*ESTEEM Academic Journal*
Vol. 14, Special Issue, January 2018, 38-44

# Modelling Parking Demand in Hospital

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**ARTICLE HISTORY**

Received
*24 November 2017*

Received in revised form
*1 December 2017*

Accepted
*25 January 2018*

**ABSTRACT**

*The availability of adequate parking spaces in hospital environment has been always an important factor to achieve a better traffic system. We study the visitors' demand for hospital parking. In the selected study areas of Serdang Hospital, Sungai Buloh Hospital, Kulim Hospital and Seberang Jaya Hospital, there are always complaining about lacking of parking supplied which leads to illegal roadside parking that interrupting traffic flow of the surrounding area. Lack of parking is mainly contributed by the increasing number of patients visiting the hospital. The main objective of this study is to develop a parking demand model based on the number of hospital beds as a guide for relevant authorities. Linear regression method was used to develop the model. Our findings show that, although extra parking has been provided in some hospitals, the problem with illegal parking still happens.*

**Keywords:** *hospital parking, illegal roadside parking, lack of parking, parking demand model, linear regression.*

## 1. INTRODUCTION

In Malaysia, private cars are the dominant mode of transportation for daily activities. Increasing population and the level of motorization caused parking problems. According to statistics provided by the Road Transport Department Malaysia (2016)[1], the number of newly registered vehicles for year 2005 and 2011 was 537,900 and 594,610 respectively. It was a steady increase of 10.5% within 6 years with an average of about 1.75% increase per year. In conjunction with the increasing number of cars owning, design of parking facilities becomes one of the crucial criteria to be considered during the planning stage of land use. This is especially important for development that requires a high number of parking like a hospital, shopping mall, airport and stadium. Land use will greatly influence parking demand. For instance, office buildings generate high parking demand for all day parking, whereas retail uses generate high demand for short-term and weekend parking. Hospitals' parking lots are limited, occupied mainly by employees, physicians, patients, visitors and public with no limits of time. Insufficient parking facilities not only will cause traffic congestion, but also air pollution, wasting of time and resources too. Thus, demand projection and views of interest groups are both important criteria in the provision of parking facilities.

There are several factors affecting the parking demand such as population scale, working position and volume of vehicle. Parking fee, turnover ratio and type of building are also the common factors that contribute to the increases of the parking demand (Li et al, 2009)[2]. In addition, traveling purposes will also affect the parking demand. Different traveling purposes like working, shopping and medication will lead to different parking demand. Different parking

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duration is required by each user. Type of buildings can affect parking demand too. Every building has its functions, characteristics and purposes that lead to different parking demand. Parking demand can also be affected by the management policy. Appropriate parking policy can support the local economy and resident's need. It can help to maintain and improve the safety of cars (Walsh, 2011)[3]. Among factors that lead to insufficient number of parking include inadequate projection of parking demand by town planners and real estate developers and lack of guidelines provided. Besides, there are also land owners that convert parking spaces into shops for renting to supermarkets (Au, 2012)[4]. In addition, inconsiderate behavior of drivers or shop owners also contributes to insufficient parking in many places.

Generation of the parking demand model is important in analyzing current parking conditions. There are different parking prediction commonly used by researchers in developing parking model which produce different results and data. Parking demand forecast model on regional development shows that the parking demand forecast model which is generated based on the development area produce more accurate result and has better applicability. It can also be a scientific basis for parking facilities for construction and parking demand control. In one of the research done, development factors are used to modify the trip attraction (Chen et al, 2012)[5]. Next, the research on the location parking index based on function division of parking space produce results on parking location from the parking index model. However, parking index based on the object and the subject equilibrium theory did not produce an accurate result of the parking demand. The parking standard index model should be generated based on the building parking space function division in combination with location condition, because it produces better results on developing environment (Li et al, 2009)[2]. Wong et al, 2000[6]proposed the parking demand models for private cars and good vehicles developed as one of the parking demand study. In the research, it is assumed there is a linear and additive demand function. It also concludes that different type of land-use gives a different and unique parking demand accumulation. Khan et al, 2015 [7] included number of beds and area(acres) in their multiple regression analysis to study hospitals parking demand in Punjab and suggested that number of beds is more reliable variable to estimate the parking demand.

Parking survey is a data collection method in the study of parking. There are several types of a parking survey such as patrol survey, cordon count survey and parking interview. Patrol surveys are frequently used to estimate average parking duration(Cao & Menendez, 2012)[8]. The cordon counts are conducted at the central business district (CBD). It uses an imaginary closed loop as cordon area and use count station. It gives the volume of the vehicles that entering and leaving the cordon area (Garber & Hoel, 2002)[9]. Parking interview surveys provide information on how long the users use the parking. This technique used include parking beats, registration number or video. Parking interview surveys provide more detail information on the users' journey purpose, frequency and origin, and the number of passengers. They can also provide information on the reason why a particular parking area has been chosen (Slinn et al, 2005)[10]. In the current paper, cordon count survey is adopted and modified to suit the study sites as described in the subsequent section.

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## 2. EXPERIMENTAL

### *2.1 Cordon Survey*

There are four study areas that have been selected to conduct this study which includes Serdang Hospital, Sungai Buloh Hospital, Kulim Hospital and Seberang Jaya Hospital. Parking conditions in all selected areas were studied and the actions taken by the authority in assuring the traffic flow were also recorded. The collection of data was divided into three portions, population, parking inventory and the cordon count survey. The population of the selected areas was determined by checking on the number of hospital beds. In the parking inventory, the number of existing parking in each area is counted. The existing parking is divided into different zones which include staff parking, public parking, handicap and reserved parking. This research focus on the public parking only. Then, the cordon count survey was conducted by determining the existing car in the area and a number of cars entering and leaving the area. This survey is conducted for 7 days in each study area from 8am to 5 pm to obtain data on the number of vehicles parked in a study area during a specific period of time. First, the number of vehicles already in that area is counted or estimated. Then the number of vehicles entering and exiting during that specified period is noted, and added or subtracted from the accumulated number of vehicles. Accumulation data are normally summarized by time period for the entire study area. The occupancy can be calculated by taking accumulation or total spaces. Peaking characteristics can be determined by graphing the accumulation data by time of day. The accumulation graphs usually include cumulative arrival and cumulative departure graphs as well (Khisty & Kyte, 1991)[11].

### *2.2 Linear Regression Analysis*

The collected data were then analyzed to obtain the average number of cars entering the area and the trends of car enter the area due to different time and day. The parking demand model is then developed using linear regressions. In a simple linear regression, the dependent variable, $y$ is predicted by one explanatory variable, $x$. The parking demand is expected to be affected by the independent variables chosen, the number of beds in the hospitals. Correlation coefficient, $r$ is concerned with assessing the strength of a relationship between to variables. $r$ must be significant in order to make regression analysis be meaningful (Bluman, 2012)[12]. In regression analysis, we try to find a line that best fits the data. Such line provides the best possible description of the relationship between the $y$ and the $x$. A regression coefficient in linear regression is the slope of the linear relationship between y and x that gives the amount of change in $y$ due to a change of one unit in $x$, independent of all other predictor variables.

## 3. RESULTS AND DISCUSSION

### *3.1 Analysis of Parking trend*

From the observation, the number of cars entering the area is the highest at 8.30 a.m. in the morning because it is the time where the morning shift staff reports to work. It is also the time where visitors and publics start entering the area. However, visitors will start lining up at the Specialist Clinic as early as 7.30 a.m. to meet the doctor. Besides, 10.00 a.m. is the peak hour where almost all the parking is fully occupied. Most of the car entering the area during the peak hour can hardly find any available parking, normally the driver can only drop-off the patient and leave the area to find other nearby places to park. During this particular time, total number

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of cars entering the area is same with the number of cars leaving the area. At 12.00 noon, total number of cars will start increasing because it is visiting hour, lunch hour and afternoon shift staffs will start work at 2.00 p.m.

Next, the trend of the collected data is the same in all the study areas for a different day. The number of cars is the highest on Monday and gradually decreases until Sunday. This is because Monday is the first day of the week where the Specialist Clinic is opened to publics for checking and treatments. On Friday, the number of cars will decrease due to limited time for the patient and visitors to get treatments in the morning session because the Specialist Clinic will be closed at 12.15 p.m. for lunch and Muslim Friday prayer and will be opened back at 2.45 p.m. During weekends, the number of cars entering the area decreases because the Specialist Clinic is closed and only a few of the staffs worked. The visiting hours are from 12.00 noon to 4 p.m. only.

### *3.2 Discussion*

The average number of cars parked per hour, which discussed here represents the number of visitors'/ patients' cars parked at public/visitors' parking only. The number of beds is the total number of beds that provided in that hospital. As per number of beds provided, the total number of parking according to JKR standard can be determined.

According to the guideline provided by Jabatan Perancangan Bandar Desa Semenanung Malaysia (2011)[13], the hospital car park was built according to the specifications laid down construction method of the car compartment ¼ patient beds, an additional 1 car compartment / 1 doctors and other professional staff, additional 1 car compartment / 3 employees, plus 20% of motorcycle compartments and space lay-bay for taxis.

According to the guideline, total number of public/visitors' parking that should be provided to Serdang Hospital, Sungai Buloh Hospital, Kulim Hospital and Seberang Jaya Hospital is 161, 155, 79 and 79 respectively. Data collected in this study is presented in the tables and graphs below.

Table 3.1: Analysis of parking Trends

| Hospital | Number of Bed | Number of Parking provided | Average Number of cars parked per hour | Number of parking according to the guideline |
|---|---|---|---|---|
| Kulim | 314 | 125 | 175 | 79 |
| Seberang Jaya | 314 | 310 | 175 | 79 |
| Sungai Buloh | 620 | 484 | 277 | 155 |
| Serdang | 644 | 253 | 303 | 161 |

From Table 3.1, the number of existing parking lots is greater than the required number of parking according to the guideline.

Based on our observation, it is found that the parking provided in all study areas is not sufficient to cater patients / visitors' needs. This is obvious during peak hour such as in the morning and

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during visiting hours. However, based on the data collected, although the number of parking provided is greater than the average number of cars parked per hour in Seberang Jaya Hospital and Sungai Buloh Hospital, there are many cars parked illegally. This is because of the public/visitors' parking located far from the hospital lobby/wards. It takes walking distance from the parking to the specialist clinic or wards.

Data collected from all the four hospitals has been combined to develop a parking demand model as described in the later section.

The graph in Figure 3.1 shows the differences between supply and demand of parking in each of the study areas.

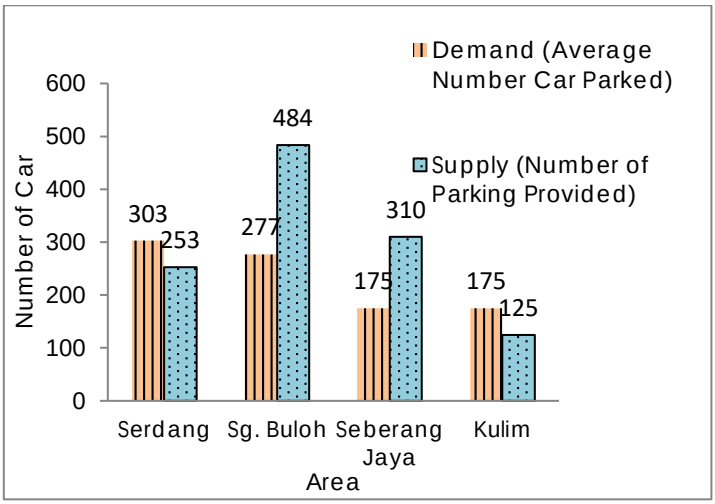


Figure 3.1: Supply versus demand of parking in hospitals

### *3.3 Parking Demand Model Development*

A simple linear regression was calculated to predict the number of cars parked based on the number of hospital beds. A significant regression equation was found (F(1,26) = 22.883, $(F(1,26) = 22.883, p < 0.05)$ with an $r^2 = 0.468$. Coefficient of correlation, $r$ = 0.684 indicates moderate positive linear relationship between $x$ and $y$. Coefficient of determination, $r^2 = 0.468$ means that 46.8% of the variability observed in parking demand can be explained by the number of hospital beds. While the other 53.2% may be explained by other explanatory variables. The predicted amount of parking demand is equal to 59.281 + 0.365 beds. For every additional unit of beds we may expect parking demand to increase by an average of 0.365 spaces.

For comparison purposes, the differences between the number of parking provided, parking standard and the parking demand modeled is shown in Figure 3.2 below. It is obvious that the parking demand model has a higher value compare to the JKR parking standard that should be provided to each hospital. Although extra parking has been provided in some hospitals, the problem with illegal parking still happens.

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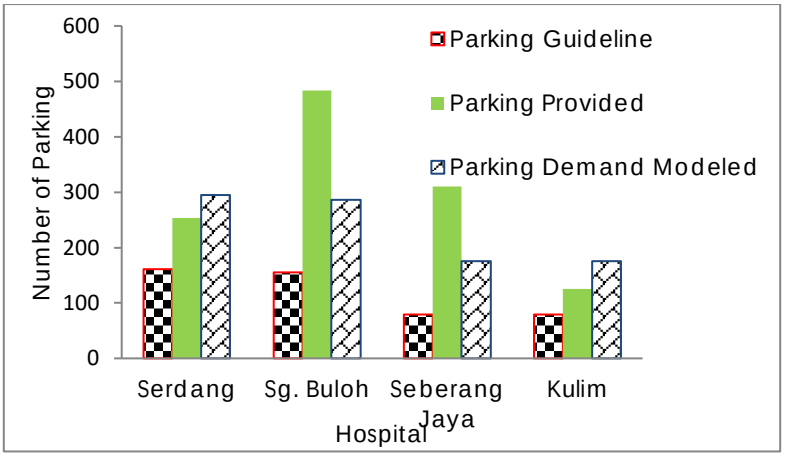


Figure 3.2: Comparison of Number of Parking Provided, Parking Standard and Parking Demand Developed

## 4. CONCLUSION AND RECOMMENDATION

According to the guideline for parking planning, optimum value for the number of parking that should be provided can be determined. However, if the hospital has a high number of staffs and patients, the number of parking provided should be adjusted accordingly to suit the demand. By using the developed parking demand model, the authority will now have the information on the number of parking that need to be added in each area. Then, proper strategies and actions can be taken to control the traffic in the area to prevent any congestion.

In conclusion, linear regression equations can be used to determine and develop a parking demand model for hospital area. It determines the number of parking that need to be provided by relating the number of cars parked and the number of hospital beds. However, such estimation should be done only within the range of the values of x, the number of hospital beds, originally sampled, since there is no statistical basis to assume that the regression line is appropriate outside these limits(Bluman, 2012)[12]. Hospital management should consider providing multi level parking or a new parking space to solve the lack of parking space. By providing enough parking facilities, illegal roadside parking can be eliminated and traffic flow within the hospital area can be eased too.

This research only considered one independent variable (number of hospital beds). In 3.3, since the predictor is significant, but the r-squared is low, we suggest to add more variables in the model. Future research could be conducted to take into account for other factors (number of outpatients registered per day) that may impact parking demand in hospitals. The separate parking demand model may be developed for other land-uses like educational, government offices, recreational places, and shopping malls.

## ACKNOWLEGMENT

The authors would like to express sincere gratitude to the Ministry of Higher Education under RAGS 2014 with reference number 600-RMI/RAGS 5/3 (224/2014) and Universiti Teknologi MARA for the opportunity to carry out this study by supporting financial aid.

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