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The Influence of Smartphone Usage Duration and Frequency on Smartphone Addiction in Early Childhood Using Binary Logistic Regression

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Abstract

This study aims to identify the influence of smartphone usage duration and frequency on smartphone addiction in early childhood. With the increasing use of technology among children, it is crucial to understand how these factors affect addiction levels. The study employs binary logistic regression to analyze data collected randomly from 100 parents of children aged 4 to 5 years who attend kindergarten in Padang, Indonesia. Smartphone usage duration is measured in hours per day, while frequency of use is measured by the number of uses per day. The analysis results indicate that both the duration and frequency of smartphone use have a significant impact on smartphone addiction. However, based on the odds ratio value, the duration of smartphone use has a more significant influence compared to frequency on addiction levels. These findings provide valuable insights for parents, educators, and policymakers in developing strategies to manage and limit smartphone use in early childhood to prevent addiction risks that could affect their development. This study is expected to serve as a reference for further research and more effective interventions in managing technology use among children.

Kata Kunci: Duration, Frequency, Smartphone Addiction, Binary Logistic Regression

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INTRODUCTION

Previous research has indicated that the duration and frequency of smartphone usage are significant factors contributing to technology addiction across various age groups. Relationship between daily usage and frequency trends with smartphone addiction in young adults [1]. However, this study was conducted with a young adult population in Northern Taiwan and did not specifically target early childhood. Additionally, 17% of preschool children exhibited signs of problematic smartphone use (PSU), particularly when daily use exceeded two hours [2], but this study also did not highlight the specific roles of duration and frequency in the context of early childhood smartphone addiction.

The importance of smartphone usage duration and frequency as predictors of PSU in adolescents [3]–[5]. However, this study did not explore the use of statistical methods, such as binary logistic regression, to analyze data in the early childhood population.

Thus, there is a gap in the literature regarding a comprehensive analysis of the effects of smartphone usage duration and frequency on smartphone addiction in early childhood, particularly using a binary logistic regression approach. This study aims to fill this gap by investigating the influence of smartphone usage duration and frequency on smartphone addiction in early childhood using binary logistic regression methods. This approach is chosen due to its significant advantages, including its ability to analyze relationships between independent and dependent variables where the dependent variable is dichotomous, such as in the context of addiction (yes/no). Binary logistic regression also allows for the consideration and control of confounding variables that may affect the outcomes, resulting in more accurate estimates and clearer interpretations of the impact of smartphone usage duration and frequency on addiction. Binary logistic regression is a statistical analysis method used to model the relationship between independent variables and a binary or dichotomous dependent variable [6]. This method has been applied in various fields, including health and education. In health studies, binary logistic regression is used to analyze factors influencing types of breast cancer and the occurrence of stillbirths [6]. In the field of education, this method is used to determine factors affecting students' academic performance [7]. Additionally, binary logistic regression has also been applied in the analysis of household poverty [8]. This study will examine the influence of duration and frequency on smartphone addiction in early childhood using binary logistic regression.

METHODOLOGY

Data collection

This study uses a case study method by applying binary logistic regression to questionnaire data related to smartphone addiction. The questionnaires were filled out by a randomly selected sample of 100 parents of children aged 4 to 5 years attending kindergarten in Padang City.

The variables used in this study include one dependent variable, smartphone addiction status among young children in Padang City, and two independent variables, the duration and frequency of smartphone use by these children. The details of these variables can be seen in Table 1.

Table 1. Research Variables

Variable		Category
Dependent	Smartphone addiction status	1=Addiction 0=Non Addiction
Independent	Frequency	2= Once a day 3= Twice or more a day
	Duration	4= Less than 30 minutes 5= More than 30 minutes up to 120 minutes 6= More than 120 minutes

In Table 1, it can be seen that both the dependent and independent variables are categorical. This categorization allows for a detailed analysis of the relationship between smartphone usage duration and frequency with addiction status.

Binary Logistic Regression

Binary logistic regression is a type of regression analysis used to examine categorical dependent variables, with independent variables that can be categorical, continuous, or a combination of both. Logistic regression analysis is used to obtain the probability of occurrence of a dependent variable. One type of logistic regression is binary logistic regression, used specifically when the dependent variable has two categories, such as "yes" or "no," "occurs" or "does not occur" [9]. The equation for logistic regression, including binary logistic regression affected by k predictor variables, is as follows:

$$E[Y|\mathbf{x}] = \frac{\exp(\beta_0+\beta_1 x_1+\cdots+\beta_k x_k)}{1+\exp(\beta_0+\beta_1 x_1+\cdots+\beta_k x_k)} \quad (1)$$

where $\boldsymbol{x} = (x_1, x_2, \dots, x_k)$ epresents the vector of observations for predictor variables, k is the number of predictor variables, β_0 is the model intercept parameter, and $\beta_1, \beta_2, \dots, \beta_k$ are the logistic regression parameters.

The response variable in binary logistic regression, denoted as Y, consists of two categories: $Y = 1$ indicating "addiction" and $Y = 0$ indicating "non-addiction." The conditional probability of success given x, or $P(Y = 1|\boldsymbol{x})$, is expressed as $\pi(\boldsymbol{x})$ and

$P(Y=0|\boldsymbol{x})$ is expressed as $1-\pi(\boldsymbol{x})$. Thus, the conditional mean of Y given the observation vector x is equal to the probability $\pi(\boldsymbol{x})$, because:

$$E[Y|\mathbf{x}] = 1 \cdot P(Y=1|\mathbf{x}) + 0 \cdot P(Y=0|\mathbf{x}) = \pi(\mathbf{x}), \quad (2)$$

with

$$0 < E[Y|\mathbf{x}] = \pi(\mathbf{x}) < 1.$$

So,

$$\pi(\mathbf{x}) = \frac{\exp(\beta_0+\beta_1 x_1+\cdots+\beta_k x_k)}{1+\exp(\beta_0+\beta_1 x_1+\cdots+\beta_k x_k)}, \quad (3)$$

This function $\pi(\boldsymbol{x})$ is non-linear with respect to the parameters $\beta_0, \beta_1, \ldots, \beta_k$. The equation can be transformed into a linear function through the logit transformation $g(\boldsymbol{x}) = \ln\left(\frac{\pi(x)}{1-\pi(x)}\right)$ resulting in:

$$g(\boldsymbol{x}) = \beta_0 + \beta_1 x_1, \ldots, \beta_k x_k \quad (4)$$

Here, $g(\boldsymbol{x})$ is called the logit model, which is a linear function of the parameters of the predictor variables.

Overall Significance Testing

Before develope a logistic regression model, a significance test of the parameters is first conducted. The initial test performed is to evaluate the role of parameters within the model as a whole. This test is used to determine whether the predictor variables collectively have an effect on the response variable or not. The hypotheses used are as follows:

$H_0 :\ \beta_1 = \beta_2 = \cdots = \beta_i = 0$
$H_1 :$ paling sedikit koefisien $\beta_i \neq 0$

The test statistic used is:

$$G = -2log\left(\frac{l_0}{l_1}\right) = -2[\log(l_0) - \log(l_1)] = -2(L_0 - L_1) \quad (5)$$

where:
l_0 : Maximum likelihood value for the model under the null hypothesis
l_1 : Maximum likelihood value for the model under the alternative hypothesis
L_0: Maximum log-likelihood value for the model under the null hypothesis
L_1: Maximum log-likelihood value for the model under the alternative hypothesis

The value $-2(L_0 - L_1)$ follows a Chi-square distribution with $df = p$. At a significance level of α, the test criterion is to reject H_0 if $-2(L_0 - L_1) \geq x^2_{(p)}$ or p-value $< \alpha$ and accept otherwise [10].

Individual Significance Testing

Partial significance testing is used to determine whether the parameters in the model are significant to the model or not. This test is conducted using the Wald Test with the following hypothesis formulation:
H_0: $\beta_i = 0$ (The logit coefficient is not significant to the model)
H_1: $\beta_i \neq 0$ (The logit coefficient is significant to the model)

And the test statistic:

$$W^2 = \left[\frac{\beta_i}{SE(\widehat{\beta_\iota})}\right] \tag{6}$$

The W^2 value follows a Chi-square distribution with $df = 1$. Jika $W^2 \geq x^2_{(1,\alpha)}$ or p-value $< \alpha$ then H_0 ditolak, and H_1 accepted. $\widehat{\beta_\iota}$ is the estimated regression parameter and SE $(\widehat{\beta_\iota})$ is the standard error [10].

Model Fit Testing

The tool used to test the model fit in logistic regression is the Hosmer-Lemeshow test. This test evaluates how well the model fits the data, with the observed values being the same or close to what is expected in the model. The Hosmer-Lemeshow statistic follows a Chi-square distribution with $df = g - 2$ where g is the number of groups, using the formula:

$$\chi^2_{HL} = \sum_{i=1}^{g} \frac{(0_i - N_i\bar{\pi}_\iota)^2}{N_i\bar{\pi}_\iota(1-\bar{\pi}_\iota)} \tag{7}$$

where:
N_i: Total observation frequency for the i-th group
0_i: Observation frequency for the i-th group
$\bar{\pi}_\iota$: Average estimated probability for the i-th group

To test model fit, the obtained Chi-square value is compared with the Chi-square table value with $df = g - 2$. Jika $\chi^2_{HL} \geq \chi^2_{g-2}$ then H_0rejected and H_1 accepted [9].

RESULTS AND DISCUSSION

Respondent Characteristics

This study involved 100 parents of children aged 4 to 5 years attending kindergarten in Padang City, Indonesia. Of the total respondents, 43% of the children are male, and 57% are female. The majority of children (71%) are 5 years old, while 29% are 4 years old. To provide more detailed information, please refer to Table 2.

Table 2. Respondent Characteristics

Category		Percentage
Gender	Male	43
	Female	57
Age	4 years old	29
	5 years old	71
Duration	≤ 0.5 hours per day	20
	0.5 – 2 hours per day	46
	≥ 2 hours per day	34
Frequency	Once a day	27

	More than once a day	73
Purpose	Entertainment	70
	Educational	30
Parent's Education Level	Master's degree	8
	Bachelor's degree	42
	Diploma	7
	Senior High school	38
	Junior high school	5

This data provides an overview of the variation in respondent characteristics and patterns of smartphone usage by early childhood children in Padang City, forming the basis for the analysis in this study.

Research Variables

This study identifies two main types of variables. The dependent variable in this research is categorical, coded as '0' if the child is not addicted to smartphones and '1' if the child is addicted to smartphones. The independent variables are factors suspected to influence smartphone addiction, consisting of two primary variables: duration of smartphone usage, measured in hours per day the child uses a smartphone, and frequency of smartphone usage, measured by the number of sessions or interactions the child has with the smartphone in a day. This study aims to analyze how these two independent variables affect the status of smartphone addiction in early childhood using binary logistic regression methods.

Overall Significance

The first test performed is to evaluate the role of parameters within the model as a whole. The test statistic G follows a Chi-square distribution with degrees of freedom, p or $G \geq x^2_{(\alpha,p)}$, H0 is rejected if $G \geq x^2_{(\alpha,p)}$, with α being the chosen significance level. If H0 is rejected, it means that the model involving the predictor variables is significant at the significance level α. The test results are shown in Table 3.

Table 3. Overall Significance Test

-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
37.284[a]	0.274	0.548

Table 1 shows that the likelihood ratio value is 37.284. Meanwhile, the table Chi-square value is 5.991 with α = 0.05 and df = 2. Based on these results, it can be seen that $G \geq x^2_{(\alpha,p)}$, which is 37.284 > 5.991, so H0 is rejected. This indicates that at least one logistic regression coefficient is significant at α = 0.05. Additionally, Table 1 also shows the logistic regression coefficient of determination as 0.548, which means the contribution of predictor variables to the dependent variable is 54.8%.

Individual Significance

To determine which parameter coefficients are significant, individual significance testing is conducted. This test can be performed using the Wald test. The Wald test statistic follows a Chi-square distribution with degrees of freedom 1, or is commonly written as $Wix^2_{(1,\alpha)}$. H0 is rejected if the $Wi > x^2_{(1,\alpha)}$. If H_0 is rejected, it means that the parameter is statistically significant at the significance level α. The Wald test statistics are shown in Table 4.

Table 4. Individual Significance Test

	B	S.E.	Wald	Df	Sig.	Exp(B)
X1	3.785	1.064	12.650	1	0.000	44.041
X2	2.543	0.771	10.867	1	0.001	12.717
Constant	-25.059	6.127	16.729	1	0.000	0.000

With α = 0.05 and degrees of freedom (df) = 1, the table Chi-square value is 3.84. Based on the Wald test statistics shown in Table 2, the Wald statistics for variables such as duration and frequency of smartphone usage by children exceed the table Chi-square value. Therefore, H0 is rejected, indicating that both duration and frequency of smartphone usage have a significant effect on the status of smartphone addiction in 4 to 5-year-old children in Padang City.

Model Fit Testing

Model fit testing is conducted using the Hosmer-Lemeshow test. The test criterion is to reject H0 if $\chi^2_{HL} \geq \chi^2_{(\alpha,g-2)}$ or p-value $\leq \alpha$, and accept H_0 otherwise[11]. the Chi-square table, $\chi^2_{(\alpha,g-2)} = 5.991$, with $g = 4$ groups. This value is greater than $\chi^2_{HL} =$ 3.363 obtained from the Hosmer-Lemeshow test results, so H_0 is accepted. The test results and the Hosmer-Lemeshow contingency table are shown in Tables 5 and 6.

Table 5. Contingency Table for Hosmer and Lemeshow Test

	Addicted = No		Addicted = Yes		Total
	Observed	Expected	Observed	Expected	
	18	17.988	0	0.012	18
	28	28.757	1	0.243	29
	18	17.489	0	0.511	18
	17	16.255	1	1.745	18
	7	7.289	3	2.711	10
	1	1.222	6	5.778	7

Table 6. Hosmer and Lemeshow Test

	Chi-square	df	Sig.
	3.363	4	0.499

Table 3 shows that for two observations of smartphone addiction, both for the non-addicted (0) and addicted (1) categories, the observed and predicted values do not show extreme differences. This indicates that the logistic regression model used in this study can predict the observed values well. The statistical test results show a significance probability of 0.499, which is greater than 0.05, so H_0 is accepted. This means the regression model is suitable for further analysis as there is no significant difference between predicted classifications and observed classifications.

After parameter significance testing, it has been found that the variables Duration (X_1) and Frequency (X_2) of smartphone usage in children affect smartphone addiction (y) in children, resulting in the following model: $g(x) = -25.059 + 3.785X_1 + 2.543X_2$. The intercept of -25.059 in this model represents the logit value when both variables, duration and frequency are zero. The coefficient for duration of 3.785 indicates that for each one-unit increase in smartphone usage duration, the logit of the probability of addiction increases by 3.785 units. This shows that a longer duration is directly related to an increased risk of smartphone addiction. Meanwhile, the coefficient for frequency of 2.543 indicates that for each one-unit increase in the frequency of smartphone use, the logit of the probability of addiction increases by 2.543 units. This suggests that more frequent smartphone use is associated with a higher likelihood of addiction.

This model indicates that both the duration and frequency of smartphone usage have a significant impact on smartphone addiction in children. The longer and more frequently children use smartphones, the higher the likelihood they will become addicted. The negative logit value at the intercept suggests that without the influence of duration and frequency, the likelihood of addiction is relatively low, but it increases sharply with an increase in these two variables.

Interpretation of the Odds Ratio Value

The odds ratio values for the two main variables considered in this study, namely the duration and frequency of smartphone usage, are presented in Table 7.

Table 7. Odds Ratio Value

Variable	Odds Ratio
Duration (X1)	44.041
Frequency (X2)	12.717

Based on Table 7, an odds ratio of 44.041 for a specific category compared to the reference category means that, If the odds ratio for a particular duration category is

44.041, children who fall within this category have 44 times higher odds of developing smartphone addiction compared to children who use smartphones for a shorter duration, assuming frequency remains constant. Additionally, an odds ratio of 12.717 means that children who use smartphones two or more times a day have 12.717 times higher odds of addiction compared to children who use smartphones only once a day, assuming duration remains constant.

CONCLUSION

This study has evaluated the influence of smartphone usage duration and frequency on smartphone addiction among early childhood using binary logistic regression. The analysis reveals that both the duration and frequency of smartphone use significantly influence addiction levels, with duration showing a stronger effect compared to frequency. After parameter significance testing, it has been found that the variables Duration (X_1) and Frequency (X_2) of smartphone usage in children affect smartphone addiction (y) in children, resulting in the following model: $g(x) = -25.059 + 3.785X_1 + 2.543X_2$. This indicates that the longer a child uses a smartphone each day, the higher their risk of addiction. Based on the odds ratio value, the duration of smartphone use has a more significant influence compared to frequency on addiction levels. This study also serves as a strong foundation for further research on smartphone addiction, offering a more comprehensive perspective on understanding the dynamics of smartphone addiction, including how duration and frequency interact to influence addiction. This could help in identifying more effective intervention strategies and designing targeted policies to address smartphone addiction in early childhood.

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