Investigating hospital parking demand characteristics in Iraq: Al-Sadar Hospital as case study

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Abstract. Al-Sadar Hospital is an effective medical center in Al-Najaf city in Iraq, which serves up to 1200 patients. This study has focused on two types of data from this hospital viz. general information and filed data about parking vehicles. A drone has also been used for collecting field data in this study in addition to direct interviews with people and manual counts for both traffic volume and parking vehicles. The duration for parking vehicles was long. The investigated trips are from the same city and from other cities or provinces. According to the results of analysis for both data and information, it was found that the number of parking spaces available (legal and illegal) for each bed was one space which, is less than the default value (2.2 spaces for each bed). On the other hand, the required spaces for employees are also less than the default value (4.3). The results indicate that there is an urgent need for increasing the number of parking spaces to match the demand for the parking vehicles.

Keywords
Parking demand, hospital parking, on-street parking, average turnover.

1. Introduction
Providing of parking facilities is from the essential things to a community and lack of parking spaces is one of the widespread problems encountering operators, designers and planners. Such problems could be defined either in terms of supply (too few parking spaces are available) or in terms of poor management of the existing ones[1].

There are various types of parking facilities. These are either off-street parks or on-street [2]. Parking spaces are provided alongside the on-street on one or both sides of the street. Secondly, off-street parks are either privately or publicly owned these parks include surface lots and garages. Surface lots are on a prepared surface and open to the sky [2]. Whereas, multi-story parking consists of a building designed specifically to service parking cars with a number of floors, which satisfy the parking demand. In addition, parking characteristics such as clear visibility, parking-space marking are required to enable drivers to remember the location of their vehicles [3].

The parking requirements are various for different land use zones. Table 1 indicates the requirements of parking for each type of facilities [2]. Regarding the hospital requirements of parking space, this is different from one country to another. For example, in the United States, spaces are 2.2 per bed, in China are 2.7 spaces for each bed and in Jordan, it is one space for each bed. This study aims to investigate the hospital parking characteristics through field surveys.
Table 1. Requirements of parking space (adopted from [2]).

| Type of facility                          | Required parking space |
|------------------------------------------|------------------------|
| Respirational plot area< 300m²           | One space              |
| Office 70 m²                             | One space              |
| Each 10 seats in a restaurant            | One space              |
| Each 20 seats in cinema or theatre       | One space              |
| Hospital for each bed                    | 2.2 spaces             |
| 4 employees in a hospital                | One space              |

2. Required parking data

Essentially, to form parking policy and proper management for parking, there is a need for some information about the amount, location and duration of parking. Therefore, there is an urgent need to define these surveys and to find out the best time to conduct such surveys. Moreover, these data from each survey should be accurate and care should be given to make sure that the results are confident [4]. The data surveys are accumulation, license plate method and interview. To analyze parking data, several steps include summarizing, coding, and interpreting the data to get the relevant information required for making the right decision [5].

Average parking time is the average time spent by each vehicle that used vehicle parking during the inventory period and the nature of the situation is essential in determining the parking pattern (short, medium, long). While standing for less than 30 minutes is short-term standing, while the medium-term stand is for periods between 30 minutes and 60 minutes, while the long-term is for more than 60 minutes [6].

3. Hospital parking problem

Limited studies, which focus on dealing with the hospital parking. Das [7] collected data from private hospitals of Dhaka city. These data were collected by patrol, conducted on both weekdays and weekend throughout a period of eight hours each covering both the morning and evening peak periods. This study indicated that overall parking demand is always higher than the available supply in most of the cases. The most important recommendations of this study are that various innovative policy measures such as restriction pricing fixation of time duration etc. that should be practiced to minimize this problem. Parking policy should be strictly maintained and regularly updated according to the emerging situations. The author found that the road surrounding the hospital is from the busiest roads in Dhaka with major networks to other key locations within the city. Consequently, the illegal on-street parking nearby this hospital badly affects the traffic condition in the road surrounding the hospital. Therefore, the improper parking space and traffic management are somehow responsible for deteriorating the overall traffic condition there.

Extended the study of Islam [8] and portrayed how the unavailability of parking space in a hospital becomes a contributor of traffic congestion generator rather than mitigating the impact. Edwards [9] indicates that parking requirement for a hospital is dependent on the numbers bed available for the patient. As a final outcome of the study, it was found that approximately 2.17 car spaces per hospital bed are required. Building Construction Act [10] and Parking Policy for Dhaka Metropolitan Development Plan (DMDP) Area (2002) both laid out legislative measures and detailed standards regarding parking space in Bangladesh. The parking space will have to be at least twenty-three (23) square meters for single vehicle parking. This figure varies with the size of the building or number of building users [10]. Again the Parking Policy for DMDP Area, 2002 provides some recommendations for managing the Parking Demand and Parking supply.
• Restrictive parking shall be adopted in areas where the demand exceeds the available parking spaces.
• Both the off-street and on-street parking should be provided Parking Policy for DMDP Area (2002).

4. The negative effects of the parking problem

The lack of parking spaces and inadequate management of many existing waiting facilities increase the search for vacant spaces, followed by many of the negative effects and damage that are exacerbated day after day and are reflected in different aspects of life in cities such as traffic, national economy, environment, human health and other aspects, the most important effects such as time and obstruction of traffic flow. The obstruction of traffic flow effect could be summarized as:

A - slow traffic of cars: A recent study indicates that nearly 2/3 traffic of the local streets of the cities are produced by the search for places to stop cars [11] and lead to very slow movement of cars and traffic congestion, especially at peak traffic hours [12].

B- Double parking: Lack of parking spaces in front of or near public facilities (such as ministries and banks) leads to prohibited parking and street deductions are part of the street [13]. Thus, it reduces street capacity by 70-40% causing traffic congestion [14].

In addition to the above, it was reported that on-street parking had a lot of effects on traffic stream such as accidents, environmental pollution, obstruction to firefighting operations and congestion [15]. So, on-street parking leads to significant lowering in the road capacity resulting in reduced speed and increased journey time and delay. This could produce great economical loss to the society.

5. Study area

Al-Sadar Hospital has been selected as a study area in order to investigate the parking behavior. This selection has been done for the significant location and services introduced by this hospital. Figure 1 shows the location of this hospital on the Kufa-Najaf road, which is the major arterial linking Al-Najaf city with Kufa city. The main traffic problem could be diagnosed close to the hospital is traffic congestions. These congestions are attributed to its location on the roads leading to the University of Kufa and high number of on–street parking vehicles on the roads surrounding the hospital as indicated in figure 2.

Figure 1. The location of the hospital.
**Figure 2.** On-street parking vehicles along the road facing the main gate of the hospital.

### 6. Data collection

The best method of data collection depends mainly on the nature of the study [5]. In this study, different methods have been used such as direct interview, manual volume counts, video camera and drone.

An unmanned aerial vehicle (UAV), commonly known as a drone is an aircraft without a human pilot aboard. UAVs are a component of an unmanned aircraft system (UAS); which include a UAV, a ground-based controller, and a system of communications between the two. The flight of UAVs may operate with various degrees of autonomy: either under remote control by a human operator or autonomously by on board computers [16]. The type used in this study is Mavic pro platinum. This could be directed by remote control as indicated in Figure 3.

**Figure 3.** Mavic Pro Platinum.

The main stage of any study is to collect suitable data depending on the nature of study and the required data for this study. Table 2 indicates the number of visits to the hospital in order to collect parking data. Therefore, the collected data are classified into three groups in order to give a comprehensive picture for the evaluation of the hospital parks. These data are accumulated parking vehicles, the origin and destination and average turnover for each park. The main requirement for these types of data is the observer who monitors and investigates the number of vehicles and conducts the interview with each person coming to the park the vehicle. In addition to the above data, other general information is also required.
Table 2. Number of visits for parking survey.

| Number of visits | The duration of survey | Date       |
|------------------|------------------------|------------|
| 1                | 7 AM - 10 AM           | 22-2-2017  |
| 2                | 7 AM - 12 PM           | 16-7-2017  |
|                  | 5 PM - 7 PM            |            |
| 3                | 7 AM - 12 PM           | 18-7-2017  |
| 4                | 7 AM - 12 PM           | 23-7-2017  |
| 5                | 7 AM - 12 PM           | 30-7-2017  |
| 6                | 7 AM - 12 PM           | 22-10-2017 |
| 7                | 7 AM - 12 PM           | 17-12-2017 |
| 8                | 7 AM - 12 PM           | 18-12-2017 |
| 9                | 7 AM - 12 PM           | 19-12-2017 |
| 10               | 7 AM - 12 PM           | 24-12-2017 |
| 11               | 8 AM -10 AM            | 6-3-2018   |

6.1 General information
The general information, which is urgently needed in such study is the number of beds in the hospital. According to the information obtained from the administration unit in the hospital (2017), the number of beds could be classified as following:
- Surgical emergency = 46 beds.
- Internal emergency = 23 beds.
- Open Heart Center = 57 beds.
- Fertility Center = 6 beds.
- Neuroscience Center = 56 beds.
- Kidney Center = 56 beds.
- Number of beds on floors = 434 beds.

This classification may be useful in order to indicate the parking demand for each part of hospital. These all used beds in the hospital. The total number is 678 beds. Figure 4 indicates the number of beds for five years. The most important thing that could be noticed from the figure is that the number of beds increases with time. This could be attributed normal increment even there is abnormal conditions in the country.

Employees number is another important information required. Figure 5 demonstrates the number of employees for five years. It was noted that there is an increment in the number as noted in the number of beds. Regarding to the increment in the number of beds and employees, whereas; the number of available spaces is still the same.
Figure 4. Numbers of beds in Al-sadder hospital (2013-2017).

Figure 5. Numbers of employees in Al-sadder hospital (2013-2017).

6.2 Parking information
The second part of information, which is very important in this study, is the number of parks in and outside the hospital. Figures 6 illustrates the parks related to the hospital, which are either for employees or for the visitors.

Figure 7 clearly shows Park No.5, which is considered as one of the best positions for the staff because this position is completely isolated and surrounded by the BRC fence and contains sidewalks and tiling. The spaces are determined with numbers to facilitate the parking of vehicles and to be assigned easily for each employee.

On the other hand, the parks inside the hospital are three. There are two secondary parks of the Centre for Neuroscience with 75 vehicles, the second is the open-heart centre, which contains 25 vehicles and it is located directly behind the hospital as indicated in figure 8.

On the other hand, on-street parking has been determined for both sides on main road located in front of the main gate for the hospital. The total number was 430 parking vehicles.

A long queue could be observed in this road serving both the hospital and the university. The flow is upto 4000veh/hr for this road during the morning peak hour as conducted by this study. This road consists of two lanes in each direction but in reality, it just operates with one lane due to on-street parking in one direction, which comes from the university towards the hospital. Whereas, another direction, which goes from the hospital towards the university is blocked by traffic obstacles. In addition to the on-street parking, there is a high interaction between pedestrians (about 600 people in peak hour passing through the street) who cross this road with vehicles, which create another traffic bottleneck.
Figure 6. Number of parks serving the hospital.

Figure 7. Park No 5 for employees.
7. Data analysis

Before starting with the analysis of data collected, there are a lot of visual surveys which have been conducted in the study area. So, it is noted that the problem with garage parking spaces, which are not sufficient to meet the demand for the parking area. This could clearly be noticed through the parks that have been added to the parking area there to cope with high number of parking vehicles for employees. Two periods of time have been selected in accordance with the peak hours. These are from 7:00AM to 12:00 noon and 5:00 PM to 7:00PM.

The first type of data has been collected related to the origin and destination for the interviewed persons coming to the hospital. More than 600 persons have been interviewed. This method requires more skills to get the suitable information and this task also consumes a lot of time and effort. Figure 9 shows the origin distribution among different provinces and quarters for Al-Najaf city. Moreover, the points of interview have been distributed among four stations.

![Figure 9. Origin of trips coming to the hospital.](image)

The total number of vehicles, which have been reviewed are 600. The origin and destination data have recognized from the quarters of Al-Najaf city and from other provinces. The second type of data is the average turnover which was about 1.05. The average turnover could be determined by dividing the number of vehicles occupying a space during the time of study. This could be achieved by recording the last four letters from the vehicle plate number to recognize the vehicle occupying the space at specific time. Each checking for the vehicles has been carried out in 30 minutes.

The total number of available spaces in all parks for employees are:
110 + 75 + 25 + 270 = 480 spaces.

According to the general information discussed above, it was found that the ratio between the spaces and the beds is one space for every bed, and one space for every 4.3 employees. It’s obvious that the number of spaces is higher than the standard as indicated in the literature (See Table 1).

The analysis of staying time as indicated in table 3 for on-street parking indicates that the percentages of vehicles parking for 30 minutes or less is 42%, 13% for one hour, 19% for 90 minutes and 26% for more than 120 minutes, respectively.

The analysis of average turnover for off-street parking indicates that the percentages of vehicles parking for 30 minutes or one hour are zero, 6% for 90 minutes and 9% for more than 120 minutes, respectively.

| Duration (min) | Percentage of staying time |
|---------------|---------------------------|
| 30            | 42                        |
| 60            | 13                        |
| 90            | 19                        |
| 120           | 26                        |

### Table 3. Duration of on-street parking.

#### 7.1 Current parking demand

For current demands of the parks, one could summarize the number of spaces for each park as the following:

- Park no.1= 110 vehicles for employees inside the hospital
- Park no.2= 50 vehicles for employees inside the hospital
- Park no.3= 25 vehicles for employees inside the hospital
- Park no.4=25 vehicles for employees inside the hospital
- Park no.5=275 vehicles for employees outside the hospital
- Park no.6= 220 vehicles for employees outside the hospital.
- Park no.7= 70 vehicles for visitors outside the hospital.
- Park no.8= 220 vehicles for visitors outside the hospital.

As mentioned before, Parks no.6 and no.8 are illegal parks and they may be removed any time of starting the train or tram lines planned in the future.

#### 7.2 Evaluation of the results

The evaluation of the number of parking spaces can be classified into two parts: firstly, for the employees, the evaluation just for the parking spaces in the hospital. The number of employees is 2075 in (2017) whereas; the number of spaces is 480. This represents the number of spaces for Parks no.1, 2, 3, 4 and 5 but Park no.6 has been excluded because it is illegal. According to the park specifications each 4 employees one space should be provided. So, it was found that the demand for parking in this hospital is 4.3 (2075/480) spaces.

Secondly, for the number spaces required according to the number beds, the evaluation shows that the demand for parking is about 650. This number comes from illegal off-street parking (Park no.8) and on-street parking (430 parking vehicles on both sides of main roads in front of the hospital). Consequently, significantly gap in the number of parking is about 842 spaces according to the specification of 2.2 spaces for each bed. However, these 650 parking spaces are illegal. So, there is no legal parking area for the beds.
Finally, the total number of required spaces is 1062. However, there is a park with (40x150) unit dimensions, which has been added close to the hospital, which may help meet the demand for parking by building multi-story park there.

7.3 The suggested solutions
Two types of suggestions will be discussed here; one has been devoted for geometric design and building new parks and the second for using smart parking technology.

According to the evaluation, the number of parking spaces required to satisfy the parking demand could be 1000 spaces if the average turnover is taken into account. Therefore, the best solution is to construct multi-storey park with five to six stories and in each story 160 spaces.

In addition to the above, there is on-street parking management. If this management will be applied, it will help more in flexibility of on-street parking and even could be a suitable taxi station. This suggested on-street parking could be summarized by providing multi-on-street parking, which is isolated from the hospital entrance by control in order not to affect the movement from the hospital to it (movement of ambulance or any emergence case). Moreover, it will increase the mobility of movement of vehicles especially, taxies.

To develop the proposal of building a multi-story, smart parking system is suggested to be added in every story in that park. In addition, the smartness also could be applied to the on-street parking for the area of on-street parking in front of the main gate of the hospital using different types of smart payment such as by card, mobile or internet. Moreover, another management by adding additional cost through such smart system for parking vehicles, which take long time in the on-street parking.

8. Conclusions and recommendations
1. The number of spaces for employees is less than the required number according to the specifications. One space is required for each 4 employees but in our case it was found the demand of parking is one space for each 4.3 employees, which is less than the specifications.
2. The number of required spaces is 2.2 for each bed as mentioned in the specifications. Whereas, in the current hospital, it is one space for each bed, which is less than the specifications. However, the available parking spaces for bed are illegal. So there is no off-parking spaces for beds.
3. This study also investigated that parking demand characteristics are similar to the ITE specifications in terms of number of beds and employees. Therefore, these specifications could be adopted to provide the necessary parking spaces for existing and proposed hospitals.
4. Illegal on-street parking is on both direction of the hospital road. This parking leads to bottleneck and even blocks the movement from and to the hospital, especially in emergency cases. The main conclusion in this case suggests for removal of on-street parking (on-street parking prohibited).
5. There is an urgent need to build new multi-story park within the new lot assigned for the employee in order to overcome the parking demand for both employees and visitors.

References
[1] Litman T 2016 Parking-Management-Strategies, Evaluation-and Planning by Victoria Transport Policy Institute
[2] ITE, Institute-of-Transportation-Engineering 2016 Traffic Engineering Handbook. 6th edition. USA
[3] Nyamse M 2008 Multi-story car parking Complex. UY OF Nigeria
[4] O’flaherty C A and Bell M and Bonsall P and Leake G and May A and Nash C 1997 Transport Planning and Traffic Engineering. Elsevier Publisher.
[5] Garber N and Hoel L 2009 Traffic Highway Engineering. 4th Edition, University of Virginia
[6] VTPI 2005 Transport Policy Institute Online TDM Encyclopedia, (www.vtpi.org) access 11-10 2017
[7] DAS A 2017 Private Hospitals’ Parking: Health Care’s Debated Contribution in Traffic Congestion of Dhaka City. *Proceedings of International Conference on Planning, Architecture and Civil Engineering*, 9 - 11 February, Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh

[8] Islam M and Chawdhury S 2014 Demand and Supply Analysis of parking in commercial Area: A Case Study Probortak More Area, Chittagong. *International Journal of Innovation and Scientific Research* Vol. 12 No. 1, pp 315-327

[9] Edwards R 2014 Preliminary Transport Assessment. Report No. Urbis- 146001g. Ministry of Health. City of Canterbury

[10] Housing and public works ministry, Government of the people’s republic of Bangladesh 1996 Building Construction Act. URL: http://www.rajukdhaka.gov.bd/rajuk/page/web/devcontrol/building_Act_1996.pdf (accessed on 7 November 2017).

[11] White S 2007 No-Vacancy:-Park-Slopes-Parking-Problem (http://www.transalt.org/news/releases/126)

[12] Aleqt 2017 (http://www.aleqt.com/2014/04/13/article_840886.html (access 1-9 2017).

[13] Alloush Q 2012 Analysis of Transportation and Traffic Conditions in Hilla City. Babel Center for Human Studies, Vol 2

[14] Mohamed A and Riad K 2005 Design and Planning Criteria for Parking Spaces in Commercial Areas in the Egyptian City, *Journal of Engineering Research in Shubra*

[15] Kadiyali R 1987 Traffic Engineering and Transportation Planning Khanna Publishers, New Delhi.

[16] Wikipedia 2017 (https://ar.wikipedia.org/wiki/) (Accessed 28 - 9 - 2017)