International Journal of Innovation, Creativity and Change. www.ijicc.net
Volume 15, Issue 3, 2021

Applying Waiting Queue Models to Solve Queue Problems During the Corona Pandemic in Khartoum State Hospitals (Al-Hikma Hospital as a Model)

Dr. Ahmed Osman Ibrahim Ahmed[1], Dr. Mohamednour Eltahir Ahmed Abdelgadir[2], [1,2]Associate Professor, Department of Business Administration, Imam Abdul Rahman bin Faisal University, Faculty of Applied Studies and Community Service

The research dealt with the application of waiting lines models in Al-Hikma Hospital in Khartoum State. The research problem lied in the phenomenon of queues in the hospital, which was exacerbated by the Corona pandemic, which necessitated hospitals to conduct more restrictions on auditors in order to avoid the risks arising from the possibility of transmission of the virus. The research aimed to solve the problem of waiting clients using queue models. The researcher adopted the observation method to collect data and information and also adopted the quantitative methods for Windows 2 to extract the findings. The most important findings of the research lied in that the waiting of patients in the circumstances of the new Corona virus has health consequences related to the nature of the virus and the way it spreads. This necessitated the application of other measures to prevent congestion and waiting. One of the findings was also that the waiting period for customers is long compared to known waiting standards despite the application of some rules such as the appointment system and restriction on a spatially attending hospitals for emergency cases only. The most important research recommendations were to increase the number of service providers, taking into account the cost component, conduct studies related to customer satisfaction, and constantly survey the work environment to avoid any shortcomings, increase competitiveness, and the need to observe known global protocols through follow-up and training.

Keywords: *Waiting Queue Models, Coronavirus Pandemic, Khartoum State Hospitals*

General framework of the research

Introduction

The health sector is considered one of the most important sectors in the service field due to its direct relationship with human health and life. This made facilities that provide health services in a state of constant challenge to provide health care services in accordance with international standards that satisfy the service applicant and to achieve adequate satisfaction. In order to achieve this goal, In order to achieve this goal, it was necessary for health facilities to search for best management practices that help achieve those standards related to customer satisfaction. That helps achieve those standards related to customer

Therefore, many decision-makers tended to use operations research methods, which are considered among the most important methods currently used to solve many of the problems facing managers and help them make their decisions with a high level of accuracy and rationality.

There are many methods of operations research, some of which are used to solve allocation problems, others are used to solve succession problems, and some are used to solve paths or substitution problems, and many other problems that are used to solve operations research methods.

One of the most important problems facing many hospitals in Khartoum State is the problem of queues and the overcrowding of patients. Operations research methods have found a solution to this problem by using waiting line models that address waiting problems for service seekers in various institutions, whether productive or service institutions. As the customer's satisfaction represents the goal that the institutions and companies seek to ensure that he continues to deal with the specific institution and does not deviate from it due to his long wait and boredom that leads him to search for another service provider to provide him with the service in a short time. All this prompted the researcher to pay attention to the various issues of operations research for its ability to solve many problems facing establishments of all kinds, in light of the lack of interest of managers in some countries of our Arab world in these important ways and methods.

Research problem:

The researcher noticed the size of overcrowding and waiting for service seekers at Al-Hikma Hospital in Khartoum State. The applicant may wait more than two hours to receive service and meet the doctor, and this period, by all criteria, is considered a very long period, especially in a health field. Thus, this leads to a delay in receiving service, which is clearly evident in the number of waiting service seekers, thus leading to their dissatisfaction, increasing their discontent, and the possibility of them searching for another party to provide them with service

in a shorter time. This may cause the hospital to lose its customers in favour of other hospitals that are able to better serve them. Also, this congestion in light of the Corona pandemic posed an additional challenge because it is known that overcrowding and not following the rules of social distancing lead to the possibility of infection.

All this led the researcher to try to answer the following question:

Does the use of waiting lines models provide alternatives to solutions that help the hospital director solve the queue problem in light of the Corona pandemic? From this main question, the following sub-questions emerged:

1. Does the use of queuing models solve the patient waiting problem in the hospital?
2. What is the used solution mechanism that leads to solving this problem?
3. Is there another mechanism that can be followed in light of the Corona pandemic?

Research importance:

The importance of the research lies in that it seeks to solve the patient waiting problem, which was exacerbated by following more rules in light of the Corona pandemic, which leads to their dissatisfaction and thus the possibility the hospital loses an estimated number of its current and potential clients in the future. In addition it deals with one of the important quantitative methods that address chronic problems facing us in our daily life, which is waiting to receive the various services provided to us.

Research aims:

The research aims to achieve the following:

1. Presenting a quantitative model that helps the hospital administration to solve the customer waiting problem, in light of the conditions that the health sector is going through locally and internationally as a result of the spread of the new Corona virus.
2. The possibility of generalising this form to similar cases in other institutions.
3. To draw the attention of decision makers to the possibility of solving the problems they face by relying on different quantitative methods and methods.

Research parameters:

The limitations of the research are represented in the researcher's assumption of one channel of service provision, knowing that there are six specialties that are served in the hospital, that is, there are six queues. What applies to one queue can apply to the sixth queue if the application of new rules represented in the application of examination and isolation procedures associated with the emerging corona virus are taken into account.

Spatial limits:
The spatial limitations of the research are, Al-Hikma Hospital in Khartoum State (Jabra area).

Temporal limits:
The time limits for research extended from 1/4/2020 - 1/6/2020

Previous studies:
The lack of Arab studies in the field of operations research is noticeable; the following are some studies and research:

• A research titled **"Application of waiting lines models to measure the quality of banking service (**Rijal, 2009). The researcher focused on the impact of quality on the performance of organisations by providing services that meet customer needs and achieve their satisfaction by measuring the quality of banking service." The study aimed to answer the following question: How can the quality of banking service be measured by adopting queue models, by focusing on the following basic axes: quality problem in banking service, queue models as a quantitative method for measuring quality, application of queue models to measure withdrawal and deposit service in a the local development agency "Jijel". The most important findings of the research were: The main reason for the problem of waiting and the length of time it takes by the client to obtain the service is due to the employee of the first stage of it. Among the findings, the work of the cashier is also characterised by the speed of its implementation of operations and the large number of mistakes committed by clients due to lack of awareness.

The most important recommendations of the research were: the need to work to reduce the lengthy administrative procedures related to the manual recording of data performed by the first-stage employee and to be satisfied with the registration on the computer, the management follow the motivational measures for the employees, encourage the distinguished employee, determine the dimensions of quality accurately and inform the employees of the bank.

• Research entitled **"Analysis of waiting lines for services using queues models and their role in making quality improvement decisions** (Serdouk, Al-Saeed and Abdul-Razzag, 2009). The researchers talked about the importance of providing services, which leads to customer satisfaction and thus increased competitiveness and survival." The system in which services are provided is considered one of the sensitive aspects related to their quality, and one of the most important components of this system is the service queue, which is dealt with through the theory of queues, as it is the distinguished scientific method for analysing waiting lines.

In this study, the researchers relied on the following: a conceptual framework for services, the concept of service quality, queuing models, and decisions to improve service quality. They concluded that the decision-maker in service institutions in light of competition seeks to have

the waiting line to receive service as short as possible and to the extent that it guarantees customer satisfaction in light of seeking a balance between the costs associated with providing good service to customers and the costs of waiting to receive this service in the manner that leads to reduced overall costs.

• A research entitled **The Queues theory and its role in addressing bottlenecks in the health service** (Al-Hilali, 1998). The researcher dealt with the phenomenon of overcrowding in hospitals and health service centres and reached the importance of using the theory of waiting lines to treat congestion in health service centres by explaining the optimal number of doctors and nurses to be provided to eliminate the suffocation phenomenon, and satisfy the auditors of health units.

The theoretical framework of research

Before discussing the waiting lines in terms of definition, origin, development and the most important areas of their use, we must clarify the precise relationship between quantitative analysis and administrative decision-making.

Several names have been given to this approach, which deals with quantitative approaches to decision-making, but in general there are two known and widely accepted approaches: (Al-Sayed, 2003, 3:11)
- (MS) Management Science
- (OR) Operation Research Entrance

Within the framework of this research, the researcher will limit himself to the operations research approach as it is the most common among the various writers. The first book on Operations Research was published in 1946 under the name (**Methods of Operations Research)** by Morris and Kemball- (Mandoura and Al Mansour, 2009, (31: 4).

1/2 Operations Research as a Quantitative Introduction to Administrative Decision Making: (Ali & Al Fadul, 1999 (23: 5)

The primary goal of operations research is to consider the decisions made in any facility, whether production or service decisions, as a specific solution to a specific problem. Through this system, quantitative methods and tools usually play their role in providing the data and digital indicators necessary for the decision-making process in order to reach the optimal solution. Operations research is the general framework that combines these methods and tools.

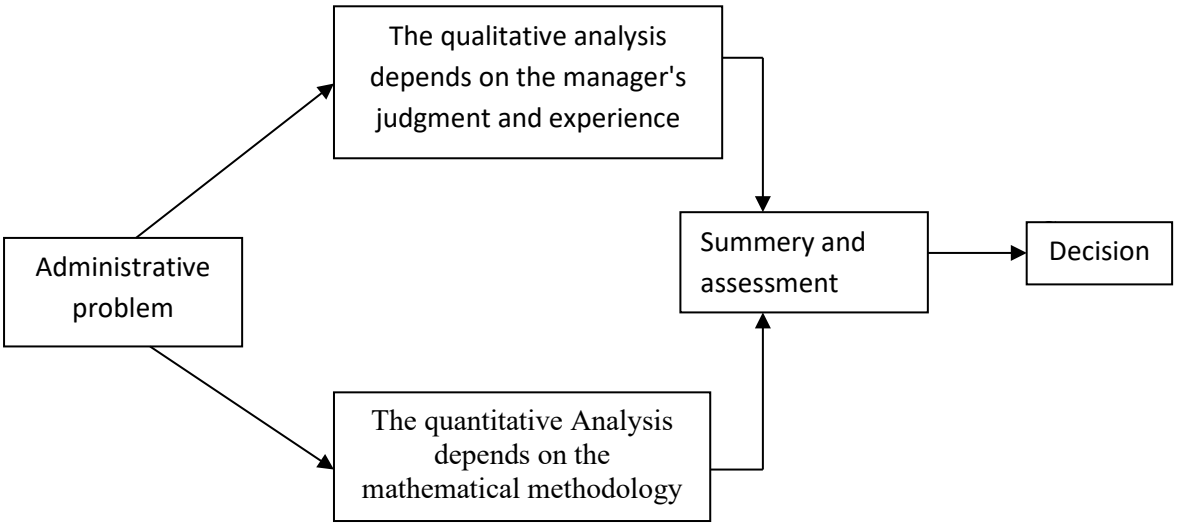
The usefulness of operations research as a quantitative input in practice is evident through the following matters (Ali and Al-Fadul 24: 5):

• It contributes to the process of bringing the problem closer to reality according to simple practical formulas and specific mathematical models that reflect the circumstances of the problem within the framework of organised and rational scientific thinking.
• Circulating standard and ideal criteria for decision-making, as the administration that is able to develop a specific mathematical model for a problem can apply this model in the future when it faces a similar problem.

Business establishments depend on two types of analysis: (Al-Sayed, 2003 (16: 3)
- Qualitative analysis
- Quantitative analysis

Where qualitative analysis depends on the judgment of the director and his personal experience, it can then be described as an art rather than a science. The roots of this approach go back to the old administrative schools that used trial and error method (Mousawi, 2009 (21: 6). If the manager has little experience or is not aware of the problem in question, then the manager in this case must rely on quantitative analysis and on the data and facts accompanying the problem in preparation for developing a mathematical expression to describe the goals, constraints and relationships involved in the problem. The following is a figure showing the relationship between decision-making and quantitative and qualitative analysis:

Figure (1/2). The relationship between decision-making and quantitative and descriptive analysis



Anderson, David R, Sweeney, Dennis j, A. Williams., Quantitative Methods For Business, Second Edition, U.S.A, West Publishing Co, 1983, P : 2

2/3 Different Definitions of Operations Research:

The Operations Research Society in the United Kingdom defined it as (the application of scientific methods to the complex problems that arise when directing and managing large systems of people, equipment, materials, and funds in the field of industry, commerce, government, and defence. The distinctive approach is to prepare a scientific model of the system that includes a measure of factors. According to this model, the returns of the various alternative decisions and strategies can be predicted and compared with the aim of assisting the administration in determining its policy and procedures in a scientific manner 9Herman, 1969 (2: 4)).

As for Dantzing, he defined it as management science, meaning the science of making and implementing decisions (Herman, 1969 (2: 107)).

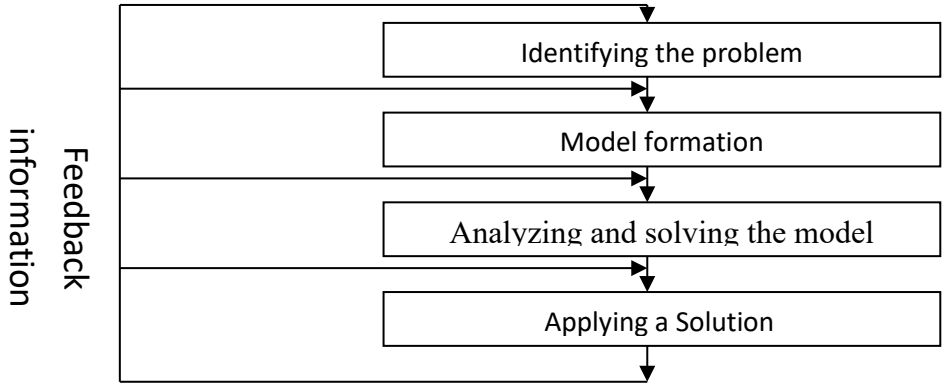
Wagner defined it as "the science approach used to solve problems encountered by top management (Herman, 1969 (2: 4)).

The researcher reached the following definition of operations research through the previous definitions: It is the science that uses quantitative and digital means and mathematical models to reach the optimal decision that helps the organisation to solve problems and confront environmental variables in light of the available human and material resources.

2/4 General Steps to Operations Research Methods: Herman, 1969 (2:13)

Despite the multiplicity of tools and methods used in operations research applications, they all agree on the main elements that make up the common general set of steps for operations research methods. The following figure shows these steps:

Figure (2/2). General steps of operations research methods



Source: Farid Abd Alfatah zain Alabdeen:"Resources of operations and their application in problems resolution and decision making" Vol.1, Cairo, 1997, p.13-In Arabic

In the previous section, we dealt with the methods of operations research, and below we will deal with the queue models in some detail.

Waiting Queue Models:

The queues theory addresses the problems faced by different service systems, the most important of which is determining the number of service providers (servers) and the number of service centres (service lines) in order to reduce the percentage of customers who leave service centres due to congestion (the large number of service seekers). It is natural that the average service time decreases with the increase in the number of service providers (Mandura and Mansour (4: 527)). But here the cost component overlaps, so the increase in the number of service providers leads to an increase in the operating costs of the facility and the small number of its providers, which results in customer dissatisfaction from the length of waiting and here it is necessary for the facility management to search for the optimal balance that achieves what it seeks. This is what is trying to address the theory and models of waiting lines, while at the same time ensuring customer satisfaction.

The Emergence and Beginning of Queues: Rander, 2006 (3: 569)

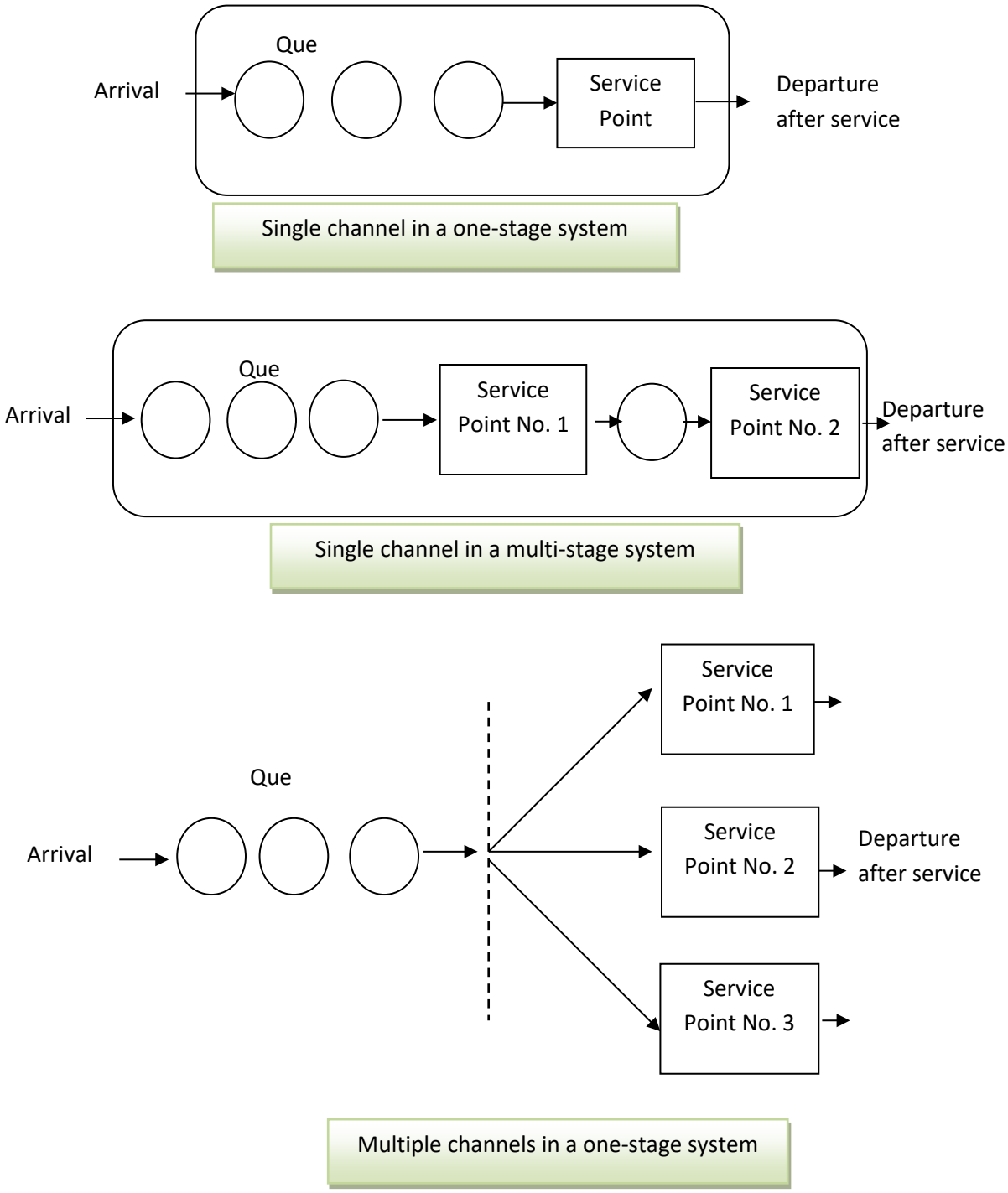
The pioneer of this theory is the scientist A.K. Erlang (1959), an engineer who worked in the field of telephone line movement and was working on trying to reduce the waiting time for telephone calls. After the end of World War II, his interest in solving these problems shifted at the level of business organisations. Waiting lines can be defined as the accumulation of individuals or machines in a waiting state in order to be provided with a specific service (Jalal, 1993 (180: 2)).

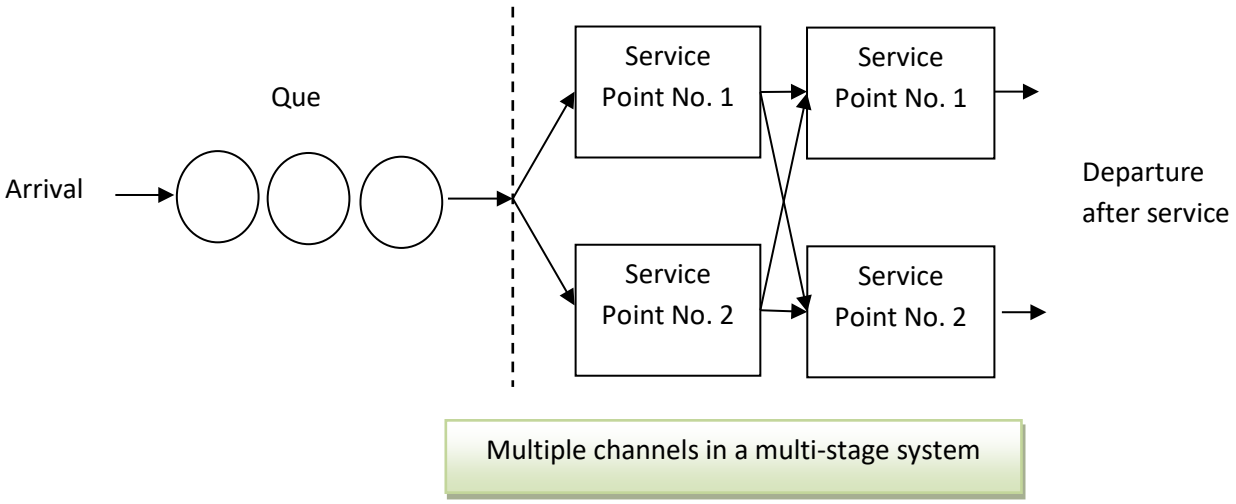
Table (1/2). Examples of waiting lines

Site	Inputs	Outputs
Bank	Arrival of clients	Clients " Service
Blood Bank	Arrival of blood givers	Blood received by ill people
Basin of ships repair	Ships back from the sea, and sent to repair	Ships repaired and sent back to sea

Source: Waynel. Winstom, Operation research: Application and Algorithms, 4th, Canada, Thomson Learning, 2004, p1052

Figure 2/3. Four models of queue system





Source: Anderson, David R, Sweeney, Dennis j, A. Williams., Quantitative Methods For Business, Second Edition, U.S.A, West Publishing Co, 1983, P : 2

Steps of queuing analysis: (Ahmad, 2017 (220: 1)

1. The system under study should be viewed as a queue system.
2. An appropriate queuing system must be chosen to represent this studied system.
3. Use mathematical equations or simulations to analyse the queuing system.

Queuing system components:

1. **Distribution of access**: It means how the service seekers reach the point where that service is provided. Access may be at a fixed rate and it may be random, meaning that the rate of arrival varies from time to time. There are two ways to express the rate of arrival, it may be the number of units that arrive and join the system per unit of time and may be expressed as the time that elapses between two consecutive hyphens.

2. Service distribution: This means the manner in which the service is provided, whether the service is provided consistently or randomly. The service rate is expressed in two ways: it may be in the form of the number of units for which the service is provided per unit time, and it may be in the form of the required time to provide service to a customer.

3. The method of providing the service: This may be that the one who arrives first is the one to whom the service is provided first, and the customer who arrives may be the one to whom the service is provided first. There is another system called precedence where the service is provided to those seeking it according to their urgent need for it, as happens in hospitals in critical cases.

4. Service Provision Centre: It depends on the number of service providers in the system, as there may be one service provider and there may be more than one service provider.

5. Number of service seekers: The number of service seekers varies, as their number may be limited, and their number may be infinite.

6. System energy: It is defined as the largest number of units the system allows to enter, and this number may be limited and may not be final.

7. Other features of the queuing system: Some customers may reach the queue but not join it because there is a large number of people waiting for service the moment they arrive. The second feature is that some customers may join the queue for a certain period and then leave it before they get the service they were waiting for. And the third feature is that some customers may join a certain queue and then leave it to join another queue in which the same service is provided because it is less in number than the first queue they were in.

Mathematical models used in addition to the most important mathematical symbols:
(n): The number of units in the system (in queue + for which the service is provided).
(pη): the probability of having (n) units in the system in equilibrium.
(λ): The average number of units that arrive and join the queue in one time unit.
(μ): The average number of units that are served per unit of time by one service provider.
(L): The expected number of units in the system.
(Lq): Expected number of units in queue.
(ω): The time expected to be spent by one unit in the system.
(ωg): The time one unit is expected to spend in line.
(e): [usage factor] The probability that the service provider is busy.

The following are examples of how to handle queue problems:

1. **Average number of clients per Queue:** $$Lq = \frac{\lambda^2}{\mu(\mu-\lambda)}$$
2. **Average number of clients per system** $$L = \frac{\lambda}{\mu-\lambda}$$
3. **Average number of clients per system** $$Wg = \frac{\lambda}{\mu(\mu-\lambda)}$$
4. **Average number of clients per system** $$W = \frac{1}{\mu-\lambda}$$

Queue Models:
There are a number of models of waiting lines in which some mathematical formulas can be derived using the birth and death processes of the row, and these models include the following:

One-channel case model for service provision:
This model assumes that there is one channel or one person who provides the service to the units that request the service. This model is referred to by the expression $\mu/\mu/1$ and the components of this model are the following (Kaabour, 1992 (258: 8)):
1. System power is infinite.
2. The number of service seekers is not final.
3. The arrival distribution follows the Poisson distribution, with a rate of capacity per unit time.
4. The service distribution follows an exponential distribution with a rate of amount per λ Unit time.
5. The access rate is less than the service rate, that is $(\lambda \angle \mu)$
6. The method of providing the service is: For the one who comes first, the service is provided to him first.
7. There is only one channel to provide the service.

A one-channel case model with the knowledge that the length of the queue is limited: This applies to the case of Al-Hikma Hospital (Ahmed, 2017 (236: 1)).

1. The number of service seekers is known.
2. System capacity is limited.
3. The access distribution follows the Poisson distribution.
4. The service distribution follows an exponential distribution with a rate of μ amount per unit time.
5. The method of providing the service is: For the one who comes first, the service is provided to him first.
6. There is only one channel to provide the service.

Field study
Before going into the details of the field study, it is necessary to indicate the methodology that the researcher followed, the tools used to collect information and data, and how the study sample was chosen

Research Methodology:
The research is based on the application of operations research methods, specifically relying on queue models, assuming that the customer's access to service follows the Poisson distribution and the service time follows the exponential distribution.

Research tools:
The research relied on the observation method to collect data and field information that will be used to solve the research problem, as data on the rate of arrival of service seekers and their waiting times were collected by the researcher recording those times. The program Quantitative Methods for Windows 2 (QM) was used by the computer to extract the search findings.

Research community:
Represented by individuals who deal and attend Al-Hikma Hospital in Khartoum State

The research sample:
It was represented by the individuals who deal with Al-Hikma Hospital in Khartoum State who are waiting to receive service during the period from 1/4 - 1/6/2020. Their average number per day, divided by their arrival periods, reached 125 individuals. The average arrival rate was 24 individuals per hour, and the hours of observation for taking the sample for the researcher per day were 6 hours.

It has been noted that the model that applies to Al-Hikma Hospital is the one-channel model with the knowledge that the length of the queue is limited to providing the service and thus the previous requirements apply to it. Taking into consideration the health conditions that have made some health facilities overcrowded compared to others, especially in light of the closure of most health facilities in the private sector in Khartoum State, which has put great pressure on government health facilities operating in Khartoum State.

Through the method of observation that the researcher worked to obtain information, and over the time period specified for the research from nine in the morning until eight in the evening with deduction of midday hours for a period of 90 days (working days from Saturday to Thursday), it was found that the pattern of clients' arrival to receive the service was as follows:

• Customer arrival rate (by calculating the average arrival time during working hours and for the specified search period = approximately 24 clients / hour.
• The average time to provide the service to the customer = approximately 30 minutes.

Research Findings:
Using the program Quantitative Methods for Windows 2 - for short (QM), as shown in Tables (3/1), (3/2) and (3/3), the following findings were reached:

Table (3/1) the Single Channel System

Indicator	Value	Indicator	Value	minutes
System of single channel		Average of employment of service giver	80%	
Arrival average (Lamda)	24	Average of clients in queue	28	
Service Average(mu)	30	Average of clients in system	29	
No._of service providers	1	Average of time spent by client in queue	0.093	56
		Average of time spent by client in system	0.97	58

Source: Prepared by the researcher ,using QM

Knowing that the first table represents the actual reality in Al-Hikma Hospital, when analysing table (3/1), we note that:

1. The average usage of the service provider is 80%

2. Average number of patients in grade 28

3. The average number of patients in the system is 29

4. The average time a patient spends in queue is 56 minutes.

5. The average time a patient spends in the system is 58 minutes.

6. The probability of having 26 patients in the system is 96%.

7. The probability of having 28 patients in the system is 64%.

When discussing the findings reached, we note that the efficiency or occupancy rate of the service provider is 80%, which is a high percentage indicating the high occupancy of the hospital and the high demand of patients to receive treatment. It is also noted that the average presence of patients in the queue room or in the system is high, as it ranges between (28-29) patients. This was directly reflected on the time the client spends in the queue or system, where the periods ranged between (56-58) minutes, which is a very long waiting period compared to all criteria, especially for a patient seeking treatment, which leads to dissatisfaction with the recipient of the service and the possibility of him leaving without receiving the service he seeks or searching for another place that can serve him more quickly.
There is another result related to the rate of use of the service provider, which is the probability of having customers in the system, as the research showed that the probability of having 26 patients in the system (96%) is a high percentage that reflects the urgent need to solve the problem of long waiting times for patients.

Table (3/2) Single Channel System and Service Providers 2

Indicator	Value	Indicator	Value	Minutes
Single channel system		average service provider usage	40%	
Access rate (Lamda)	24	Average number of clients in queue	26	
Service rate (mu) Service rate (mu)	30	the average number of customers in the system the average number of customers in the system	28	
Number of service providers	2	the average time a client spends in queue	0.43	26
		Average time a customer spends in the system	0.46	28

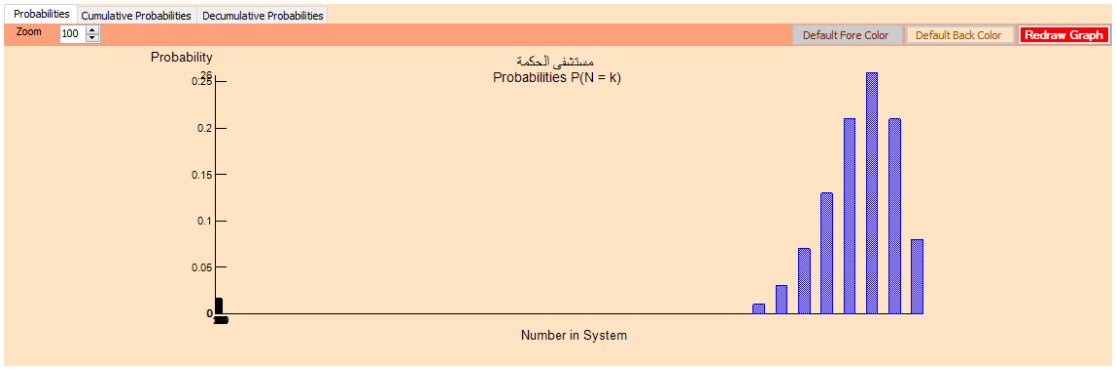
Source: Prepared by the researcher, using QM

The researcher tested the hypothesis of the existence of 2 service providers in Table (3/2). Below are the results of the analysis for this hypothesis

1. The average usage of a service provider is 40%.
2. Average number of patients in a queue 26.
3. The average number of patients in the system is 28.
4. The average time a patient spends in queue is 26 minutes.
5. The average time a patient spends in the system is 28 minutes.
6. The probability of having 23 patients in the system is 99%.
7. The probability of having 26 patients in the system is 76%.

When discussing the findings reached, we notice that the efficiency or occupancy rate of the service provider decreased to 40%, and this percentage indicates the great impact that occurred as a result of adding another service provider. It is also noted that the average presence of patients in the queue or in the system is still high, as their number ranged between 26-28 patients. The difference appears in the average waiting time, it decreased to 26-28, which is a big difference compared to the previous result. Below is a figure showing the possibility of patients in the system.

Figure (3/1) the possibility of having patients in the system



Below, the researcher made another hypothesis represented in the presence of 3 service providers, and the difference is evident in Table (3/3)

Table (3/3) Single Channel System and Service Providers 3

Indicator	Value	Indicator	Value	Minutes
Single Channel System		Average Service	27%	
Reach Rate (Lamda)	24	Average number of clients in queue	23	
Service rate (mu)	30	The average number of customers in the system	**26**	
Number of Service Providers	3	The average time a customer spends in queue	0.27	16
		Average time a customer spends on the system	0.3	18

Source: Researcher preparation using QM

1. The average usage of a service provider is 27%
2. Average number of patients in the waiting line 23.
3. The average number of patients in the system is 26.
4. The average time a patient spends in queue is 16 minutes.
5. The average time a patient spends in the system is 18 minutes.
6. The probability of having 21 patients in the system is 99%.
7. The probability of having 27 patients in the system is 28%.

When discussing the findings reached, we note that the efficiency or occupancy rate of the service provider decreased to 27%, and this percentage indicates the great impact that occurred as a result of adding another service provider. It is also noticed that the average presence of patients in the queue or in the system decreased to 26-28 patients, but the difference appears in

the average waiting time, it decreased to 16-18, which is a big difference compared to the previous result.

However, these assumptions of adding another service provider are offset by another component, which is the cost component. Although looking at costs in the field of health care has a concept that differs from that found in profit-seeking institutions, but it still represents a hindrance in light of the limited resources of hospitals that depend on the state budget and those directed to health in particular and the difficulty of providing sufficient budgets to provide a large number of doctors. Therefore, it is necessary to search for a state of balance between expected returns and expenditures.

It is also known that waiting for patients in light of the emerging corona virus has health consequences related to the nature of the virus and the way it spreads, which has necessitated the application of other measures to prevent congestion and waiting, and the most important of these rules that have been followed:

1. Dealing with emergency cases in the hospital only.

2. Non-emergency cases were dealt with by providing medical consultations over the phone. (This method was used on voluntary initiatives by some doctors after noticing the size of the overcrowding and the lack of doctors in hospitals to meet the needs of patients)

3. The research team noticed that most hospitals, especially in the private sector, are closed, which poses a great challenge to the health sector in Khartoum State, especially if we know that it includes about a third of the population of Sudan (about 10 million people) and in light of the low capabilities that resulted from the complete closure that the world witnessed.

Recommendations:

1. The use of global health rules that were circulated by the competent authorities, which clarify the nature of cases and the numbers that health facilities can receive in light of the Corona pandemic.

2. The need for increased attention from the hospital administration to the clients 'problems represented in the long wait, which may negatively affect their degree of satisfaction.

3. Using other methods to organise patients' attendance at the hospital, such as serving appointments by phone, or using some applications that help in organising this.

4. Conducting studies related to customer satisfaction to avoid the possibility of clients leaving the hospital and losing current and potential clients of the hospital.

5. Increase the number of service providers by increasing the number of channels to become two channels at least, which leads to reducing waiting times for customers. This is explained by the second result that was reached on the assumption that there are two service providers instead of one service provider, as is the case now.

6. Using quantitative methods in studying the optimal number of doctors and nurses who provide service to clients by studying the cost component to reach a state of balance between the number of service seekers and service providers.

7. Increasing customer interest by constantly surveying their opinions and listening to their suggestions. Providing the services that the client needs contributes to increasing the degree of satisfaction and thus ensures the continuation of his dealings with the hospital.

8. Permanent survey of the hospital work environment to notice deficiencies and work to avoid them in order to increase competitiveness and competitiveness.

9. Attention to educating patients about the risks that may occur as a result of frequenting the hospital without taking the necessary precautions to deal with the emerging corona virus.

10. Through the presence of the observers to record the arrival rates, they noticed the dissatisfaction of many individuals who visited the hospital constantly due to the fact that it serves a specific geographical area. The most important points on which their dissatisfaction focused on were:

- The hospital does not have enough waiting places to accommodate all the expected number.
- Doctors are sometimes late, which leads to overcrowding.
-Dissatisfaction with the level of ventilation in the available seating areas.

Future studies:

1. A study on the effect of the cost component on the number of service providers in Khartoum State Hospitals.

2. A study using the allocation method to determine the optimal number of service providers that would be compatible with service seekers.

References

Arabic references:

1. أحمد عثمان إبراهيم, مقدمة في بحوث العمليات: مدخل اتخاذ القرارات الإدارية, الدمام, المتنبئ للنشر والتوزيع, 2017م.
2. أحمد فهمي جلال, مقدمة في بحوث العمليات والعلوم الإدارية, القاهرة, دار الفكر العربي, 1993م.
3. إسماعيل السيد و جلال العبد, الأساليب الكمية في الإدارة, القاهرة, الدار الجامعية, 2003م.
4. سعود محمد مندورة وكاسر نصر المنصور, بحوث العمليات واتخاذ القرارات الإدارية(مفاهيم وطرائق كمية), السعودية, الخوارزم للنشر والتوزيع, 2009م.
5. علي حسين علي ومؤيد عبد الحسين الفضل ونجاح باقر إبراهيم, بحوث العمليات وتطبيقاتها في وظائف المنشأة, عمان, مؤسسة الأقصى للخدمات الجامعية, 1999م.
6. منعم زمزير الموسوي, بحوث العمليات مدخل علمي لاتخاذ القرارات, عمان, دار وائل للنشر والتوزيع, 2009م.
7. محمد أحمد الطراونة وسليمان خالد عبيدات, مقدمة في بحوث العمليات, ط1, الأردن, دار الميسرة للنشر والتوزيع, 2008م.
8. محمد محمد كعبور ، أساسيات بحوث العمليات: نماذج وتطبيقات، ليبيا, منشورات كلية المحاسبة – غريان، 1992م
9. فريد عبد الفتاح زين العابدين, بحوث العمليات وتطبيقاتها في حل المشكلات واتخاذ القرارات, ج1, القاهرة, 1997م

Foreign references:

1. Anderson, David R, Sweeney, Dennis j, A. Williams., Quantitative Methods For Business, Second Edition, U.S.A, West Publishing Co, 1983
2. Herman, c.c., and Magee, F., operations Research, London, The New English Library LTD, 1969
3. Barry Rander,Ralph M.Stair Jr, Michael E Hanna , Quantitative analysis for mangement, 9th ed, USA, Pearson Prentice Hall, 2006
4. Waynel. Winstom, Operation research: Application and Algorithms, 4th, Canada, Thomson Learning, 2004

Research published in forums:

1. السعدي رجال, تطبيق نماذج صفوف الانتظار لقياس جودة الخدمة البنكية, الملتقى الوطني السادس حول الأساليب الكمية ودورها في اتخاذ القرارات الإدارية, جامعة سكيكدة, الجزائر, 27-28 مارس 2009م
2. فاتح سردوك وحواس عبد الرزاق وبوشول السعيد, تحليل طوابير انتظار الخدمات باستخدام نماذج صفوف الانتظار ودورها في اتخاذ قرارات تحسين الجودة, الملتقى الدولي: صنع القرار في المؤسسة الاقتصادية, جامعة محمد بو ضياف, الجزائر, إبريل 2009م