smartphone* (efeito direto) e com os sintomas de sofrimento psiquiátrico (efeito indireto), mediado pela dependência do aparelho celular. Além disso, a dependência de *smartphone* foi responsável por um aumento na intensidade dos escores de sofrimento psiquiátrico com efeito de grande magnitude. Desse modo, verifica-se que as relações entre uso/abuso de smartphones e saúde mental são complexas e requerem novos estudos que suportem ações de intervenção para adolescentes.

PALAVRAS-CHAVE: *Smartphone*. Transtorno Mental. Adolescente.

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