JSRMBS Journal of Scientific Research in Medical and Biological Sciences
ISSN 2709-0159(print) and ISSN 2709-1511 (online)
Volume 5, Issue 4 Article 9
DOI: https://doi.org/10.47631/jsrmbs.v5i4.875

ASSOCIATION OF SMARTPHONE USE IN ONLINE LEARNING TO CHILDREN'S COGNITIVE IMPAIRMENT DURING COVID-19 PANDEMIC

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ARTICLE INFO

Recieved: 21 Augt 2024
Revised: 19 Nov 2024
Accepted: 10 Dec 2024

Keywords:
Smartphone Use, Online Learning, Children Cognitive Impairment, COVID-19 Pandemic

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ABSTRACT

Online learning during COVID-19 pandemic increased smartphone use which had a negative impact, that students were stimulated to access other applications, this increased the risk of smartphone use by students. Excessive use of smartphones and electronic devices has various negative impacts on children. Excessive habits can cause social changes, sleep disturbances, and even cognitive function disorders in the form of memory, attention, and executive functions. This research is observational analytic research using cross sectional method. The number of samples in this study were 63 subjects according to the inclusion and exclusion criteria, with the sampling technique using consecutive sampling. Data analysis used Chi-square, Mann-Whitney U Test (non-parametric). Multivariate analysis using logistic regression test. Qualitative data analysis to identify phenomena with in-depth interviews. Sampling was done by purposive sampling. The results of this study found that the use of smartphones in online learning was related to impaired cognitive function of elementary school-aged children during the COVID-19 pandemic in Ngablak District, Magelang Regency. The results of in-depth interviews with 3 informants obtained 3 themes, that are: a) online learning systems are divided into 3 categories, types of online learning, online learning media, and online learning constraints; b) smartphone use during online learning consists of 2 categories; characteristics of smartphone use, and the effect of smartphone use on children; c) children's cognitive function during online learning consists of 4 categories, that is; student achievement before online learning, student achievement after online learning, increase in learning subject scores, and students' cognitive abilities during online learning.

INTRODUCTION

Coronavirus Disease 2019 (COVID-19) was first reported in Wuhan City, China on December 31, 2019. The transmission of COVID-19 cases is rapid and has spread between countries so that on January 30, 2020, WHO declared COVID-19 a public health emergency that is disturbing the world (1). The Government of the Republic of Indonesia has issued a policy on guidelines for the prevention and control of COVID-19 which includes the implementation of new habit adaptations aimed at accelerating the recovery of the health, economic and socio-cultural sectors of the community. The implementation of this policy is by limiting public activities, government services

and restrictions on non-essential sectors such as education, so that daily activities and learning are dominated by online interactions (online) (2-4).

Distance learning or online learning is done online through various available applications such as Zoom, Google Meet, Google Classroom which are application-based media (5) so that facilities and infrastructure such as laptops, computers, smartphones, and internet network assistance are needed. Several studies have proven that the most widely used facilities in online learning are laptops and smartphones, with the main facility most widely used in online learning being smartphones (6).

The impact that needs to be considered in online learning is the increase in smartphone usage. Online school and the limitations to play with friends directly result in children spending more time using smartphones and being stimulated to use smartphones not only for learning activities but also for entertainment activities such as chatting, accessing social media, watching videos, listening to music, playing games online or offline so that the duration of smartphone usage increases (6-9)

Use of smartphones and excessive electronic devices have various negative impacts on children. Excessive habits can cause social changes, sleep disorders, and even cognitive dysfunction in the form of memory function, attention, and executive function (10). Habits of Using Smartphones with high intensity is negatively related to academic results, besides also indicating poor attention span and time management skills (11). Excessive use of smartphones can also cause dependency, resulting in decreased neuronal excitability associated with impaired arithmetic function, increased impulsivity, and decreased attention (12). Based on these problems, a study was conducted to determine the relationship between smartphone use and online learning methods. on cognitive impairment in children during the COVID-19 pandemic.

METHODOLOGY

The method used in this study is the mixed methods method, which combines quantitative and qualitative research. The study began with quantitative research in the form of observational analytical research using the cross-sectional method. sectional to determine the relationship between smartphone use in online learning methods and cognitive dysfunction in elementary school children in Ngablak District, Magelang Regency. The study was continued with qualitative research from interviews using video calls. to the parents of research subjects.

The population in this study were school-age children who participated in online learning in Ngablak sub-district, Magelang regency. The sampling technique used stratified random sampling technique to select elementary schools, and then consecutive sampling technique was used to obtain research subjects. The subjects of this study were children with a population that met the inclusion criteria in the form of participating in online education using smartphones, elementary school students in grades 4, 5, and 6, and were willing and permitted by the child's parents to participate in the study. The exclusion criteria in this study were children who were seriously ill with acute or chronic illness during the study, had a history of significant head injury, and had congenital disabilities. Data analysis using Chi-square, Mann-Whitney U Test (non-parametric). Multivariate analysis using logistic regression test. Qualitative data analysis to identify phenomena with in-depth interviews. Sampling was done by purposive sampling after 1 year follow up.

RESULTS AND DISCUSSION

A total of 63 research subjects were obtained, consisting of 37 (58.5%) women and 26 (41.5%) men. The average age of respondents was 11.31 years with a deviation of 1.21 years, while the

average Body Mass Index (BMI) was 18.44 kg/m2 with a deviation of 3.51 kg/m2. The total duration of smartphone use by respondents was 4.20 hours/day, with a deviation of 1.66 hours/day, with a duration for studying of 1.14 (±0.33) hours/day, and for other activities of 3.06 (±1.67) hours /day. The average total MMSEC value obtained was 33.31 with a deviation of 2.51. The results of the analysis showed that 23 (36.6%) children had cognitive impairment, and 40 (63.4%) other children were normal. The group of children with cognitive impairment had an average MMSEC value of 29.58 (± 0.82), while the group of children with normal MMSEC was 31.38 (± 1.42). The SAS-SV value to measure the tendency for smartphone dependence was obtained an average of 33.82 with a deviation value of 7.44. The results of the analysis of the SAS-SV measurement results showed that 37 (58.5%) children had smartphone dependence, and 26 (41.5%) other children were normal. The demographic characteristics of the study subjects can be seen in table 1.

Table 1. Demographic Characteristics of Research Respondents

No.	*Variables*	*Proportion (%)*	*Mean (± SD)*	*Normality Test*
1.	Gender - Man - Woman	 26 (41, 5 %) 37 (58, 5 %)	 - -	-
2.	Age (years)	-	11, 31 (± 1.21)	0.019
3.	BMI (kg/m ^{2})	-	18, 44 (± 3.51)	< 0.001
4.	Elementary School Class - Grade 4 - Grade 5 - Grade 6	 17 (26, 8%) 17 (26, 8%) 29 (46, 3%)		-
5.	Duration of smartphone use for learning (hours/day)	-	1, 14 (± 0.33)	< 0.001
6.	Duration of smartphone use for other activities (hours/day)	-	3, 06 (± 1.67)	0.010
7.	Total duration of smartphone use (hours/day)	-	4, 20 (± 1.66)	0.011
8.	MMSEC Value	-	33, 31 (± 2.51)	0.025
9.	MMSEC Interpretation - Cognitive Disorders - Normal	 23 (36, 6%) 40 (63, 4%)	 29. 58 (±0.82) 31. 38 (±1.42)	-
10.	SAS-SV Value	-	33, 82 (± 7.44)	0.174
11.	SAS-SV Interpretation - Dependence - Normal	 37 (58, 5%) 26 (41, 5%)	 - -	-

Information: BMI: Body Mass Index; MMSEC; Mini Mental State Examination Child ; SAS-SV: Smartphone Addiction Scale- Short Version ; SD : Standard Deviation

Bivariate analysis was conducted to determine the relationship between various variables and cognitive impairment in elementary school children. The group of children with cognitive impairment obtained a total duration of smartphone use of 5.73 (±0.70) hours, while the group of students with normal cognitive function obtained a total duration of smartphone use of 3.32±1.39 hours with a p value <0.001. The duration of smartphone use for activities other than studying was also found to be greater in the group of students with cognitive impairment (4.6±0.73 hours) compared to the group of students with normal cognitive function (2.1 ± 1.39 hours), with the results of the analysis test obtained a p value <0.001 indicating a significant relationship between these variables and the cognitive function of elementary school students in grades 4, 5, and 6. Different results were found in the relationship between the duration of smartphone use for studying and cognitive impairment. The duration of smartphone use for learning in the group of

children with cognitive disorders was found to be 1.13 ± 0.35 hours, while in the group of children with normal cognitive function, almost the same amount was obtained, namely 1.15 ± 0.34 hours. The results of the analysis obtained p = 0.799 which showed that there was no relationship between the duration of smartphone use for learning and the cognitive function of elementary school students. Bivariate analysis of the relationship between variables and cognitive function can be seen in table 2.

Table 2. Relationship of Variables to Cognitive Function

No.	*Variables*	*Cognitive Disorders*	*Normal*	*p-value*	*Mean Difference (95% CI)*	*OR (95% CI)*
1.	Gender [a] - man - Woman	8 15	18 22	0, 422	-	0 , 58 (0, 15 – 2, 18)
2.	Age (years) [b]	11, 73 (± 1, 43)	11, 07 (± 1, 01)	0 , 127	0, 65 (-0, 21 – 1, 53)	-
3.	BMI (kg/m ^{2}) [b]	18, 01 (± 3, 98)	18, 68 (± 3, 27)	0 , 221	-0 , 67 (-3, 17 – 1, 82)	-
4.	Duration of smartphone use for learning [b]	1, 13 (± 0, 35)	1, 15 (± 0, 34)	0, 799	-0, 02 (-0, 25 – 0, 21)	-
5.	Duration of smartphone use for other activities [b]	4, 6 (± 0, 73)	2, 1 (± 1, 39)	< 0, 001	2, 42 (1, 75 – 3, 10)	-
6.	Total duration of smartphone usage [b]	5.73 (± 0, 70)	3 , 32 (± 1 , 39)	< 0, 001	2, 40 (1, 74 – 3 , 07)	-
7.	SAS-SV Interpretation [a] - Dependence - Normal	19 4	18 22	0, 005	-	8, 86 (1, 65 – 47, 54)

Description: a Analysis using Chi-Square ; b Analysis using Mann-Whitney Test ; BMI: Body Mass Index; MMSEC : Mini Mental State Examination Child ; SAS-SV: Smartphone Addiction Scale- Short Version ; OR: Odds Ratio ; 95% CI: 95% C onv idence Interval

Variables that have a p- value <0.25 are then subjected to multivariate analysis to determine the relationship between variables and the cognitive function of elementary school students in grades 4, 5, and 6. It was found that the variables that were proven to be significantly and independently related against cognitive impairment compared to the normal group is the total duration of smartphone use (p = 0.008), duration of smartphone use for activities other than studying (p = 0.008) , and smartphone dependence (p = 0.032). The results of the multivariate analysis of the age and BMI variables showed no relationship to cognitive function, namely a p value of > 0.05.

The results of the multivariate analysis obtained the Odds Ratio (OR) value of the total duration of phone use on cognitive function of 15.544, which indicates that a greater total duration of smartphone use can cause cognitive impairment by 15.544 times. Other factors related to cognitive function are the duration of smartphone use for other activities and smartphone dependence, with the OR results of each variable being 13.511 and 1.158. This shows that students who have a longer duration of smartphone use have a 13.511-fold risk of experiencing cognitive impairment,

and students with smartphone dependence have a 1.158-fold higher risk of experiencing cognitive impairment compared to the normal student group. The results of the multivariate analysis of the relationship between variables and cognitive function can be seen in table 3.

Table 3. Multivariate Analysis of the Relationship of Variables to Cognitive Function

No.	*Variables*	*OR*	*95% CI*	*p-value*
1	Age	1, 844	0, 929 – 3, 659	0, 080
2	IMT	0, 838	0, 691 – 1, 142	0, 355
3	Smartphone addiction	1, 158	1, 013 – 1, 325	0, 032
4	Duration of smartphone use for other activities	13, 511	1, 765 – 158, 476	0, 008
5	Total duration of smartphone use	15, 544	2, 038 – 118, 549	0, 008

Description: BMI: Body Mass Index; OR: Odds Ratio; 95% CI: 95% C onvidence Interval

This study also conducted an analysis to determine the relationship between smartphone use and various domains of cognitive function. There are five domains assessed in the MMSEC, namely: orientation, registration, attention/calculation, memory, and language. There is one domain that has the same value in each respondent from both groups tested, namely the registration domain. Thus, the registration domain cannot be analyzed further because the average value is the same for both groups. The correlation between smartphone use during online learning and cognitive function domains was analyzed using the Spearman method.

The results of a negative correlation relationship were obtained in the analysis of the duration of smartphone use for activities other than learning and the total duration of smartphone use on each domain of cognitive function, namely the domains of orientation, attention, memory, language, and total MMSEC value. This indicates that the longer the duration of smartphone use for activities other than learning and the total duration of smartphone use, the lower the value of each domain. Significant results were obtained from the relationship between the duration of smartphone use for activities other than learning and the domains of orientation, attention, memory, and total MMSEC value with $p < 0.05$. Significant results were obtained in the analysis of the relationship between the total duration of smartphone use and the domains of attention, memory, and total MMSEC value with $p < 0.05$. The relationship between the total duration and smartphone use for activities other than learning and the domains of cognitive function can be seen in table 4.

Table 4. Relationship between Smartphone Use and Cognitive Function Domains

Relationship between Duration of Smartphone Use for Activities Other Than Learning and Cognitive Function Domains		
Variables	Correlation Coefficient	p-value
Orientation	-0, 322	0, 040
Registration	-	-
Attention/Calculation	-0.450	0.003
Memory	-0.505	0.001
Language	-0.287	0.069
Total MMSEC	-0.498	0.001
Relationship between Total Duration of Smartphone Use and Cognitive Function Domains		
Variables	Correlation Coefficient	p-value
Orientation	-0,267	0,092
Registration	-	-
Attention/Calculation	-0.419	0.006
Memory	-0.453	0.003
Language	-0.266	0.093
Total MMSEC	-0.445	0.004

Description: MMSEC: Mini Mental State Examination Child

This study was continued with in-depth interviews with 3 informants consisting of 2 students' mothers and 1 student's father. Based on the results of the interview, the theme was determined, in this study 3 themes were obtained as below:

Theme 1: Online Learning System during the Pandemic

This theme emerged from the categories of online learning types, online learning media, and online learning constraints. The category of online learning types describes the type of learning during the COVID-19 pandemic, obtained pure online learning and blended learning as stated below:

> *"I didn't go to school during COVID when I was online on WhatsApp. He's on WA, sis. Continuously asked to collect assignments, only to be given assignments and tell them to collect them. Later, I'll just go to school to collect assignments..." (I-3)*

> *" The learning system uses cellphones, there are WA (WhatsApp) groups, then assignments are given. The assignments are photographed and then the photos are collected. They are done and then collected. Then there are also turns once a week. There are face-to-face meetings" (I-1)*

The online learning media category explains the media used during online learning by elementary school students in grades 4, 5, and 6. The media used are WhatsApp and YouTube, according to the interview results as follows:

> *" Eh, the media used for learning is using a cellphone, Mbak, in the WhatsApp group. Once, I was told to watch it on YouTube..." (I-2)*

> *"Use Youtube and in WA groups …" (I-1)*

The category of online learning obstacles explains the obstacles and difficulties faced during online learning. The interview results showed various difficulties experienced by informants in accompanying their children during online learning such as the unavailability of smartphones, poor signal, and children becoming lazier and less independent:

> *"The difficulty is having to buy a cellphone that has an internet package. Previously, I didn't have one, so I had to buy a cellphone, sis……" (I-2)*

> *"…. They are just learning to use a cellphone, so it becomes difficult. The signal is also difficult. Sometimes they can find a signal in a far place. So the children become lazy. Their job is only to respond and help with this" (I-1)*

Theme 2: Use of Smartphones during Online Learning

This theme consists of 2 categories, namely the characteristics of smartphone use during online learning, and the influence of smartphone use on elementary school students during online learning. The category of characteristics of smartphone use during online learning found an increase in smartphone use, smartphone use for activities outside of school to play games , chat with friends, and the total duration of smartphone use for 6-8 hours, and the duration for studying was 1-2 hours. The interview results were obtained as follows:

> *" So the doctor came more often. At first I didn't have a cellphone, now I asked to buy a cellphone for school" (I-1)*

> *"For school, 2 hours." (I-1)*

> *"Yes, sometimes 1 hour, Sis. 1 to 2 hours and a half, you know…" (I-2)*

> *" It's been a long time, Sis. Yes, in total, Miss, you played more than 2 hours once. "If it's 8 hours a day, Sis." (I-3)*

".....Sometimes she uses it for more than 6 hours a day" (I-2)

The 2nd category in this theme is the influence of smartphone use on elementary school students. The influence felt by the informant on their child is a change in emotions and behavior such as children becoming lazy and often angry, in addition it was also found that children became unfocused as summarized in the interview. following:

"...In fact, there are games that you can play on your cell phone, but you ask me to play them quite often. So lazy to study." (I-2)

"Yes, sometimes I get angry when I'm busy playing on my cellphone. Anake became lazy, just called him to shut up." (I-1)

"……. Then, for example, when you're playing on your cellphone, you just need to focus on your cellphone. Being called doesn't mean anything." (I-3)

Theme 3: Children's Cognitive Functions during Online Learning Using Smartphones

This theme consists of 4 categories, namely student achievement before online learning, student achievement after online learning, improvement in subject scores, and student cognitive abilities during online learning. The category of student achievement before and after online learning shows an increase in achievement after online learning compared to before online. The increase in achievement was due to students being assisted by parents in doing assignments. This is summarized in the following interview:

"Previously, when I didn't use a cellphone, the value was lower, sis" (I-2)

" The grades are better when I'm online, I can help you with your assignments, sis." (I-3)

The next category is the increase in subject scores, both math and Indonesian. This is like the following interview:

"Yes, it went up. For Mathematics it became 78, Language became 84. Previously, the highest was 70 for Mathematics, Ma'am. For Language, the highest was 80. If not, then 70 or 75. "(I-1)

The category of cognitive abilities of online learning students showed a decrease in cognitive abilities during online learning using smartphones. The causes of the decrease in cognitive abilities according to informants were due to children becoming lazy, parents helping with assignments, and children not focusing as summarized in the following interview.

"It's decreasing, Sis, because no one explained to me, meet in person, you know, Sis. If you can't find it online, you won't focus."(I-3)

" Oh, it's getting worse, sis, the more I use this cellphone, the less I can do it " (I-2)

"The decline is because the child has become lazy, sis" (I-2)

"I can't do a lot of things because my parents help me, sis" (I-1)

"... children play with cellphones, so they can't focus, they can't do their assignments" (I-3)

Discussion

Research result explains the characteristics of smartphone use by elementary school students, namely an increase in the frequency of smartphone use by children, and the use of smartphones outside of school activities, namely for playing games and communicating with friends via Whatsapp media. This is in accordance with the research of Hedderson et al. (2020) which explains the increase in smartphone use for non-academic activities during the pandemic even after social restrictions were eased (13).

This study found that the average total duration of smartphone use by students was 4.20 hours/day, with an average duration of phone use for learning being 1.14 hours and for other activities being 3.06 hours. These results are supported by research by Serra et al. (2020) which explains that the majority of child and adolescent respondents in Italy used smartphones 4 hours/day during the COVID-19 pandemic. 9 The results of qualitative research also suggest an increase in the total duration of smartphone use to 6-8 hours per day with a duration of time for learning activities of only 1-2 hours. These results are in accordance with research by Mokhtarinia et al. (2020) namely the average total time of smartphone use is 6.85 hours per day, with use mainly for accessing social media at 77.9% (14).

This study shows that the duration of smartphone use for activities other than learning and the total duration of smartphone use are related to cognitive impairment in children. The effects of prolonged use can reduce the time needed to improve children's cognitive capacity. 10 Prolonged use of mobile phones activates the brain's reward system, which will reduce and inhibit the plasticity of brain synapses (15). The results of the study also showed a significant correlation between the duration of smartphone use and the domain of children's cognitive function. A negative correlation was found between the duration of smartphone use for activities other than learning in the domains of orientation, memory, attention, and total MMSEC scores. The total duration of smartphone use also showed a negative correlation in the domains of attention, memory, and total MMSEC scores. These results are supported by Yoo & Do's research, which showed the influence of excessive smartphone use on the domains of attention, memory, and response speed of children (16).

P rovement complexity fiber brain, improvement amount cell brain, and the more organized some of big neural network occurs at the age of 10-14 years. 17 The cognitive control system consists of several regions that are consistently activated by cognitive control or executive commands, namely the prefrontal cortex, orbitofrontal cortex (OFC), and parietal cortex. Smartphone use too early and excessive can cause various disturbance development brain. (18) Excessive use of smartphones can cause the orbitofrontal cortex to shrink, especially in the lateral right hemisphere. This area experiences peak development at the age of 8-9 years, so giving smartphones before that age can cause imperfect development of the orbitofrontal cortex. (19) In addition to decreased volume, there are also changes in the structure of nerve fibers in the white matter of the orbitofrontal cortex which is involved in emotional control, attention focus, decision-making ability and cognitive activity (20).

Excessive smartphone use can cause decreased neuronal excitability in the prefrontal cortex area which is associated with impaired arithmetic function, increased impulsivity, and decreased attention. 12 The involvement of putamen damage in the brain also contributes. in the disruption of cognitive processes. 19 There is also a decrease in the gray matter area in the dorsolateral PFC which plays a role in cognitive control, executive function, the reward system in the limbic, and also causes memory storage disorders and impulsivity (21-22).

study also shows that smartphone dependency results in cognitive impairment. This relationship was also found in other studies that explained that smartphone dependency causes more severe cognitive impairment. 23 The direct factor is the multidomain effect of smartphone use. Smartphones can interfere with attention function, so that the information obtained becomes inefficient. 24 This attention disorder will then result in a disrupted information storage process, resulting in a decrease in working memory capacity and increased risk of cognitive impairment. 25 Addiction decreases REM sleep duration, slow-wave sleep and sleep efficiency, which in turn results in decreased memory consolidation and impaired recall (26-27).

CONCLUSION

This study found that the use of smartphones in online learning methods was related to cognitive dysfunction in elementary school children during the COVID-19 pandemic in Ngablak District, Magelang Regency.

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