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Parking Space Requirement Analysis at the University of North Sumatra General Hospital

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ABSTRACT

Hospitals are places of activity that provide vital services to the community. In reality, most hospitals face the challenge of providing adequate parking facilities. One of them is the difficulty of providing parking space facilities that match the actual level of demand. The research aims to obtain information on parking demand by modelling car and motorcycle parking. The methods used are linear regression and non-linear regression methods. On poly days for car parking demand with the equation: Y_1=8.166×10-89×41.386 X_1 and motorcycles with the equation: Y_2=7553.126-1112960.605/X_1, Y_2=6033.071-1392502.512/X_2, and Y_2=6389.337-1570378.771/X_3. On non-poly days for car parking demand with the equation: Y_1=868,250-3,250X_2 and motorcycles with the equation: Y_2=-457,000 + 6,000X_4.

Keywords: hospital; parking; linear regression; nonlinear regression; parking needs.

INTRODUCTION

The need for parking facilities is a phenomenon that often occurs in big cities. With the increase in the population of a city, it will cause an increase in the need to carry out various activities, in carrying out traveling activities in general, residents in big cities use private vehicles so that indirectly an adequate amount of parking is needed. Parking is one of the elements of facilities that cannot be separated from every activity carried out in a public facility [1]-[3].

In line with the increasing need for health services, the demand for facilities supporting these services is also getting bigger. One of the facilities that should be available is a parking lot. The available parking lot must be able to accommodate the vehicles of visitors and employees or hospital employees [4]-[7].

One of the public facilities in the health sector that attracts many visitors is the hospital. The hospital is one of the bodies engaged in the health sector which plays an important role in creating the quality of life and living environment for the community, thus creating a high degree of health. The increasing number of patients who own cars or motorbikes should be balanced by an increase in the availability of good parking, so an expansion of parking lots for hospital visitors is needed [8], [9].

Hospital parking is a crucial facility that must be well-planned because it directly impacts the comfort, safety, and smooth operation of healthcare services. Several factors that must be considered when providing parking in hospitals include capacity, circulation, security, accessibility, and user comfort. First, parking capacity must be sufficient for the number of vehicles of visitors, patients, medical personnel, and employees [10]. Needs can be calculated using the standard parking space unit (SRP), which is adjusted to the number of beds and the area of the hospital building. Second, the circulation pattern for incoming and outgoing vehicles must be clear, with separate lanes to avoid congestion and a drop-off area close to the main entrance for emergency patients or the elderly. Third, security aspects are crucial, including adequate lighting, CCTV surveillance systems, and trained parking attendants. Fourth, accessibility must be considered by providing dedicated parking spaces for people with disabilities, ramps, and proximity to key hospital facilities. Furthermore, parking areas should be clearly marked, neatly organized, and easily understood by users [11], [12]. By considering capacity, circulation, security, accessibility, and comfort, hospital parking areas can support smooth service delivery and create a welcoming environment for patients and visitors [13].

The lack of parking lots, especially four-wheeled vehicles in several hospitals in Medan City, causes visitors to park their vehicles on the shoulder of the road, reducing road capacity and obstructing traffic flow both entering and exiting and passing through the hospital at peak visitor hours. Parking facilities in hospitals affect safety and comfort. If parking facilities are available properly, safely, and comfortably, it will further improve the quality of hospital services. Based on this, research was conducted at USU Hospital in Medan City.

Problem Statement

Based on the description above, the problems in this study can be formulated as follows:

1. How to determine the need for motorized vehicle parking space at USU Hospital in Medan City.
2. How is the relationship between the number of parking spaces for motorized vehicles needed with the existing variables at USU Hospital in Medan City, namely the number of doctors, the number of paramedics, the number of employees, and the number of beds.
3. How to find out the variables at USU Hospital that greatly affect the need for motorized vehicle parking lots.

Research Objectives

The objectives of this research are:

1. To analyze the parking demand for motorized vehicles at USU Hospital in Medan City.
2. To analyze the variables that significantly affect the parking demand of motor vehicles at USU Hospital in Medan City.
3. To model the relationship between the number of motor vehicle parking spaces required and the existing variables at USU Hospital in Medan City, namely the number of doctors, paramedics, employees, and the number of beds.

Scope of Research

The scope of this research, so that this research is not separated from the background and problem formulation are as follows:

1. Research conducted at USU Hospital.
2. Evaluation of motorized vehicle parking space requirements at USU Hospital.
3. This research was conducted for six days, namely on Monday, Thursday, Friday and three times Saturday starting at 08.00 - 19.00 WIB at USU Hospital.

RESEARCH METHODOLOGY

Research Location

The research was conducted at the USU Hospital which is located on Jl. Dr. Mansyur No.66, Medan Baru District, Medan City, North Sumatra Province. USU Hospital Medan is one of the C-class state university hospitals and will become a referral center for the community, especially Medan City and the people of North Sumatra in general. RS USU Medan officially operated on December 4, 2024.

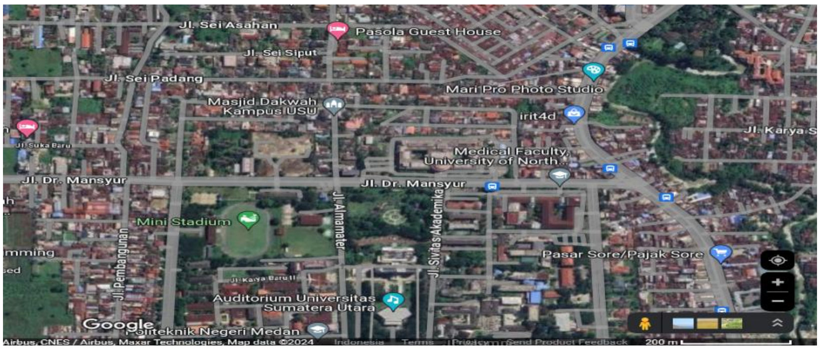

Figure 1. Location RS USU

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Scope and Stage of Research

The sequence of activities of this research is presented in a flowchart that can be seen in Figure

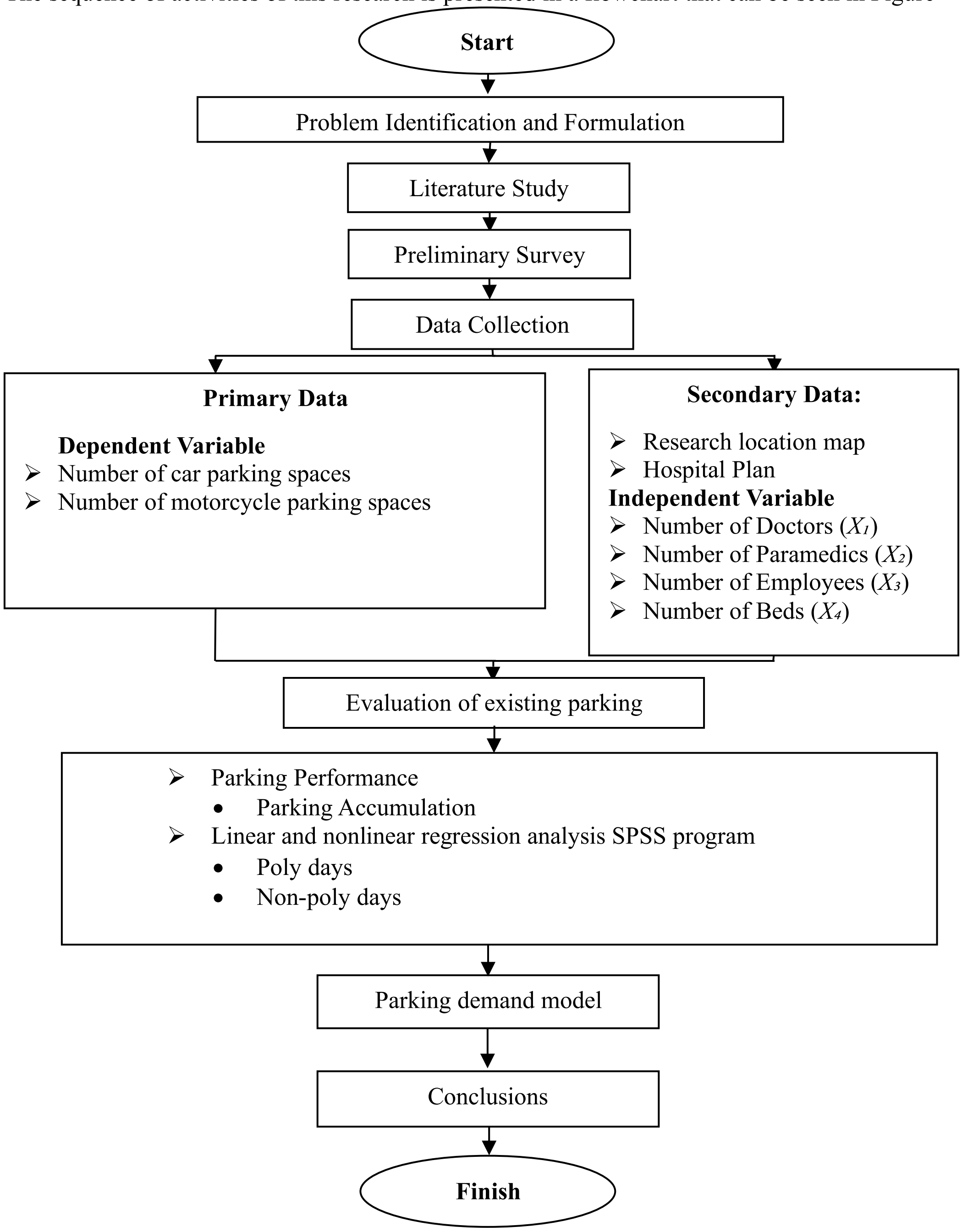

Figure 2. Research flowchart

Data collection

Data Source

The primary data source of the research comes from primary survey collection while the secondary data source of the research comes from literature studies, the internet, and the owner of the hospital to be studied.

Survey Method

The survey was conducted at USU Hospital for three days, namely Monday, Thursday, and Friday from 08.00 to 19.00 WIB. Data regarding parking vehicles are divided into 15 minutes intervals to determine the largest parking space requirements. Counting beds, paramedics, employees, and the number of doctors at USU Hospital.

The method of implementing data collection is as follows:
1. Counting the number of vehicles that have been in the USU Hospital parking lot before the observation hour begins.
2. Fill out the survey form that has been provided.
3. Recording the type and number of motorized vehicles entering/exiting the parking lot by recording the license plate number of the motorized vehicle and recording the time the motorized vehicle enters/exits.

Research Variables

This study observes variables consisting of dependent variables and independent variables. The variables that will be observed are:

1. Dependent Variable
    a. Car Parking Space Requirement
    b. Motorcycle Parking Space Requirement
2. Independent Variables
    a. Number of Doctors (X_1)
    b. Number of paramedics (X_2)
    c. Number of employees (X_3)
    d. Number of beds (X_4)

Data Processing
Parking Volume Analysis

Parking volume is the number of vehicles that have used parking spaces in a parking lot within a certain time. Parking volume is analysed for six days and consists of car parking volume and motorcycle parking volume.

Linear and Nonlinear Regression Analysis

The parking space demand model will be analyzed using linear and nonlinear regression methods with the help of the Statistical Program for Special Science (SPSS) program. Some of the statistical tests that will be performed are:

1. Correlation Test (Pearson Correlation)

    The bivariate test / correlation test is carried out to determine the correlation between the dependent variable and the independent variable. Correlation parameters can be assessed based on the correlation coefficient on a scale of -1 to 1. The correlation between independent variables is expected to have a weak correlation (<0.5) while the correlation between dependent and independent variables is expected to have a strong correlation (>0.5).

2. T-test

    The t-test is used to determine which independent variable has a significant effect on the dependent variable. If the Thitung value is greater than Ttabel, it can be said that the independent variable has a significant effect on the dependent variable (Hypothesis H_o is rejected and Hypothesis H_a is accepted). The Thitung value can be formulated as follows.

3. Coefficient of Determination (R^2)

    The coefficient of determination is a statistical indicator used to determine the percentage of influence of the independent variables simultaneously on the dependent variable. The

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coefficient of determination can be seen in the R2 value on a scale of 0 to 1. The coefficient of determination is getting stronger as the R2 value increases which is close to 1.

RESULTS AND DISCUSSION

Parking Lot Requirement Analysis Based on Variables

To find the relationship between hospital parameters related to this study, namely: number of doctors, number of paramedics, number of employees, and number of beds with parking demand for cars and motorcycles, the data from the study were analyzed using linear and nonlinear regression methods.

Table 1. Hospital Parameter Data and Vehicle Parking Space Requirements on Poly Days

No	Parameter Hospital	Monday	Thursday	Friday
1	Car Parking Space Requirement	280	163	210
2	Motorcycle Parking Space Requirement	319	224	293
3	Number of Doctors (X_1)	154	152	153
4	Number of Paramedics (X_2)	244	240	242
5	Number of Employees (X_3)	259	255	257
6	Number of Beds (X_4)	103	100	101

Table 2. Correlation Analysis Between Variables

Correlations

		(X_1)	(X_2)	(X_3)	(X_4)	Maximum Space Requirement car	Maximum Space Requirement motorcycle
Number of Doctors (X_1)	Pearson Correlation	1	1,000**	1,000**	,982	,994	,968
	Sig. (2-tailed)		,000	,000	,121	,072	,163
	N	3	3	3	3	3	3
Number of Paramedics (X_2)	Pearson Correlation	1,000**	1	1,000**	,982	,994	,968
	Sig. (2-tailed)	,000		,000	,121	,072	,163
	N	3	3	3	3	3	3
Number of Employees (X_3)	Pearson Correlation	1,000**	1,000**	1	,982	,994	,968
	Sig. (2-tailed)	,000	,000		,121	,072	,163
	N	3	3	3	3	3	3
Number of Beds (X_4)	Pearson Correlation	,982	,982	,982	1	,997*	,902
	Sig. (2-tailed)	,121	,121	,121		,049	,284
	N	3	3	3	3	3	3
Maximum Space Requirement car	Pearson Correlation	,994	,994	,994	,997*	1	,933
	Sig. (2-tailed)	,072	,072	,072	,049		,235
	N	3	3	3	3	3	3
Maximum Space Requirement motorcycle	Pearson Correlation	,968	,968	,968	,902	,933	1
	Sig. (2-tailed)	,163	,163	,163	,284	,235	
	N	3	3	3	3	3	3

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 2 shows the correlation between variables in matrix format. The variable that has the highest correlation with variable Y_1 is X_4 of 0.997 while the variables that have the highest correlation with variable Y_2 are X_1, X_2 and X_3 of 0.968.

Table 3. Hospital Parameter Data and Vehicle Parking Space Requirements on non-poly days

No	Parameter Hospital	Saturday 8/6	Saturday 15/6	Saturday 22/6
1	Car Parking Space Requirement	85	75	82
2	Motorcycle Parking Space Requirement	119	131	143
3	Number of Doctors (X_1)	11	10	12
4	Number of Paramedics (X_2)	241	243	243
5	Number of Employees (X_3)	255	254	258
6	Number of Beds (X_4)	96	98	100

Parking demand modeling

Linear Regression for Cars on Poly Days

Linear regression for cars is carried out in stages, namely against each one variable. The results of the one-variable regression model for cars can be seen in Table 4 below.

Table 4. One-Variable Linear Regression Results for Poly Day Car

Variables	Model	R Square
X_1	Y_1=-8732,833 +58,500X_1	0,987
X_2	Y_1=-6860,833 +29,250X_2	0,987
X_3	Y_1=-7299,583 +29,250X_3	0,987
X_4	Y_1=-3676,429+ 38,429X_4	0,994

Based on the table, the variable that has the largest coefficient of determination (R-Square) is the X_4 variable with an R-square value of 0.994.

Nonlinear Regression for Poly Day Cars

Nonlinear regression for cars will be modeled on each independent variable. Nonlinear regression models consist of logarithmic, inverse, and power.

Table 5. Model Comparison Y_1 poly days

Model	Regresi Linier		Logarithmic		Invers		Power		R Square Maks.
	R Square	Sig.	R Square	Sig.	R Square	Sig.	R Square	Sig.	
X_1	0,987	,072	0,987	,073	0,986	,074	0,999	,025	Power
X_2	,987	,072	,987	,073	,986	,075	,998	,025	Power
X_3	,987	,072	,987	,073	,986	,075	,998	,025	Power
X_4	,994	,049	,995	,047	,995	,044	,978	,095	Invers

Based on the regression model comparison of the Maximum Car Space Requirement (Y_1) with the independent variables Number of Doctors (X_1), Number of Paramedics (X_2), Number of Employees (X_3), and Number of Beds (X_4), it was found that the Power model has the highest R Square value for variables X_1 (0.999), X_2 (0.998), and X_3 (0.998) with a significance value of 0.025, indicating that the Power model is the best fit for these variables

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The regression equation is: $Y_1=8{,}166\times10^{-89}\times X_1^{41{,}386}$

Linear Regression for Poly Day Motorcycles

Linear regression for motorcycles was performed on each single variable.

Table 6. One-variable Linear Regression Results for Motorcycles on Poly days

Variables	Model	R Square
X_1	Y_2=-6988,833 +47,500 X_1	0,936
X_2	Y_2=-5468,833 +23,750 X_2	0,936
X_3	Y_2=-5825,083 +23,750 X_3	0,936
X_4	Y_2=-2660,000 + 2,000 X_4	0,814

Based on Table 6, the variables that have the largest coefficient of determination (R-Square) are variables X_1, X_2, and X_3 with an R-square value of 0.934.

Nonlinear Regression for Poly Day Motorcycle

Nonlinear regression for cars will be modeled on each independent variable. Nonlinear regression models consist of logarithmic, inverse, and power.

Table 7. Model Comparison Y_2 Poly days

Model	Regresi Linier		Logarithmic		Invers		Power		R Square Maks.
	R Square	Sig.	R Square	Sig.	R Square	Sig.	R Square	Sig.	
X_1	,936	,163	,937	,162	,938	,160	,919	,184	Invers
X_2	,936	,163	,937	,161	,938	,160	,919	,184	Invers
X_3	,936	,163	,937	,161	,938	,160	,919	,184	Invers
X_4	,814	,284	,817	,281	,820	,279	,789	,304	Invers

Based on Table 7 Comparison of regression models on the maximum space requirement of motorcycles (Y_2) with independent variables Number of Doctors (X_1), Number of Paramedics (X_2), Number of Employees (X_3), and Number of Beds (X_4), it was found that the Invers model has the highest R Square value for variables X_1 (0.938), X_2 (0.938), and X_3 (0.938) with a significance value of 0.160 indicating that the Invers model is the most appropriate for these variables.

The regression equation is:

$Y_2=7553.126-1112960.605/X_1$

$Y_2=6033{,}071-1392502{,}512/X_2$

$Y_2=6389{,}337-1570378{,}771/X_3$

Linear Regression for Cars on Non-Poly Days

Linear regression for cars is performed on each one variable. The results of the one-variable regression model for cars can be seen in Table 8 below.

Table 8. One-Variable Linear Regression Results for Non-Poly Day Cars

Variables	Model	R-Square
X_1	Y_1=42,167 + 3,500X_1	0,465
X_2	Y_1=868,250 - 3,250X_2	0,535
X_3	Y_1=-204,500 + 1,115X_3	0,205
X_4	Y_1=154,167 – 0,750X_4	0,085

Based on the table, the variable that has the largest coefficient of determination (R-Square) is the X_2 variable with an R-square value of 0.535.

Nonlinear Regression for Non-Poly Day Cars

Nonlinear regression for cars will be modeled on each independent variable. Nonlinear regression models consist of logarithmic, inverse, and power.

Table 9. Model Comparison Y_1 non-Poly days

Model	Linear Regression		Logarithmic		Invers		Power		R-Square Max.
	R Square	Sig.	R Square	Sig.	R Square	Sig.	R Square	Sig.	
X_1	0,465	0,522	0,491	0,505	0,518	0,489	0,506	0,496	Invers
X_2	0,535	0,478	0,535	0,478	0,535	0,478	0,521	0,487	Linear Regression
X_3	0,205	0,701	0,206	0,700	0,207	0,699	0,218	0,691	Power
X_4	0,085	0,811	0,089	0,807	0,092	0,804	0,081	0,816	Invers

Based on the regression model comparison of the maximum car space requirement (Y_1) with the independent variables of number of doctors (X_1), number of paramedics (X_2), number of employees (X_3), and number of beds (X_4), it is found that the linear regression model has the highest R square value for variable X_2 (0.535), indicating that the linear regression model is the most appropriate for these variables.

The regression equation is:

$Y_1 = 868{,}250 - 3{,}250\, X_2$

Linear Regression for Non-Poly Day Motorcycles

Linear regression for motorcycles was performed on each one of the variables.

Table 10. One-variable Linear Regression Results for Motorcycles on non-Poly days

Variables	Model	R-Square
X_1	$Y_2 = 65{,}000 + 6{,}000X_1$	0,250
X_2	$Y_2 = -2050{,}000 + 9{,}000X_2$	0,750
X_3	$Y_2 = -931{,}000 + 4{,}154X_3$	0,519
X_4	$Y_2 = -457{,}000 + 6{,}000X_4$	1,000

Based on Table 10, the variable that has the largest coefficient of determination (R-Square) is the X_4 variable with an R-square value of 1.000.

Nonlinear Regression for Non-poly day Motorcycles

Nonlinear regression for motorcycles will be modeled on each independent variable. Nonlinear regression models consist of logarithmic, inverse, and power.

Table 11. Model Comparison Y_2 non-Poly days

Model	Linear Regression		Logarithmic		Invers		Power		R Square Max.
	R Square	Sig.	R Square	Sig.	R Square	Sig.	R Square	Sig.	
X_1	0,250	0,667	0,228	0,683	0,206	0,700	1,000	-	Power
X_2	0,750	0,333	0,750	0,333	0,750	0,333	0,773	0,316	Power
X_3	0,519	0,488	0,518	0,489	0,516	0,490	0,491	0,506	Linier
X_4	1,000	-	1,000	0,004	1,000	0,008	1,000	0,013	Linier regression

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Based on the regression model comparison of the maximum space requirement of motorcycles (Y_2) with the independent variables of number of doctors (X_1), number of paramedics (X_2), number of employees (X_3), and number of beds (X_4), it is found that the linear regression model has the highest R square value for the variable X_4 (1.000) indicating that the linear regression model is the best fit for these variables.

The regression equation is as follows: Y_2=-457,000 + 6,000X_4

Discussion

The evaluation of linear and nonlinear regression models shows that R-squared is a value that indicates the extent to which independent variables affect the dependent variable. R-squared is a number that ranges from 0 to 1, indicating the degree to which the combination of independent variables collectively influences the value of the dependent variable. The R-squared (R2) value is used to assess the extent of the influence of specific independent variables on the dependent variable. There are three categories of classification for the R-squared value: strong category, moderate category, and weak category [14], [15]. R-squared value of 0.75 falls into the strong category, an R-squared value of 0.50 falls into the moderate category, and an R-squared value of 0.25 falls into the weak category.

The linear regression equation using data processing with the SPSS program shows from the ANOVA table that the Sig value is 0.485 > 0.05. This indicates that the linear regression model is not suitable and should be tested with the most appropriate nonlinear regression model. From the table output model summary, an R Square of 0.033 is obtained, which is very far from 1, and a regression coefficient of 0.182 indicates a weak linear relationship [16], [17].

Decision-making is carried out by examining the significance values in the Coefficients table. Typically, the basis for testing regression results is conducted with a confidence level of 95% or with a significance level of 5% ($\alpha = 0.05$). The criteria for the t statistical test:

1. If the significance value of the t-test > 0.05, then H_0 is accepted and Ha is rejected. This means there is no effect of the independent variable on the dependent variable.
2. If the significance value of the t-test < 0.05, then H_0 is rejected and Ha is accepted. This means there is an effect of the independent variable on the dependent variable.

The Standard Estimation Error [18] is a statistical metric used to measure the extent to which individual data points differ from the regression line established by the model. In simpler terms, it provides a measure of the model's precision in predicting the value of the dependent variable based on the values of the independent variables. A smaller value indicates that the model is more accurate in forecasting the value of the dependent variable.

Table 12. Comparison of Linear and Nonlinear Regression

Classification	Independent variables that influence			
	Linear Regression		Nonlinear Regression	
	Car	Motorcycle	Car	Motorcycle
Poly Days	Number of Beds (X_4)	Number of Doctors (X_1) Number of Paramedics (X_2) Number of Employees (X_3)	Number of Doctors (X_1)	Number of Doctors (X_1) Number of Paramedics (X_2) Number of Employees (X_3)
Non-Poly Days	Number of Paramedics (X_2)	Number of Beds (X_4)	Number of Paramedics (X_2)	Number of Beds (X_4)

The results of the comparison of various models in this study indicate that the model that best represents the characteristics of traffic in the USU Hospital area is for car movement using the power model with the variable number of doctors (X_1), and for motorcycle movement using the inverse model with the variables number of doctors (X_1), number of paramedics (X_2), and number of employees (X_3) on outpatient days. On non-outpatient days, the linear regression method uses the variable number of paramedics (X_2) for car movement and the number of beds (X_4) for motorcycle movement.

Linear regression has been noted to have a high coefficient of determination (R-Square) in modeling movement attraction [19]. The linear regression model that best represents the characteristics of attraction is for car movement with the number of doctors as the independent variable, and for motorcycle movement with the number of beds as the independent variable. Also found that the need for parking facilities for hospitals is greatly determined by the number of existing beds as the independent variable [18], [20].

The results of the study are supported by previous research models that also found a significant correlation between the number of beds (X_4) and the need for car parking space, as well as the number of doctors (X_1) and the need for motorcycle parking space. Modeled parking needs using linear and nonlinear regression. This study found that nonlinear regression models, particularly power and inverse regression, can serve as alternative models to single/multiple linear regression in modeling parking needs in hospitals.

CONCLUSION

From the analysis of the data presented in the previous chapter regarding parking at USU Hospital in Medan, the following conclusions can be drawn, the regression equation for the parking needs of cars and motorcycles obtained from the analysis of the largest parking space requirements and the parameters present in the hospital is as follows: 1) on Parking Day, the number of doctors representing the request for car parking is given by the equation: $Y_1=8{,}166\times10^{-89}\times X_1^{41{,}386}$, 2) for motorcycle parking, the representatives are the number of doctors, paramedics, and employees with the equation: $Y_2 = 7553{,}126-1112960{,}605/X_1$, $Y_2 = 6033{,}071-1392502{,}512/X_2$, $Y_2 = 6389{,}337-1570378{,}771/X_3$, 3) on non-Poli Day, for car parking requests that represent the number of paramedics with the equation: $Y_1 = 868{,}250-3{,}250X_2$. For motorcycle parking, the representative is the number of beds with the equation: $Y_2=-457{,}000 + 6{,}000X_4$.

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