TESTING THE PATIENT APPOINTMENTS QUEUING MODEL BY USING COMPUTER SIMULATION: A CASE STUDY OF IRINGA REFERRAL HOSPITAL

By

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CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by the University of Dodoma the dissertation entitled "**TESTING THE PATIENT APPOINTMENTS QUEUING MODEL BY USING ARENA COMPUTER SIMULATION**" in partial fulfillment of the requirements for the award of degree of Master of Science in Information Technology at the University of Dodoma.

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Date: ……

DECLARATION
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I, **Yuda Mnyawami**, declare that this dissertation is my own original work and that it has not been presented and will not be presented to any other university for a similar or any other degree award.

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DEDICATION

This work is dedicated to my late father, Mr. Noah Mlyafitaule Mnyawami and my mother, Ms. Meleziana Mussa Kitwange for inculcating in me a great desire to better the conditions of mankind.

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ABSTRACT

This study tests the patient appointments waiting time by using computer simulation which was carried out at the Iringa Referral Hospital (IRH). The study is triggered by the fact that in most Tanzania public hospitals like IRH, patients queue for a long time to get services. Basically, such situation leads to poor quality of service that leaves many patients unsatisfied. The study analyzed four experiments and critically evaluated appointments queuing model. Three models used to formulate and test the patient appointments queuing model. The model tested the waiting time and number of the patients to be attended as in experiment I, II, III and IV for one, two, three and four doctors respectively. The study examined the contributions and applications of queuing theory in the field of healthcare. The study summarizes a queuing theory results in the following areas: waiting time, utilization analysis, appointment systems and number of patients attended for each experiment. The system employed by Arena computer simulation to analyze proposals for improvement and optimization. The goal is to provide sufficient information to analysts who are interested in using queuing theory to model a healthcare process and want to locate the details of relevant models. Thus, this appointments queuing model is useful for the Tanzanian hospitals to arrange schedules with patients for the various services and research area of hospital simulations and modelling.

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LIST OF ABBREVIATIONS AND ACRONYMS

CIVE	College of Informatics and Virtual Education
CS	Computer Science
ED	Emergency Department
ER	Emergency Room
ERP	Enterprise Resource Planning
ICU	Intensive Care Unit
IT	Information Technology
IRH	Iringa Referral Hospital
MD	Doctor of Medicine
MSc	Master of Science
OPD	Out-Patient Department
TE	Telecommunication Engineering
UDOM	University of Dodoma
U.S.A	United States of America

CHAPTER ONE

INTRODUCTION

1.1 Background

Many hospitals in Tanzania have a common problem of long waiting time for patients which leads to patients' dissatisfaction (Muhondwa *et al*., 2008). The Iringa Referral Hospital (IRH), for example, uses the traditional way to queue the patients. When patients arrive at the service area at IRH, they queue in the waiting lines for the services but unfortunately, they wait for nothing to happen or waiting for too long time to get the required service. Due to large number of patients, several hospitals are confronted with long waiting times, delays, and queues of patients. Waiting idly in the waiting room is not a productive situation where patients can spend their time to do other useful activities that might benefit them rather than sitting for nothing.

However, appointments have been used to manage services to the service providers by hospitals to schedule the patients' appointments. Patients arrive at the hospital by appointment to be attended by the doctors or nurses. This appointment system has been used in Nigeria. According to Aliyu *et al*. (2015) appointment system in Nigeria was tested and it showed that the working hours to attend patients are seven hours but doctors working hours were only five hours. The model used one doctor and thirty three (33) patients. The average waiting time for the patient in the simulation was 2.16 hours.

The Iringa Referral Hospital provides services to the patients who seek hospital services not only Iringa region but also other regions around. Sometimes patients come from far away from the hospital to seek the hospital services. Once the patients get to

the hospital, they have to stay in the waiting lines which may be very long. Therefore, this study tested the computer simulation by using Arena model which demonstrated different testing at IRH. General and specific details for the model are provided below.

1.2 Simulation

Anderson et *et al*. (2001) define simulation as a method of learning about a real system by experimenting with a model that represents the system. Render *et al*. (2006) argued that simulation involves trying to duplicate the features, appearance and characteristics of a real system. Simulation involves modeling processes. These models enable analysts to study how a system reacts to conditions that are not easily or safely applied in a real world situation and how the working of an entire system can be altered by changing individual parts of a mathematical/logical model of a physical system that portrays condition changes at precise points in simulated time.

Models are not universally valid, but are designed for specific purposes (Law *et al*., 1991). Identifying a suitable queuing model for a particular waiting line is a very difficult task because of the stochastic nature of arrival times and service rates. Different researchers studying different queue systems (e.g. Jun *et al*., 1999; Fenghueih *et al*., 1996) have come up with different models that best fit the situation being studied. This study intends to test a patient appointment system by using Arena computer simulation that can effectively be used to reduce waiting time at the Iringa Referral Hospital.

1.4 Queue Simulation Modeling Reports

Jun *et al*. (1999) declared an extensive review of papers on the application of simulation in health care. They observed that reported work includes models examining patient routing and flows, scheduling of resources and staff sizing all of which are important issues to incorporate in a simulation models.

Fenghueih *et al*. (1996) contemplated out a case study in the utilization of doctors and staff in the outpatients department, the time spent in the hospital by the outpatient and the length of outpatient queue in a hospital at Chia-yi in Taiwan using simulation technique. They developed a model that recommended that extra sessions be added in the afternoons. The results showed that, as the number of patients increased, the queue length was reduced considerably and the patient's average time was reduced by up to 18 minutes.

Limor *et al.* (1996) demonstrated a study in a government outpatient clinic in Hong Kong. The method used in the study included a site appraisal and a time and motion study. The study focused on, first for achieving an understanding of the system under study and the process taking place, and then followed by obtaining the data necessary to the simulation. Using computer simulation modeling, the existing system was modeled and possible alternative management policies were tested on the model. They demonstrated how choices can be tested by the model and have only the preferred solution implemented. The time and motion study measured the time involved in the movement of patients through the clinic. The study showed that the average waiting time for patients in the queues was 75 minutes and 2.3 minutes for consultation. The effect of implementing an officially allocated value of 3.3 minutes per consultation was demonstrated and model showed that under these conditions, not only were the queues

forming long, but also that doctors would not be able to complete their assigned workload within the scheduled time. The distribution of waiting times in the model proved to be similar to that observed in the clinic.

1.5 Use of Arena

Nowadays, simulation studies are widely used for applications in the engineering industry as a tool to increase the capacity of manufacturing and thus the profit of a company. Simulation studies are widely used in manufacturing, material handling, delivery, business processes, and transportation. Na *et al.* (2009) contended that simulation techniques are widely used in the analysis of port and terminal planning processes and container handling system. Simulation studies helps to understand the details of the processes and graphical modeling tools and animations in Arena (Seila *et al*., 2003).

1.6 Statement of the Problem

Testing for patients waiting time by using Arena computer simulation have not been used in Tanzania public hospitals. Iringa Referral Hospital (IRH) experiences patient queues which cause patients to stay in queues for a long time. If the testing is not performed in computer simulation, the problem will remain the same without having scientific reason. Patient queues are amenable to simulations which might show how to reduce the existing problem by minimizing the patients waiting time and maximizing the doctors or nurses utilization. Patients arrive at hospital at random times without appointments and waiting for a particular service. A patient might stay in a queue without knowing whether a particular service will be provided because some nurses or doctors may have been assigned to other activities elsewhere.

The queuing system in hospitals causes patient frustration because patient expects that will be served at a time. This study demonstrated on how the patients were tested in simulation by using four doctors.

Waiting time in outpatient departments has become a long time complaint of patients especially in high population society. Patients are unsatisfied with length of waiting time in the outpatient department. Many outpatient departments throughout the world have long waiting times for treatment followed by short consultations which is the major complaint of patients. Several researches have been carried out to reduce cost and improve the efficiency in outpatient services. Most researchers have concluded that the major reason for long waiting time is poor scheduling system put in place. Outpatient departments scheduling is considered as one of important factors that bring efficiency to the health care sector, with the aim of providing an excellent service to reach patients satisfactions and use the available resources effectively (Aliyu *et al*., 2015).

Unfortunately, wait times for patients are likely to increase in the future. Along with improved medical and healthcare science and possibly healthier lifestyles the proportion of elderly in the population continuously increases. The expectations on healthcare delivery are increasing with enhanced medical care, improved diagnosis techniques and efficiency of treatments. This evidently conveys a general increased demand for healthcare and tends to raise healthcare costs. Consequently the importance of resource planning and efficiency analysis to assist healthcare decision makers to control cost development has increased simultaneously (Imahsunu, n.d.).

Longer waiting for the patients has led the global economic crisis which has a significant impact on hospital resource provision worldwide. The management of limited hospital resources is further challenged by the high level of uncertainty in

demand, which can lead to unbalanced utilization of the available resources and a potential deterioration of patient satisfaction in terms of longer waiting times and perceived reduced quality of services (Abo-hamad, 2013).

This study is, therefore, expected to confirm that the waiting time of patients would be decreased at the Iringa Referral Hospital if data will be generated by using Arena computer simulation will show the time spent by patient to get service. If patients are assigned specific time to see a doctor or a nurse then they will do other activities while waiting for the assigned time.

1.7 Objectives of the Study

1.7.1 General Objective

This study aims at testing viability of the appointment queuing model for the Iringa Referral Hospital (IRH) by using Arena computer simulation.

1.7.2 Specific Objectives

i. To formulate a patient appointment queuing model at Iringa Referral Hospital.
ii. To test the impact of simulation model at Iringa Referral Hospital.
iii. To analyze the appointment system potential impacts the best way to reduce/waiting time for patients to be attended.

1.8 Research Questions

i. Which variables are required in the formulation of a patient appointment queuing model?
ii. What will be the impacts if the simulation is carried for 8 hours at the IRH?
iii. What is the performance level of the model in elucidating how much time is spent by patient?

1.9 Scope of the Study

For several years computer simulation has enabled healthcare system to analyze their services. This study proposes to use computer simulation to analyze patient wait time at a specific Arena computer simulation. It is essentially focused on the appointment scheduling system of hospital operations by using computer simulation. This study, therefore, looks into the appointment scheduling of the IRH; how the system operates, the relevance of the system to the environment, and problems and prospects of the hospital/healthcare industry.

1.10 Significance of the Study

The study should be significant in the following ways: Firstly, it will guide hospital management in formulating policies that will result in enhanced patient service. Secondly, it will serve as a basis for further research on the beneficial use of simulation in other sectors of the economy. Thirdly, it will add to the already existing knowledge on the use of simulation in business.

1.11 Definition of Key Terms

Discharge - Tell (someone) officially that they can or must leave a particular service area (generally because their needs there have been met as well as they can be).

Admission - The process or fact of entering or being allowed to enter a place or organization.

Intensive Care Unit (ICU) – The unit in the hospital where seriously ill patients are cared for by specially trained staff.

Simulation - The computer generated imitation of the operation of a real-world process or system over time.

Emergency medical services/**Ambulance services**/**Paramedic Services** - Types of emergency service dedicated to providing out-of-hospital acute medical care, transport to definitive care, and other medical transport to patients with illnesses and injuries which prevent the patients from transporting themselves.

Inpatient - A patient who lives in hospital while under treatment.

Outpatient - A patient who receives medical treatment without being admitted to a hospital.

Staffed Beds - Beds that are licensed and physically available for which staff is on hand to attend to the patient who occupies the bed. Staffed beds include those that are occupied and those that are vacant.

Emergency Department (**ED**)/**Emergency room** (**ER**)/C**asualty department** – A medical treatment facility specializing in emergency medicine, the acute care of patients who present without prior appointment; either by their own means or by that of an ambulance.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Several organizations such as banks, airlines, telecommunications companies, and police departments, routinely use queuing models to help determine capacity levels needed to respond to experienced demands in a timely fashion. Long waiting time in any hospital is considered as an indicator of poor quality of service and it needs improvement. Managing waiting lines creates a great dilemma for managers seeking to improve the return on investment of their operations. Customers also dislike waiting for a long time. If the waiting time and service time is high customers may leave the queue prematurely and this in turn results in customer dissatisfaction. Customer dissatisfaction reduces customer demand and eventually revenue and profit (Biju *et al*., 2011). Though queuing analysis has been used in hospitals and other healthcare settings, its use in this sector is not widespread. With rapid change and realignment of healthcare system, new lines of services and facilities to render the same, severe financial pressure on the healthcare organizations, and extensive use of expanded managerial skills in healthcare setting, use of queuing models has become quite prevalent in it.

Using simulation to analyze health care queuing systems can be traced back to 1960s. It has received continuous attention from both simulation and health-care research communities. For example, Rising *et al*. (1973) addressed patient scheduling issues to improve patient throughput time and reduce clinic overtime. This chapter covers various studies that have been carried out to simulate queuing systems in hospitals.

2.2 Queuing Theory

Sundarapandian. (2009) define queuing theory as the mathematical study of waiting lines, or queues. In queuing theory, a model is constructed so that queue lengths and waiting time can be predicted.

The organizations that care for persons who are ill and injured vary widely in scope and scale, from specialized outpatient clinics to large, urban hospitals to regional healthcare systems. Despite these differences, one can view the healthcare processes that these organizations provide as queuing systems in which patients arrive, wait for service, obtain service, and then depart. The healthcare processes also vary in complexity and scope, but they all consist of a set of activities and procedures (both medical and non-medical) that the patient must undergo in order to receive the needed treatment. The resources (or servers) in these queuing systems are the trained personnel and specialized equipment that these activities and procedures require (Samuel *et al*., 2007).

2.3 Waiting Lines

Literature on queuing indicates that waiting in line or queues causes inconvenience that can be quantified as economic costs to individuals and organizations. Hospitals, airline companies, banks, manufacturing firms try to minimize the total waiting cost and the cost of providing service to their customers. Therefore, speed of service is increasingly becoming a very important competitive parameter (Katz *et al*., 1991).

Davis *et al*. (2003) asserted that providing ever-faster service, with the ultimate goal of having zero customer waiting time, has recently received managerial attention for several reasons. First, in the more highly developed countries, where standards of living are high, time itself becomes more valuable as a commodity and consequently,

customers are less willing to wait for service. Second, there is a growing realization by organizations that the way they treat their customers today significantly impact on whether or not the customers will remain loyal tomorrow. Finally, advances in technology such as computers and internet have provided firms with the ability to provide faster services. For these reasons, hospital administrators, physicians and managers must continuously find means to deliver faster services, considering that the waiting will affect after service evaluation negatively. Also, understanding the inefficiencies in the hospital and improving them is crucial for making health-care policy and budgeting decisions with the ultimate goal of containing costs (Wilson *et al*., 2004).

The use of simulation is growing and is seen as a powerful tool within the health care industry. It is able to model a wide range of topic areas and answer a variety of research questions, as explained in the systematic review regarding computer simulation in health care (Fone *et al*., 2003). Computer simulation help to decision makers is growing in acceptance and its importance. Simulation is a process of designing and creating a computerized model of a real system for the purpose of conducting experiments to provide better understanding of the behavior of the system for a given set of conditions (Kelton *et al*., 2002).

Lowery (1998, 1996) and Standridge (1999) discussed issues facing an analyst when using discrete-event simulation to study a health care system, such as what type of problems are appropriate to be addressed using simulation, the degree of model complexity, the definition of input distributions, model documentation and validation, and the interpretation and reporting of findings.

2.4 Aliyu *et al*. (2015) Appointment System Model

In this section, the clinic appointment system for the outpatient department was modeled. Aliyu *et al*. (2015) appointment system is segmented into three factors.

i. **Waiting in the Doctor Queue**: The service in this clinic is offered to three types of patients; new patients, follow up patients and return patients.

   The first two types need to takes number from the reception to see the doctor. The third type is either new or follow up patient, however doctor sent some patients to take lab tests, these patients come back to the doctor queue as a return patients. When the arrival patients take numbers from the reception, they should wait in the waiting room until their turns come.

ii. **Doctor Diagnosing Process:** After the patients enter the diagnoses room, the service time is different according to the patient's type; new, follow up or return. New patient service time is usually the longest service time, since the doctor needs to diagnose the patient's and identify the patient's problems and conditions. Follow-up patients' service time is less than that of the new patients because the doctor already has a record about these patient's conditions and problems and they usually come for check-up with doctor. The Return patients' service time is usually the lowest service time, because the doctor only looks at the lab results and gives prescription to the patients based on the results.

iii. **Lab Process:** Some number of patients needs to take lab test and then return back to the doctor room with tests results usually in the same day. The lab process normally takes about 10 minutes to finish. A highest priority is given to these patients who took lab tests (return patients), therefore, they see the doctor the next available time immediately and without having a number.

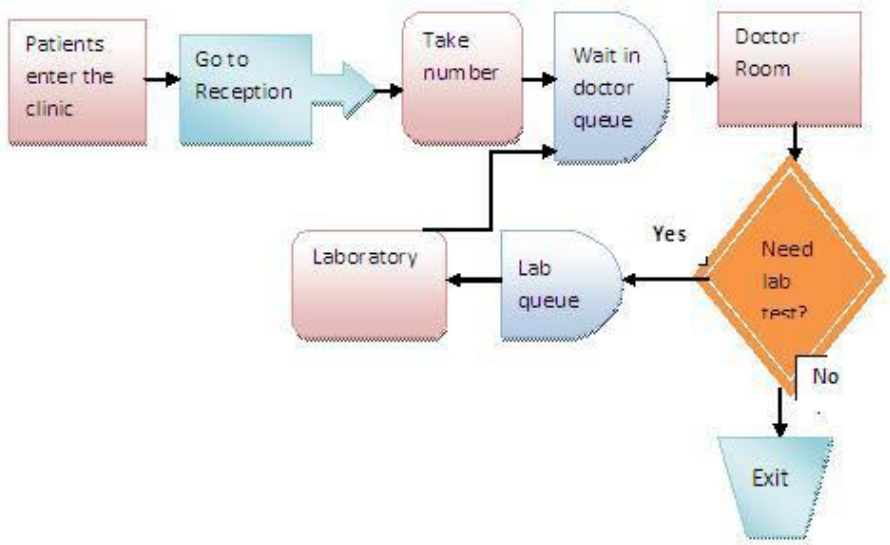

Figure 1: Aliyu *et al*. (2015) appointment system model

2.5 Mary's Appointment System Model

This model presents factors which cause the appointment in hospital to be difficult. There are factors which are caused by patients themselves such as coming late and failure to provide information if they are unable to come and even if time has been set for treatment or consultation with particular doctor or nurse. Patients come late, do not keep appointment time with doctors or nurses which cause the appointment useless. Enough availability of equipments result patients to stay in the queue or to leave. Furthermore, if the clinical officers come late and start working late, it will make patients to stay in the queues and create long waiting for the service. However, if both patients and clinical officers coordinate and streamline the appointments in the hospital, it will result the average waiting time for the patients to be reduced even if there is one doctor, two doctors, three doctors and four doctors. The patients' satisfaction will increase for good quality of hospital service delivery.

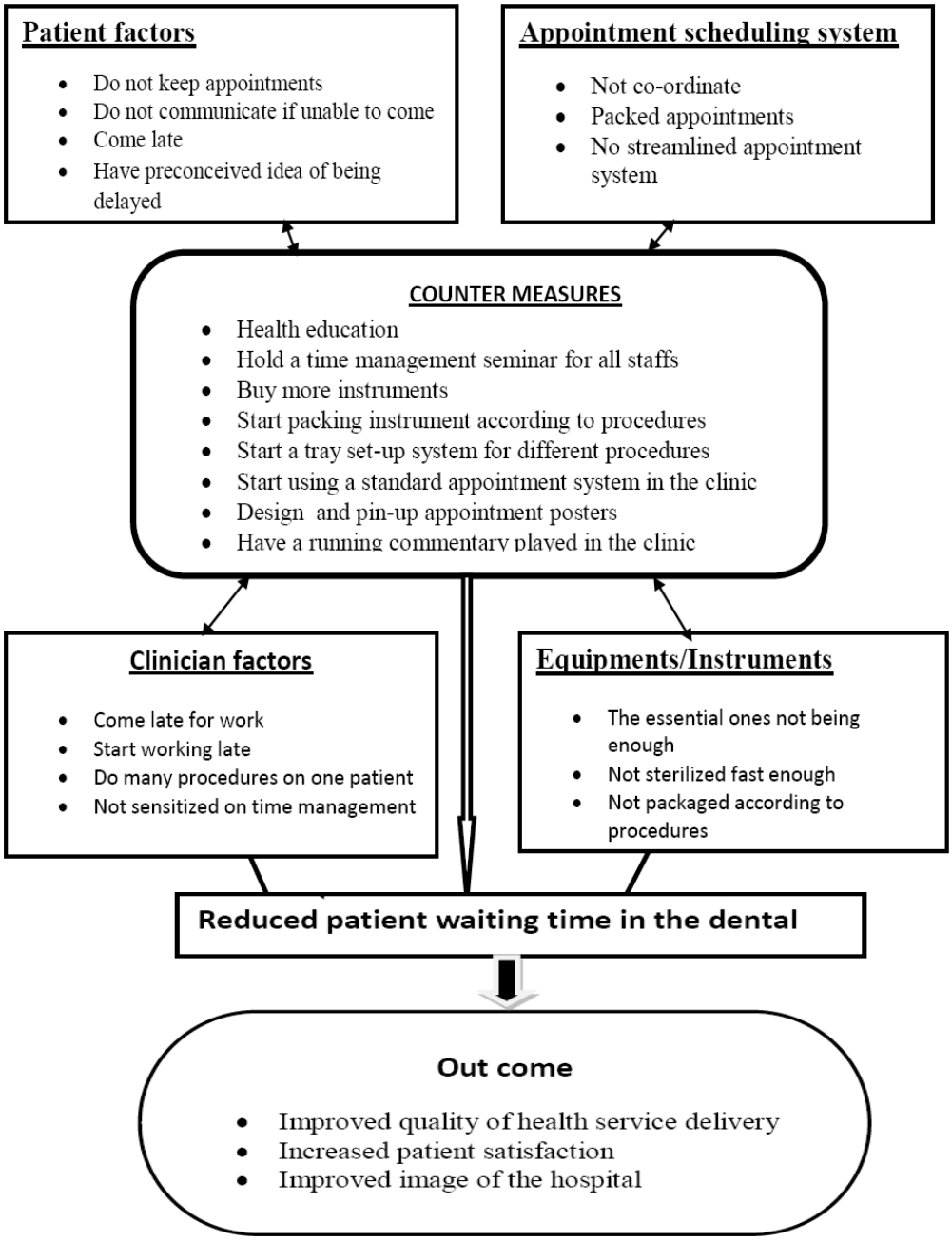

Figure 2: Mary's appointment system model

2.6 Brannstrom's Multi-servers Model

The multi-server queuing model is known in Kendall's notation as the M/M/m model, where:

- M signifies a Poisson distribution
- m = number of parallel service channels in the system.

The M/M/m model is one of the most commonly used to analyze the queuing. This model computes average wait times and queue lengths, given arrival rates, number of servers, and service rates. This particular model applies where there are multiple channels served by a single queue, as at a bank teller, airline tickets counters and hospitals. The outputs of the model are: Expected waiting time per patient in the system, expected waiting time of patient in the queue, expected number of patients in the system and expected number of patients in the queue.

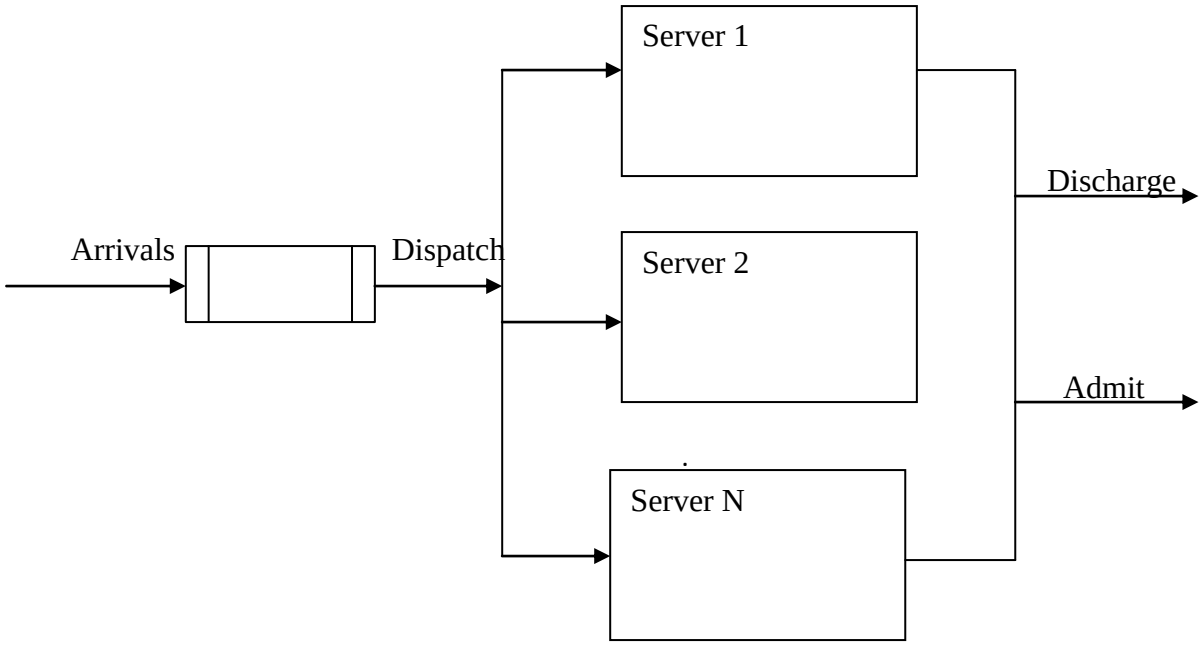

Figure 3: Multi-servers model by Brannstrom (2004)

2.7 Patient Appointment Queuing Model

In this study (Aliyu *et al*. (2015), Mary (2013) and Brannstrom (2004)) three models are used to formulate and test an appointment queuing model. The model has the following variables that are adapted from three models; appointment factors, patient factors, doctors factors, waiting time, doctor's services, discharge/admit and outcome factors. Researcher adapted three models because there are major factors which used in

all three models such as waiting time and number of patients to be attended which suits to my study.

If both doctors and patients do not keep the appointment such as coordinate and streamline with the time. And patients are coming late, failure to provide information if they are unable to come and even if time has been set for treatment or consultation with particular doctor or nurse. Also doctors come late, do not keep appointment time with patients which cause the appointment useless. Furthermore, if doctor come late and start working late, it will make patients to stay in the queues and create long waiting for the service. Moreover, number of the doctors cause the queue to be long or short but it depend with the doctors factors to attend patients. However, if both patients and doctors coordinate and streamline the appointments in the hospital, it will result the waiting time for the patients to be reduced even if there is one doctor, two doctors, three doctors and four doctors. The patients' satisfaction will increase for good quality of hospital service delivery.

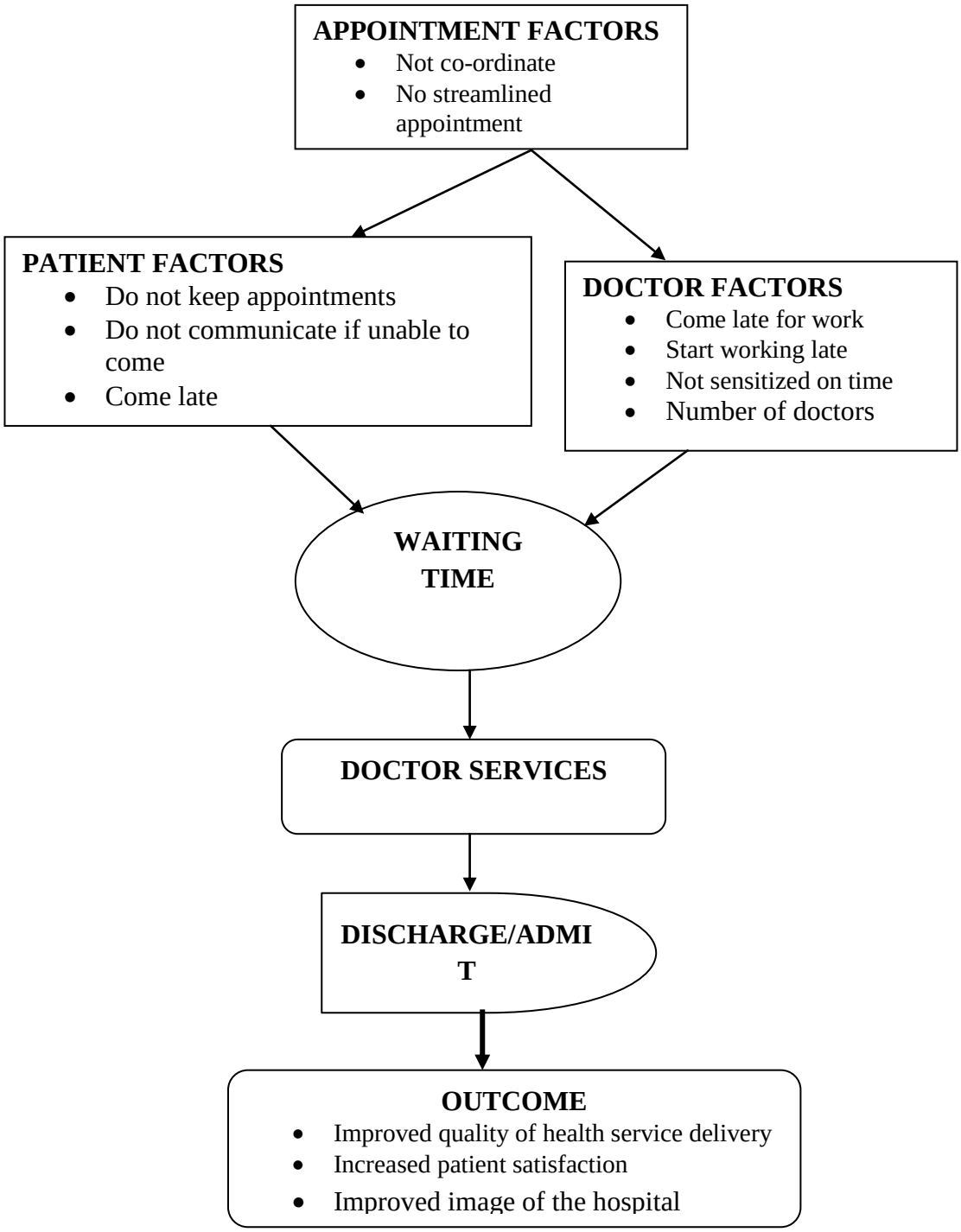

Figure 4: A model to test patients appointment queuing model as adapted and modified from Aliyu *et al*. (2015), Mary (2013) and Brannstrom (2004)

2.8 Appointment Schedule

When a patient arrives at a clinic, she/he puts his/her appointment card into one of the appointment boxes that are divided according to the blocked appointment times. This means that patients should arrive before their appointment time. Thereafter, the clerk on duty, assisted by nurses and medical assistants collect patient's card and record the patient's particulars in the daily report book. Then, the patient's profile is retrieved from the file rack. Once the profile is obtained, the patient's name is put on queue and the patient is asked to take a seat in the waiting area to wait for services. When the time comes, the patient is called into the doctor's room for treatment. After receiving the appropriate treatment, the patient is either directed to the counter for a follow-up appointment, if necessary, or is free to go home without any further appointment. In some cases, the patient is issued with a list of prescriptions for medicine that can be purchased at any authorized pharmacists.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the various methods which have been used in the study. It contains the following: research design, population of the study, sampling technique and sampling size, description of research instrument, validity of research instrument, method of data collection and method of data analysis.

Computer simulation studies in the past have been conducted on patient appointment scheduling systems. However, as it was reviewed on different literature reviews that there is no research on the study which test the patient appointment scheduling systems using Arena computer simulation at the Iringa Referral Hospital (IRH).

A thorough understanding of IRH process was obtained through on-site observations on various clinical and non-clinical staff. This method provided abundant information about patient flow at the level of detail required to construct a robust simulation model for analysis.

3.2 Research Design

This stud*y* used an experimental design. In this study the researcher adapted Aliyu *et al*. (2015), Mary (2013) and Brannstrom (2004) to test computer simulation at the Iringa Referral Hospital. This study performed the observation at outpatient department. It tests the average waiting time and number of the patients who have been provided service. Patients who are to be queued in the line to observe the time stayed in the queue. After the selection of one doctor, the experiment proceeds in a very similar way to any other experiment, with a variable being compared between different groups

(two doctors, three doctors and four doctors) over a period of time. The researcher chose 8 hours to be used in the simulation because it is considered to be the working time and the data collection was taken within 8 hours. From the three models which used to formulate and test the patient appointments queuing model which has answered objective I and objective II by using Arena computer simulation. The model tested the waiting time and number of the patients to be attended.

3.3 Research Approach

This research project uses both the quantitative and qualitative approach for collecting and converting data from the numerical form to non numerical data. Thus, the statistical and non statistical presentations made and a conclusion was drawn.

3.4 Population

From the statistical point of view, the term population refers to the total of items on which information is desired. Also, population refers to the large group from which the sample is taken (Minga, 1996). The targeted population in this study is patients who are seeking hospital services at the Iringa Referral Hospital was 150 which considered the average patients per month as indicated in Table 1.

3.5 Sample Size

Kombo and Tromp (2006) define samples size as a proper selection of a sample or representative part of a population for the purpose of determining features of the whole population in the area of study. Sample size must satisfy some requirements such as representativeness, flexibility, efficiency and reliability. Other factors such as desired accuracy, acceptable confidence level for estimate, and budgetary and time constraints play a crucial role in deciding sample size.

This study used the sample size of 109 respondents to represent the whole population in the study setting.

n = Required Sample size

N = Population Size

P = Population proportion 95% confidence level and P = .5 (50%)

e = Degree of accuracy (5%), expressed as a proportion (.05); It is margin of error

$$n = \frac{N}{1 + N(e)^2}$$

$$n = \frac{150}{1+150(0.05)(0.05)} = 109$$

3.6 Data Sources and Data Collection Procedure

The study used secondary data from the Enterprise Resource Planning (ERP) System and other databases that were kept in the Iringa Referral Hospital. A simulation analysis was conducted using Arena simulation software. Arena software contains a set of built-in functions for generating random numbers from the commonly used probability distributions. The software is designed for analyzing the impact of changes involving significant and complex redesigns associated with supply chain, manufacturing, processes, logistics, distribution and warehousing, and service systems.

Arena software provides the maximum flexibility and breadth of application coverage to model any desired level of detail and complexity. The simulation process comprised of three stages: building the model, validating the model and experimenting with the model. From the hospital's database, data for various factors associated with the

emergency care process such as number of patient treated, monthly, daily, and hourly patterns of patient arrivals.

3.6.1 Observation

Observation was used to obtain objective information about the time patients spend waiting to get a service and the time they spend with the service providers in the process of getting the initial service they come for. This method of data collection was selected by the researcher because in healthcare organization it is difficult to conduct interview and questionnaire. Data collection in these premises there are patients who are not conscious, also those who take care their patients may not respond correctly because of the frustration.

3.7 Description of the Study Area

This study was conducted at the Iringa Referral Hospital. It is located at the Iringa Municipal in the Southern Highlands Zone of Tanzania. This place connects Eastern Zone, Central Zone and South Eastern Zone. The area is located between latitudes 7.00^{o}-8.00^{o} south of equator line and longitudes 34^{o}-37^{o} East of Greenwich Meridian and it is bordered by Dodoma to the North, Morogoro to the East, Njombe to the South and Mbeya to the West. Iringa Municipality has a total population of 151,345 of which males are 71,932 and females 79,413 (United Republic of Tanzania, 2013).

3.8 Data Analysis

After data collection, data was analyzed by using Arena computer simulation package. This tool enabled data to be presented more professionally and scientifically and to test the potential appointment system. Data processed included simulation of the collected data from the field.

Data analysis provides driving force for any simulation model without input data, the simulation model itself is incapable of generating any data about the behavior of the system it represents (Banks, 1990). In this study, the following types of data were collected:

i. Patients' arrival times

The data was collected from observation and daily report book over a period of four weeks. Since it was difficult to record every patient's arrival time at the hospital, the arrival time for each patient was set at the time the patient arrived at the hospital.

ii. Doctors' process times

The data was collected from observation, the daily report book over a period of four weeks. The process time started as soon as the patient was called for treatment and ended as soon as the patient left the doctor's room.

iii. Doctors' scheduling times

The data was obtained from the staff manager who allocates the patients for the particular doctor and at specific time for 8 hours.

3.9 Validity and Reliability

3.9.1 Validity

To ensure validity, before administering the final questionnaire a pilot study was carried out so as to check the effectiveness of the observations and make corrections where necessary to ensure that observations were clear and simple that facilitated to provide precise data.

3.9.2 Reliability

To ensure reliability of data, the respondents were treated with gracefulness. The researcher administered the observations carefully so as not to influence any response.

3.10 Research Limitations

The researcher encountered some problems in undertaking this study, notably in some areas of data collecting, funding and time. The problems are as follows:

Scarcity of Material: This aspect of queuing in the healthcare industry has received very little attention from scholars. Consequently, there are a few literary publications available to the student; the researcher was therefore limited to reviewing a few pieces of literature.

Bureaucracy: Government establishments are well known for maintaining utmost secrecy as regards their operations especially financial operations. The researcher found it was difficult to obtain material relating to the study. Some officials have been very elusive and uncooperative.

3.11 Expected Results

This study enables the enhanced performance of health-care providers illuminating what approach decisions they might make to reduce patient wait time and deliver appropriate and timely health care service to the patients.

3.12 Description of Arena software

Arena software breaks down a process into discrete steps and then uses the computer simulation to answer questions, “what if I change one or more steps?” will productivity and efficiency increase or not?

The computer simulation frequently gives answers that are not obvious to human beings observing and trying to analyze a process.

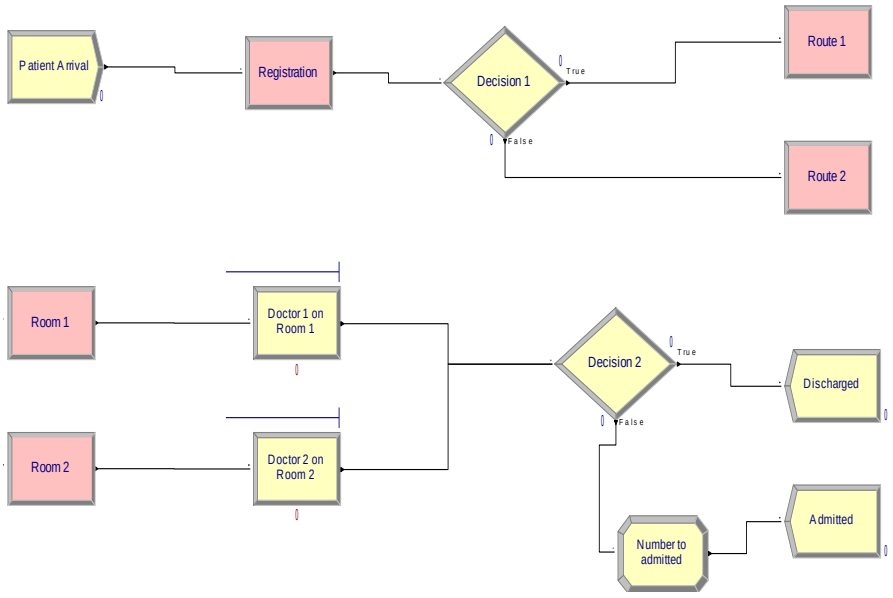

Figure 5: Arena software performance

The software is chosen because of its flexibility and ease of use. The model under study can be constructed without any programming knowledge due to its use of dialog boxes. Furthermore, Arena's input and output analyzers provide excellent tools to fit input probability distributions based on actual data, and analyze output data using classical statistical measures.

CHAPTER FOUR

ANALYSIS, FINDINGS AND DISCUSSIONS

4.1 Technical Analysis

Three stages of the methodology which include data collection, simulation model building and experimentation, have been completed in sequential order with the objective of improving patient waiting time. Different alternatives were tested in the model and the respective results were recorded. The design of the alternatives is based on considering registration clerks, triage nurses and doctors. The samples were taken into the simulation in different alternatives such as one doctor, two doctors, three doctors and four doctors.

On average 150 patients visited the IRH per day. The data for May to July, 2016 is shown in Table 2. The researcher selected these months because they were the time when this study was conducted from the data collection and experimentation of the study. Furthermore, it was the duration that provided sufficient sample size for the study.

The receptionists start giving numbers to the patients at 7:00AM while the doctors start attending the patients at 8:30AM (i.e doctor starts serving the patients at 8:30AM). Therefore, there must be a queue generated by patients before the doctor start giving and end the service at 16.30PM.

Table 1: Average patients per month at the IRH

Month	Average Patients per Month
May	146
June	151
July	143

4.2 Current status of the IRH queuing system

Table 2indicates the number of the personnel in the various workstations at the Outpatient Department (OPD) whereby the experiment was conducted. OPD in most Tanzania hospitals is where the flow of the patients start so that to be assigned particular clinical officer such as nurse or doctor.

Table 2: Current patient flow at the IRH

Workstation	Personnel	No. of Personnel in the workstation
Registration	Registration clerk	1
Triage	Triage Nurses	2
Consultation room	Doctors	4
Admission/Discharge	Discharge Clerk	1
Resuscitation	Doctor	1
Pharmacy	Pharmacist	1

4.3 Research Participants Distribution

After observation from the outpatient department time spent for each patient who arrived and seeking to get service has been indicated in the Table 3 and categorized in minimum time minutes, most likely minutes and maximum minutes.

Table 3: Range of time arrival to the different workstations

Workstations	Minimum (Minutes)	Most likely (Minutes)	Maximum (Minutes)
Registration	15	20	40
Triage	10	15	35
Doctor consultation	15	25	45
Discharge/Admission	10	15	25

4.4 Results of the Study

The simulation models were tested by using different doctors' alternatives such as by using one doctor, two doctors, three doctors and four doctors whereby average waiting time, minimum minutes, maximum minutes average and total number of patients were processed in experiment. The details of the results and discussion of the experiments are provided in the following subsections.

4.4.1 Model Validation

Before testing 8 hours for each one doctor, two doctors, three doctors and four doctors into the simulation, the study demonstrates 5 hours which were spent by one doctor. Similar work was done by Aliyu *et al*. (2015) who simulated by using one doctor and number of patients processed was 33. This model is going to confirm whether the output is the same or not for the same 5 hours. About 109 patients intended to be processed in this model.

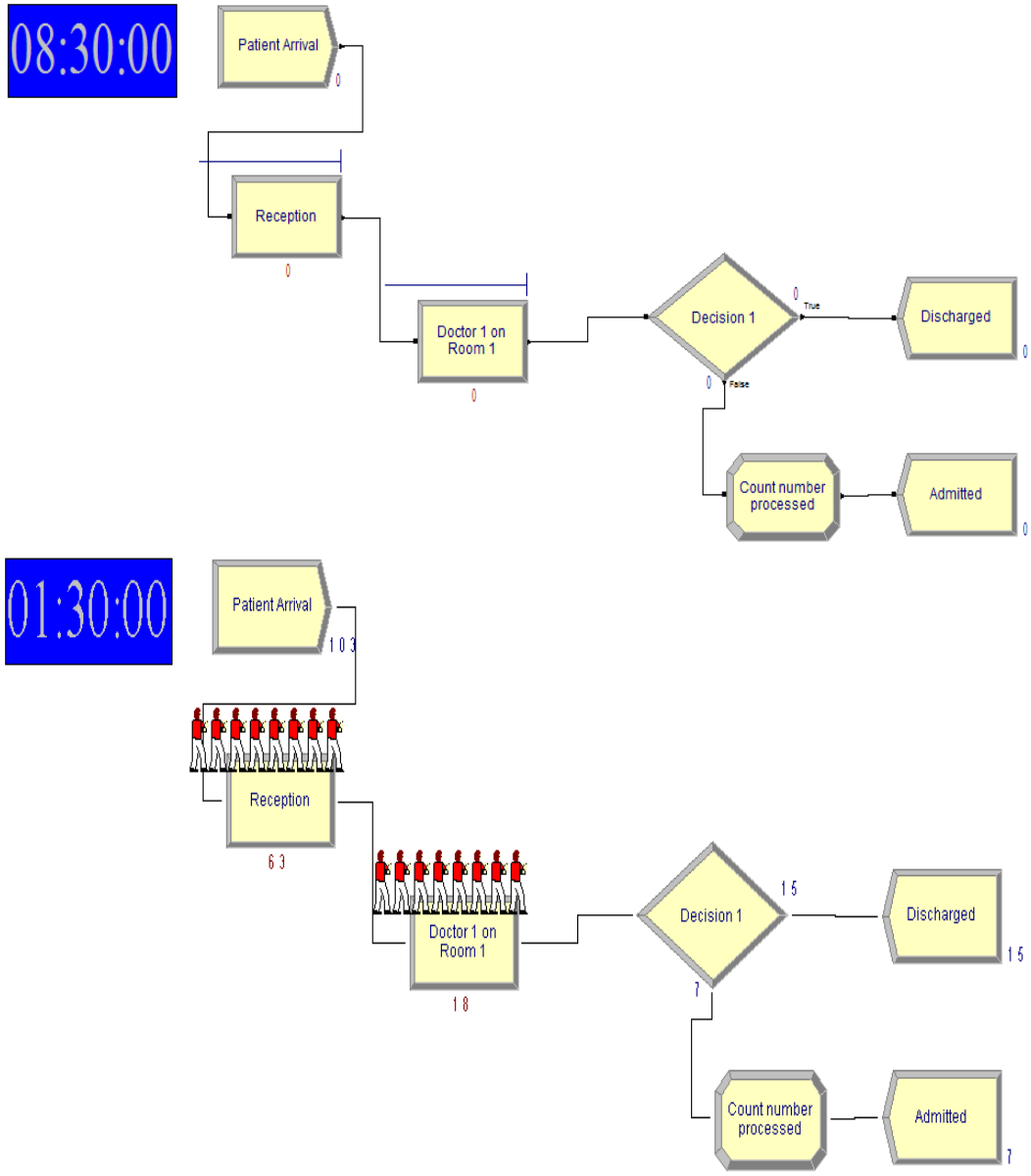

Figure 6: Simulation of one doctor for 5 hours

The simulation results show that 22 patients were processed in 5 hours using the simulation model in figure 3. Table 4 shows the simulation results for one doctor for 5 hours shift where the average waiting time to doctor was 1.03 minutes and 1.49 minutes to the reception.

Table 4: Simulation of one doctor for 5 hours

One doctor			
Average Waiting Time Minutes	Minimum Minutes	Maximum Minutes	Patients Output
1.03	0.0	2.06	22
Reception			
1.49	0.00	2.97	

When the interval of patients to arrive at hospital is very big cause the doctor to be idle, there is no patients to attend, and if the arrival time for the patients is set to be small then kept doctor busy for the hours scheduled for the patients. The results are almost similar to those of Aliyu *et al*. (2015) who got 33 patients in 5 hours. Therefore, the model can be used in hospital setting.

4.4.2 Testing simulation for One Doctor

In this experiment 109 patients were taken into the simulation. Testing was performed by using only one doctor in simulation, as the patient arrived at reception office. After being registered, the patient is either given the appointment to see particular clinical officer at that moment or she/he was given another time or day. If a patient was in good condition, he or she was allowed by the discharge officer and if his/her condition was bad then the patient was admitted.

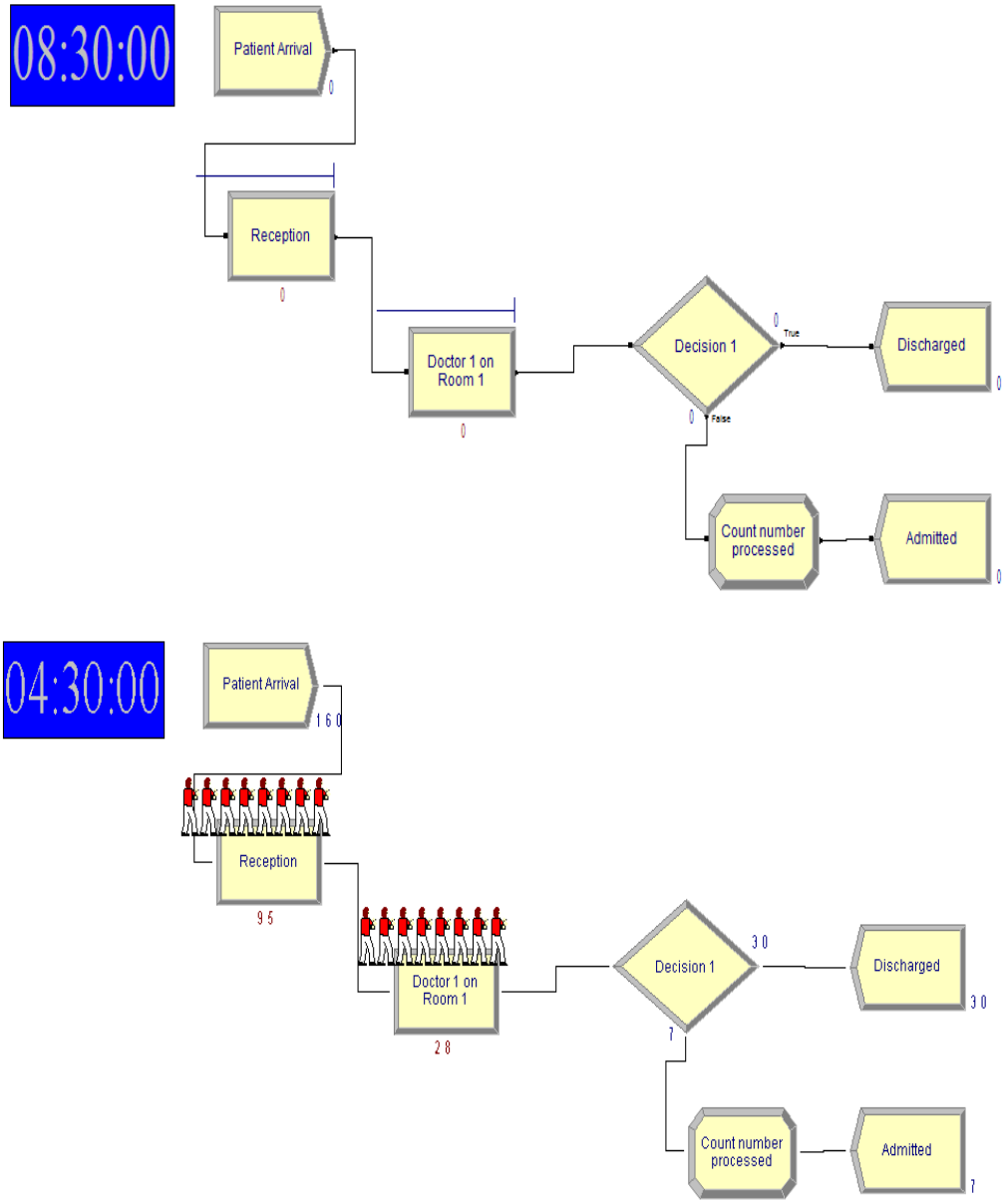

Figure 7: Simulated patients for one doctor for 8 hours

The results show that 37 patients were processed in 8 hours from the sample of 109 patients. This number of patients indicates that 33.9% of the patients were attended by one doctor in 8 hours and 66.1% of the patients were not processed.

Table 5: Simulation of one doctor for 8 hours

Average Waiting Time Minutes	Minimum Minutes	Maximum Minutes	Patients Output
One doctor			37
1.69	0.00	3.24	
Reception			
2.42	0.00	4.79	

Figure 5: Shows the percentage of patients processed by one doctor in 8 hours.

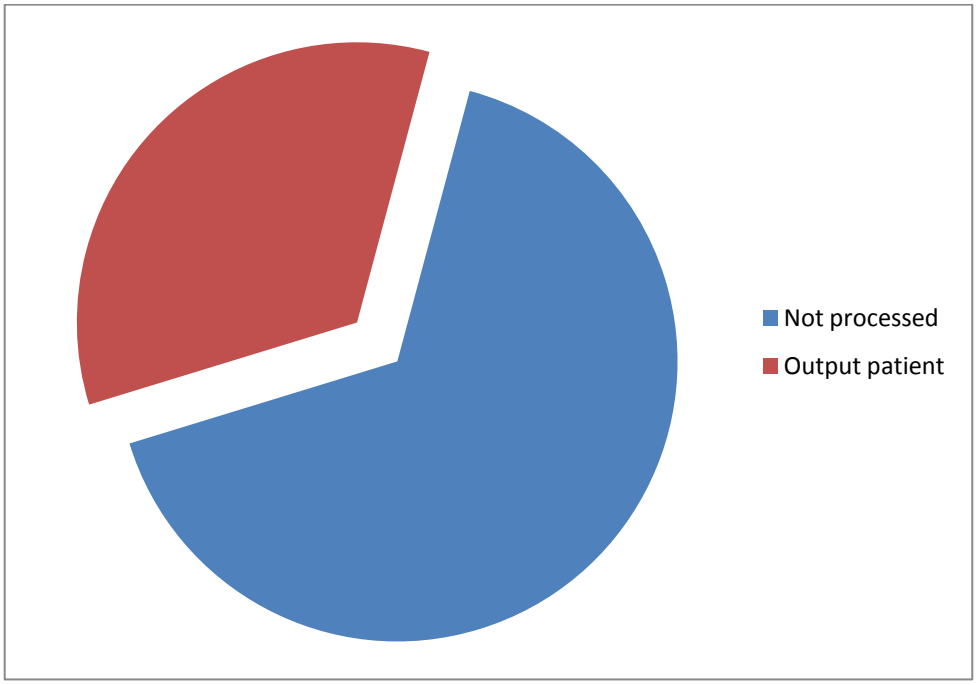

Figure 8: The output patients were 37 against sample size

4.4.3 Testing Simulation for Two Doctors

In this simulation two doctors who attended 109 patients. It checks if first route is busy that means doctor in first room is attending patient. Therefore, second route is idle whereby another patient routed to second route to doctor in second room. Also if

patient was in good condition therefore was discharged and if the patient was in bad condition was counted and admitted for the further check up.

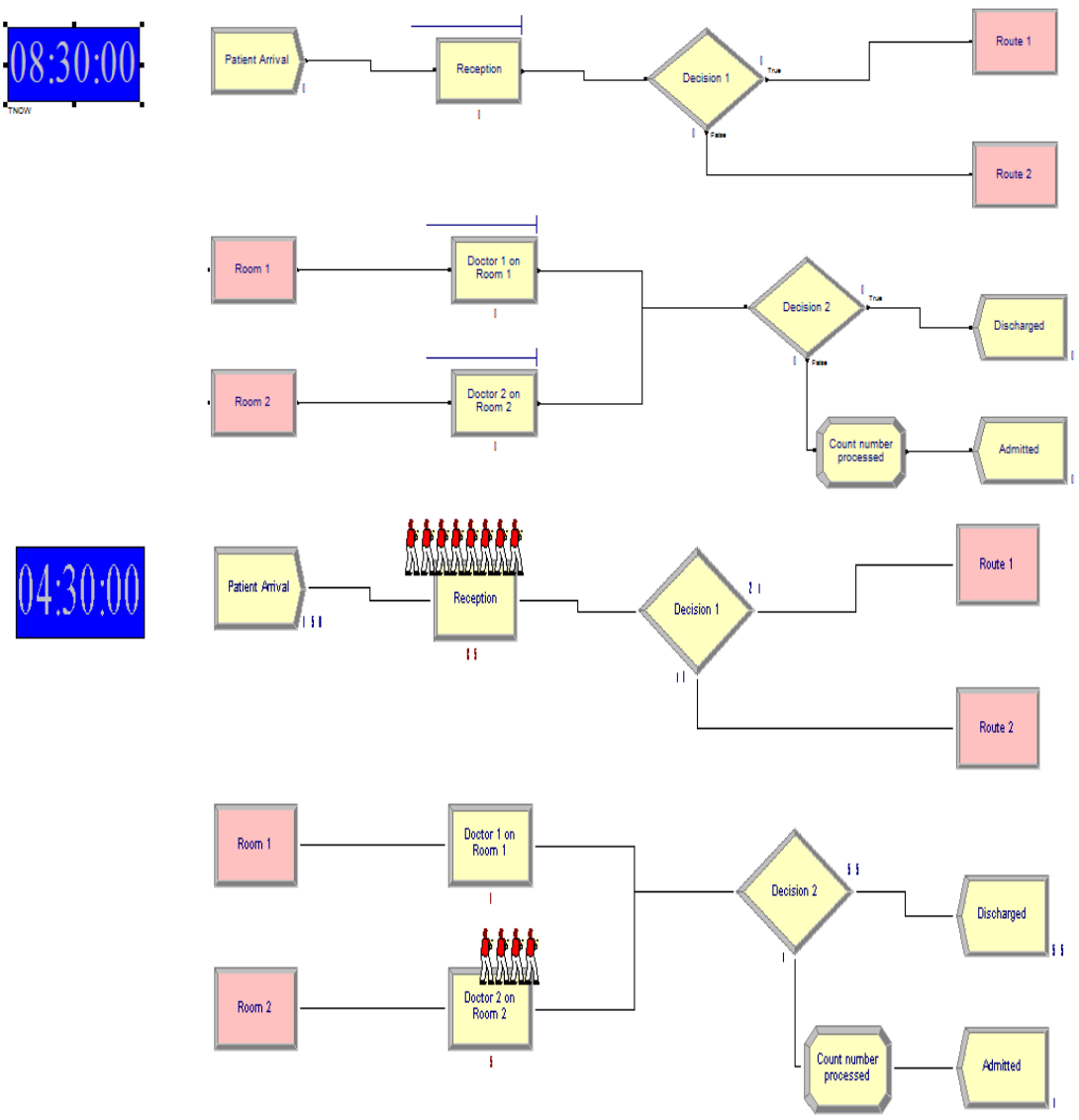

Figure 9: Simulation of two doctors for 8 hours

Table 6 shows the simulation results for two doctors for 8 hours shift. The results show that 59 patients out of 109 were processed in 8 hours when two doctors.

Table 6: Simulation of two doctors for 8 hours

Average Waiting Time Minutes	Minimum Minutes	Maximum Minutes	Patients Output
First doctor			59
0.03	0.00	0.15	
Second doctor			
0.39		0.66	
Reception			
2.09	0.00	4.13	

The average waiting time reduces because the number of the doctors increased from one doctor to two doctors, which compared with the first simulation which the patient has large average waiting time, with the different of 1.66 minutes and the patients different is 22 due to the increase of the clinical officers (doctors).

Figure 7 shows the percentage of the patients attended at the hospital by two doctors.

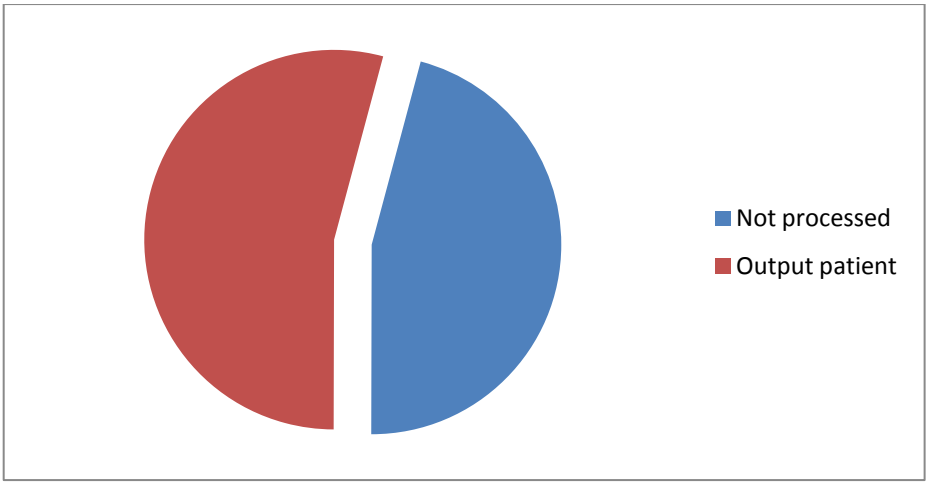

Figure 10: The number of 59 output patients against sample size

That is, 54.13% the patients were attended by having two doctors at the OPD department and 45.87% were not attended therefore were scheduled for the next day. Patients remain unprocessed because of the attending officer to be a few.

4.4.4 Testing Simulation for Three Doctors

It indicates that are there three routes such as first route, second route and third route which directed to the three doctors to the output. If the patient is directed to first route that means doctor at first room is attending patient, therefore if another patient arrived, he or she is automatically directed to second route for doctor in second room and if first and second doctor are busy, attending patient therefore the third route is used and directed the patient to doctor on third room. The first, second, third doctor generated waiting lines after arriving from the reception office desk. If the patient is in good condition by 90% as it is set in the model should be discharged otherwise the patient should be admitted for more checkup.

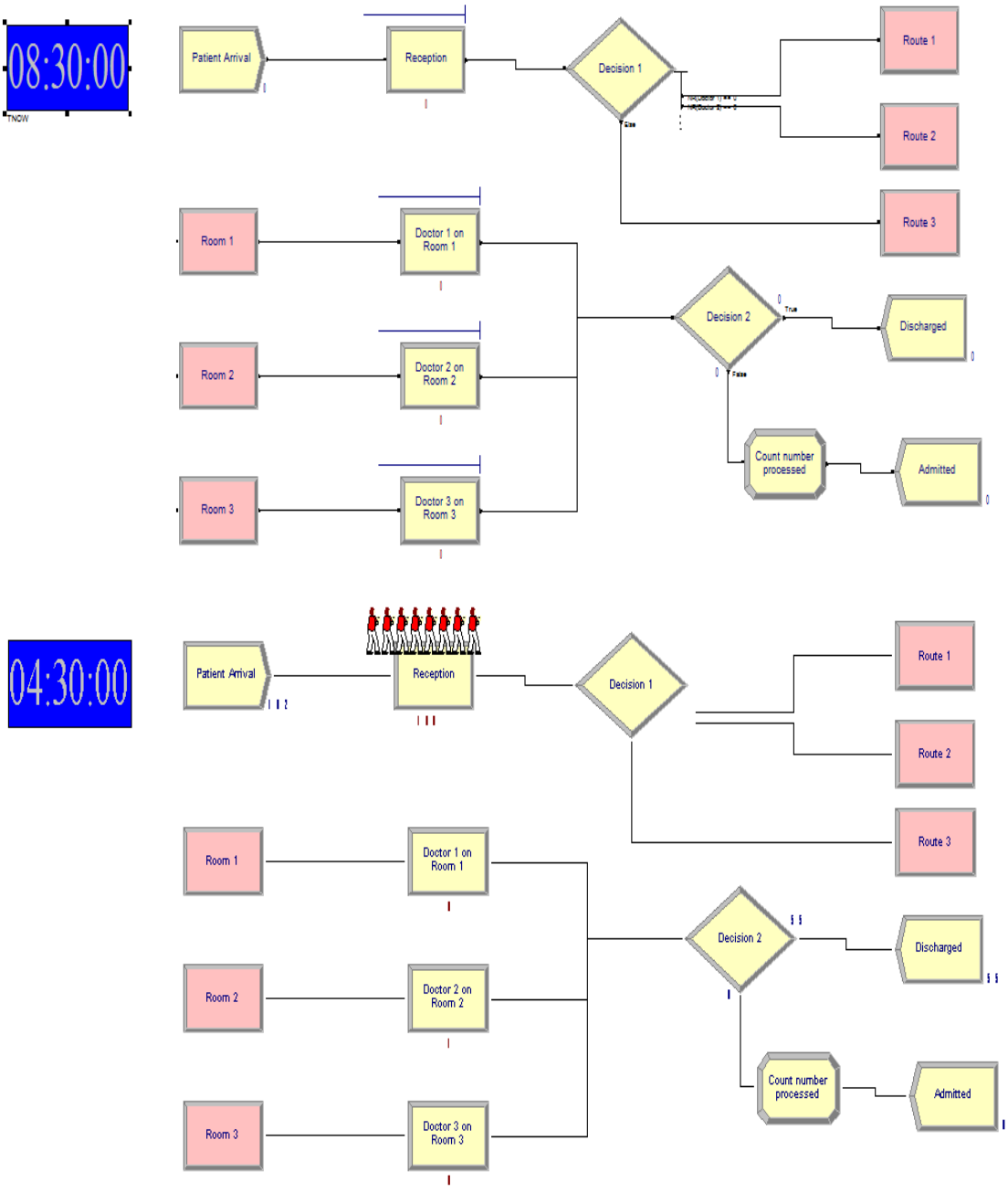

Figure 11: Simulated patients for three doctors for 8 hours

Table 7 shows the results of simulation for three doctors in 8 hours. The results show that 62 patients were processed from 109 sample size in 8 hours.

Table 7: Simulation of three doctors for 8 hours

Average Waiting Time Minutes	Minimum Minutes	Maximum Minutes	Patients Output
First doctor			62
0.02	0.01	0.02	
Second doctor			
0.02	0.01	0.01	
Third doctor			
0.01	0.01	0.02	
Reception			
2.27	2.10	2.43	

The average awaiting time for the patient decreases as the number of the doctors increased and the output of the patients increase from 59 in Table 6 with two doctors to 62 patients in Table 7 with three doctors. The time spent by the patient to wait for the service is 0.02 minutes compared to Table 5 is 0.03; the different is 0.01 minutes this shows that when the numbers of the doctors increase also the average waiting time in the queue decreases. Figure 9 indicate the percentage of patients processed and not processed at the hospital.

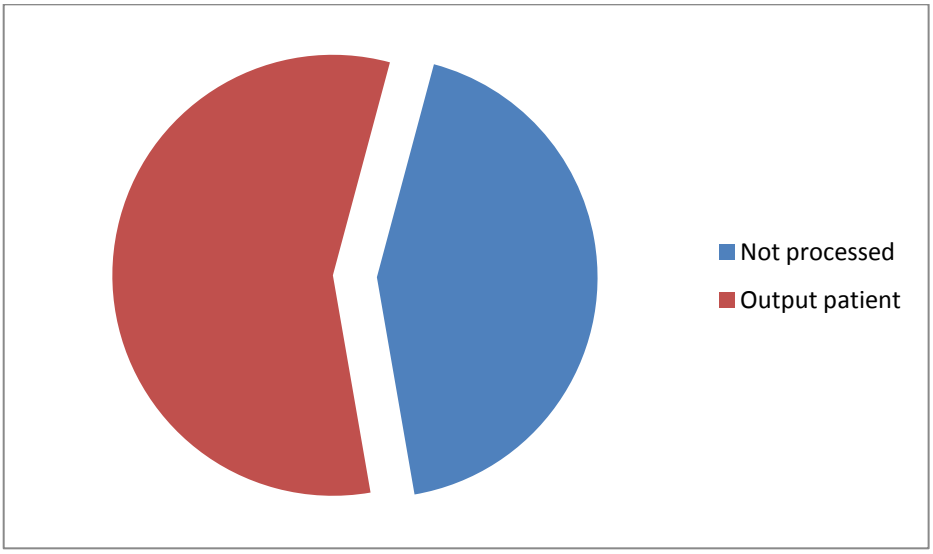

Figure 12: The output of 62 patients against sample size

The experiment demonstrates that 56.9% the patients were attended by having three doctors at the OPD department and 43.1% were not attended therefore were scheduled for the next day. The remaining patients could have been processed if the number of doctors and hours of simulation could have increased also.

4.4.5 Testing Simulation for Four Doctors

It designates that there are four routes such as first route, second route, third route and fourth route which have been directed to the four doctors to the output. If the patient is directed to first route that means doctor in first room is attending patient, therefore if another patient arrived is directed to second route for doctor in second room, if both first route and second route have been busy should to use third route for the doctor in third room. And if first, second and third route are busy also and attending patient therefore fourth route should be used to direct the patient to doctor in fourth room.

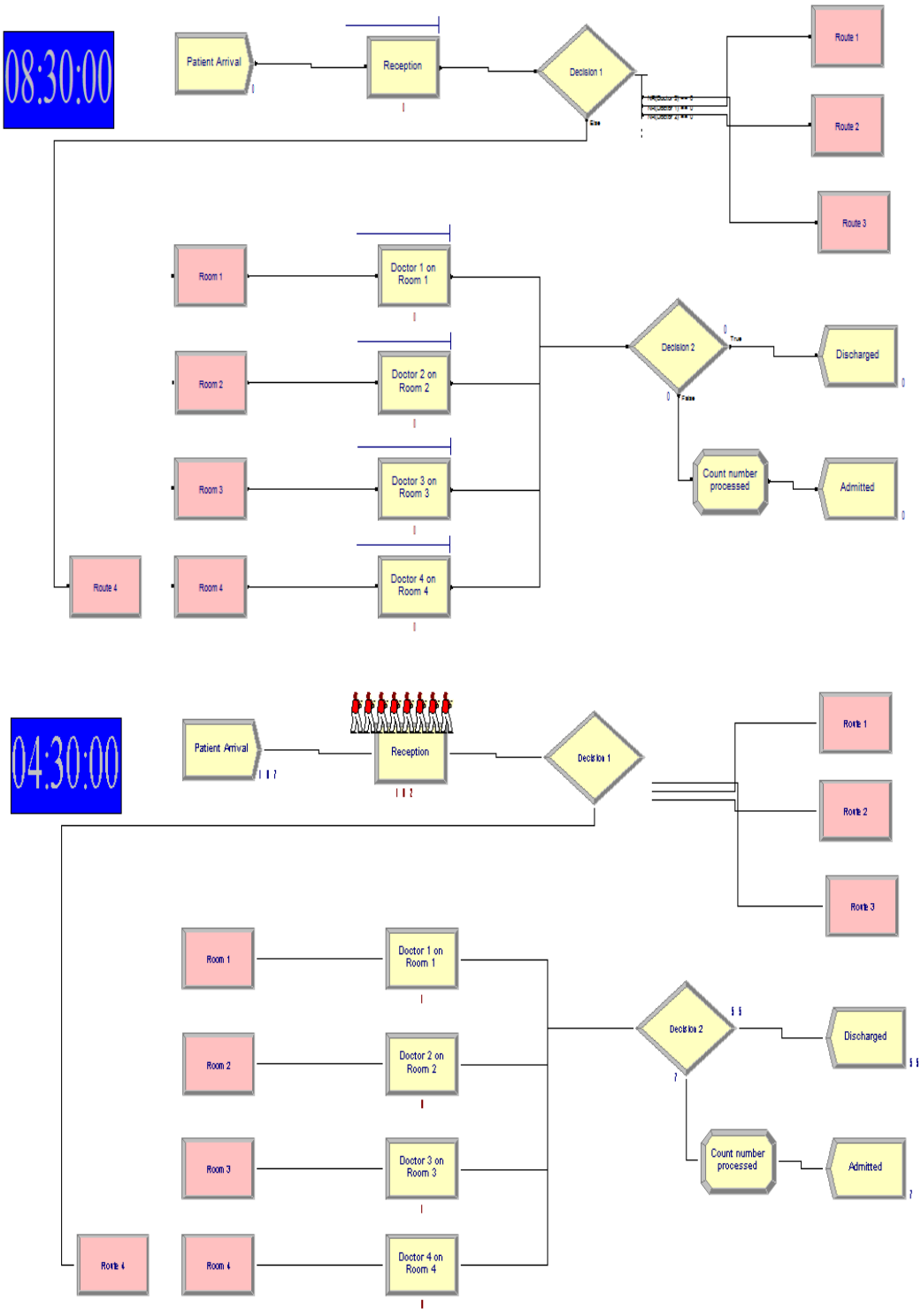

Figure 13: Simulation of patients for four doctors for 8 hours

Table 8 shows the simulation results for four doctors for 8 hours. The results shows that when the number of the patients increases with the same rate, and the number of the doctors increase then some of the doctors will stay without attending any patient. Fourth doctor has not attended any patient because there was no any patient waiting for the service, and the number of the patients processed was 69. The rate of patients flowing to the hospital remained the same while in Table 6 the attended patients were 69.

Table 8: Simulation results for four doctors for 8 hours

Average Waiting Time Minutes	Minimum Minutes	Maximum Minutes	Patients Output
First doctor			69
0.02	0.01	0.02	
Second doctor			
0.01	0.00	0.02	
Third doctor			
0.02	0.01	0.01	
Fourth doctor			
0.00	0.00	0.00	
Reception			
2.38	2.19	2.46	

The number of 69 patients is simulated within 8 hours after testing 109 samples of the patients. The percentage of the patients attended at the hospital has been depicted in Figure 11.

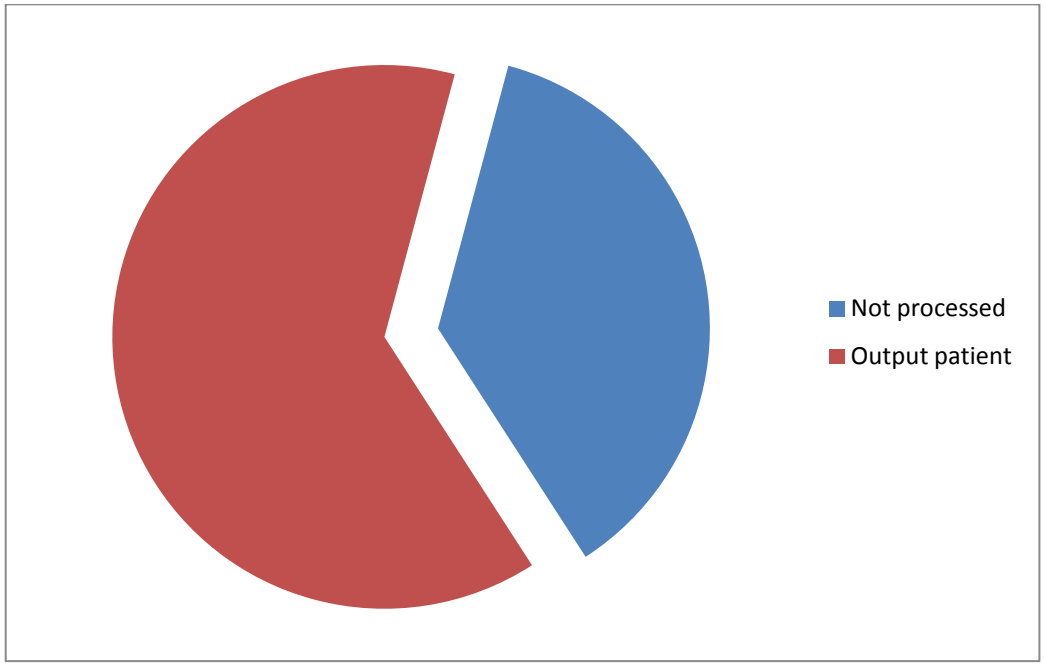

Figure 14: The number of 69 patients against sample size

It can be observed that by 63.3% the patients were attended by having 4 doctors at the OPD department and 36.7% were not attended. When the rate of patients to be attended increase as the when number of the doctors increase also.

4.4.6 Summary

This study tested one doctor, two doctors, three doctors and four doctors in the simulation, results and average waiting time differed as the numbers of the doctor increase in the simulation also the average waiting time decrease to the patient. When one doctor tested in simulation the result was 37 patients with 1.69 minutes average waiting time, when two doctors tested in the simulation result was 59 with 0.03 minutes average waiting time, furthermore when three doctors the result was 62 with average waiting time of 0.02 minutes and when four doctors the output was 69 patients with average waiting time 0.02 minutes.

Different times produced from the simulation from Table 5 to Table 8 depicted that the average waiting time in the simulation is smaller than the time obtained from the observation in Table 3. Results produced when the simulation was run with one doctor was 1.69 minutes, 0.03 minutes with two doctors, 0.02 minutes with three doctors and 0.02 minutes with four doctors compared to 15 minutes obtained from observation. This showed that patients spent several minutes to wait for service or one doctor had long queue which caused him to attend patients by 33.9% only.

Moreover, this study found that 33.9% of the patients were attended after running simulation for one doctor for 8 hours, 54.13% of the patients were resulted after simulation for two doctors for 8 hours, 56.9% of the patients were attended after computer simulation for three doctors and 63.3% of the patients were treated after simulating four doctors. This trend depict that one doctor had big number of the patients to attend which resulted 75.1% of the patients did not get service and 24.9% of the patients were attended. When two doctors added into the simulation patients increased to 54.1%.

Testing of the model was made according to the number of the doctors in the simulation compared to the sample size proposed in this study. The relation of average waiting time and patient for having one doctor in the simulation was that 37 patients were processed with average waiting time of 1.69 minutes before consulting the doctor and 2.42 minutes at the reception desk. When another doctor was added the average waiting time was reduced to 0.03 minutes and the number of the patients outputted were 59 and at reception was 2.09 minutes. It shows that when having one doctor causes the average waiting time to be compared with two doctors. When added three doctors the average waiting time reduced to 0.02 minutes queuing to the room and 2.27 minutes at the reception and 69 patients were outputted with 0.02 minutes for four

doctors. The trend of decreasing average waiting time as the number of the doctors increased indicate that patients did not stay in the queue to wait for the doctor instead they will be scheduled to other doctors.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The purpose of this study was to test the appointment queuing model by using Arena computer simulation in different alternatives and to demonstrate its impacts to the IRH. This study has demonstrated potential to make a difference at the Iringa Referral Hospital (IRH) and feel a strong desire to see this research through and would welcome the opportunity to be a part of its implementation in order to check utilization of the resources between patient and doctor.

When researcher tested one doctor for 5 hours to show the similar results which were tested by the Aliyu *et al*. (2015) by using one doctor in the simulation got the 33 patients to be attended for 5 hours spent by the doctors with 2.16 hours average waiting time for the each patient, but researcher used the same 5 hours by using one doctor the output was 22 patients. What makes to be different was the time used by doctor to attend patients, if the consultation time with doctor is large then the waiting time for patient will be large and if the consultation time with the doctor is small the average waiting time for patient will be small.

The flow of the patient remained the same which caused some of the doctors to be utilized and some doctors did not attend any patient as Table 8 shows fourth doctor did not attend any patient because patients flowed to first doctor, second doctor and third doctor. When the doctors and hours increased in the simulation caused the average waiting time and throughput increased. Therefore, simulation added up four doctors and depicted the waiting time to be reduced and the patients output increased. This

simulation model acted as a decision support tool for the hospitals involved to move forward in their decision making process as to which improvement will have the workable solutions.

This study found an insight into how different appointment schedules performed at the Iringa Referral Hospital setting. An appointment simulation using Arena simulation software was created and tested. Using computer simulation the study modeled the IRH throughput times and evaluated the effects of some changes on patient wait times in the process. The simulation results are validated with the actual values. More specifically, the simulation estimates on patient throughput times are compared against the actual values obtained from the hospital as it has been indicated in Table 3 the researcher asserts that the average waiting time is large compared to the simulation results.

The simulation results demonstrate that adding one more consulting doctor can shorten the average waiting time for the patients in the hospital process, and shows that computer simulation can be an effective decision support tool in modeling the hospital process and evaluating the effect of changes in the process. There was excellent agreement between actual data and the predictions of the model. This gives confidence that the model can produce realistic results for other planning scenarios such as doctor number 4 in Table 8 was not utilized by the patients, therefore there is no need adding more doctors to attend patients while the patient flow is very small or remain with the same rate.

This study compares the queuing process for the patients who arrive at the hospital with the appointments, which will help to maximize the doctors' utilization and minimize the patients' average waiting time.

When this model of simulation is adopted, the government will be able to distribute the clinical officers (nurses and doctors) to the different public hospitals according to the population of the patients available because some of the hospitals have unbalanced ratio between patients and clinical officers. As it is indicated in the Table 8 that the number of doctors increased to four doctors while the number of the patients remained the same which resulted fifth doctor to stay in the hospital without attending any patient.

This study is therefore expected to confirm that the waiting time of patients decreased at the Iringa Referral Hospital as the number of doctors increased. Arena computer simulation showed the time spent by patient to get service. When patients were assigned specific time to see doctor or nurse then they did other useful activities while waiting for the assigned time.

5.2 Recommendations

From the simulation results, it is observed that in case of the actual treatment of the patients, when the number of consulting doctors was increased from one to four doctors the average waiting time decreased substantially and throughput increased.

i. It is recommended that four or more doctors be engaged in attending patients to reduce patient waiting time.

ii. It is recommended that a new system should be developed where it is possible to continually track an individual patient from the time of entry to the time of departure.

iii. It is recommended that patients should be punctual with the time assigned to consult a doctor.

iv. It is recommended that patients should inform the reception office if he/she is going to cancel the appointment in order to assign another patient.

v. The appointment queuing model once accepted will be helpful to Tanzanian hospitals to arrange schedules with patients for the various services. However, this appointment queuing model has not been used in Tanzania to schedule patients to the different specialists for the treatment by using the Arena computer simulation.

vi. It is recommended that the model should be applied to test the variables on different cases, optimize business in health industry, and make decision in any business industry.

5.3 Areas of further study

i. Further simulation studies should be conducted categorizing the patients by the clinical disciplines, in which they are treated and incorporating the cost of hiring more personnel which was not taken into consideration in this study.

ii. Simulation studies which include other institutions which share resources with IRH should also be carried out.

iii. Future research work associated with this study is to consider on how to implement the changes suggested and tested by the model at the hospital and then evaluate the system performance to determine if the implemented changes resulted in real improvement. In addition, with the acceptance of the simulation approach tested should be integrated with the daily patient scheduling process for real-time online simulation.

iv. Further studies should be carried out to test unpunctuality and no-shows of patients which significantly affect the operational performance of the hospital.

5.4 Research Challenges

During this study there have been challenges in asking permission for data access. Hospital officers thought the researcher was going to conduct health study, the researcher made clarification on how the topic is merged with health matters. Some officers were not aware about on how simulation research can be incorporated in health matters.

Furthermore, it was very difficult to conduct research in health institutions and to get access of data if the method of data collection selected is not user friendly to the respondents. In health industry, is going to be very hard if the interview and questionnaire will be used for data collection, because hospital managers may think as if it will be disturbances for the patients and will result to be denied the permission fordata access at their premise.

REFERENCES

Abo-hamad, W. (2013), Simulation-based Framework to Improve Patient Experience in an Emergency Department.

Anderson, D.R., Sweeney, D.J., Williams, T.A. (2001), Quantitative Methods for Business. Bangalore: South-Western College Publishing.

Alessandra, A. J., Grazman, T. E., Parameswaran, R., and Yauas, U. (1978), Using simulation in hospital planning. 30, pp. 62-67.

Aliyu, A. I., Sulaiman, T. A. and Yusuf, A. (2015), Modeling and Simulation Analysis of Health Care Appointment System using ARENA, 4(1), 1–7.

ArenaSimulation. (2009). Arena - Forward visibility for your business. Rockwell Automation, Inc. http://www.arenasimulation.com.

Bailey, N.T. (1991), A study of queues and appointment systems in hospital outpatient departments with special reference to waiting times. *Journal of the Operational Research Society*, 2, pp 845-855.

Banks, Carson, S., and Nelson, B. L. (1996), Discrete event system simulation. (2nd ed.). New Jersey: Prentice-Hall, Inc.

Banks. (1990), The simulation of material handling systems. Simulation, 55(5), 261-270.

Best, J. (2001), Research in Education. Boston: Ayn and Bacon, ltd.

Blake, J.T and Carter, M.W. (1996), Analyses of emergency room wait time via computer simulation. 34, pp 263-272.

Brannstrom, N. (2004), A Queuing Theory Analysis of Wireless Radio Systems. Master of Science Programme.

Cochran, J. K., and Bharti, A. (2006), A multi-stage stochastic methodology for whole hospital bed planning under peak loading. *International Journal of Industrial and Systems Engineering*, 1(1), 8-36.

Davis, M. M., Aquilano, J. N., and Chase, B. R. (2003), Fundamentals of Operations Management 4th ed. Boston: McGraw Hill Irwin, Fourth Edition.

Evans G.W., Gor T.B. and Unger E. (1996), A simulation model for evaluating personnel schedules in a hospital emergency department. In: Charnes J.M., Morrice, D.M., Brunner D.T. and Swain J.J. Proceedings of the 1996 Winter Simulation Conference. Institute of Electrical and Electronics Engineers, Coronado, California, USA, pp 1205-1209.

Fenghueih, H. and Mong, H.L. (1996), Using Simulation in out-patient queues: A case study, International Journal of Healthcare Quality Assurance, 9(6), pp. 21-25

Fone, D., Hollinghurst, S., Temple, M., Round, A., Lester, N., Weightman, A., Roberts, K., Coyle, E., Bevan, G and Palmer, S.(2003), Systematic review of the use and value of computer simulation modelling in population health and health care delivery. *Journal of Public Health Medicine*, 25(4): 325-335. Frontiers of Health Services Management. 24(4): 3-15.

Garcia, M.L., Centeno, M.A., Rivera, C and DeCario, N. (1995), Reducing time in an emergency room via a fast-track. In: Alexopoulos, C., Kang, K., Lilegdon, W.R. and Goldsman, D. Proceedings of the 1995 Winter Simulation Conference. Institute of Electrical and Electronics Engineers, Washington DC, USA, pp 1048- 1053.

Gorney, L. (1981), Queuing Theory: A Problem Solving Approach. New York: Petrocelli Booko, Inc.

Greasley, A. (2003), A simulation of a workflow management system. 52(5): 256-261.

Green, L. V., Soares, J., Giglio, J. F., & Green, R. A. (2006), Using queueing theory to increase the effectiveness of emergency department provider staffing. 13(1), 61-68.

Gupta, D. (2013), Queueing models for healthcare operations. *International Series in Operations Research & Management Science* 184, http://doi.org/10.1007/978-1-4614-5885-2

Haraden, C., R. Rsesar. (2004), Patient flow in hospitals: Understanding and controlling it better.

Hall, W. R. (2006), Patient flow: The new queuing theory for healthcare.

Imahsunu, A.L. (n.d.), Queuing theory for healthcare operations management : A case study of University of Benin Health Center.

Jacobson, S. H., Hall, S. N., and Swisher, J. R. (2006), Discrete-event simulation of health care systems. In: Hall, R.W. ed., Patient Flow: Reducing Delay in Healthcare Delivery, Springer, New York, 211-252.

Jun, J.B., Jacobson, S.H. and Swisher, J.R. (1999), Application of discrete-event simulation in health care clinics: A survey *Journal of the Operational Research Society*, 50(2), pp. 109-23.

Kandemir-Caues, C., Cauas, L. (2007), An application of queuing theory to the relationship between insulin level and number of insulin receptors, *Journal of Biochemistry*, 32 (1): 32-38.

Kelton, W. D., Sadowski, P. R., and Sadowski, A. D. (2002), Simulation with arena (2nd ed.). Boston: McGraw Hill.

Khare, R. K., Powell, E. S., Reinhardt, G., and Lucenti, M. (2009), Adding more beds to the emergency department or reducing admitted patient boarding times: Which has a more significant influence on emergency department congestion? 53(5), 575-586.

Kombo, D. and Tromp, D. (2006), Proposal and thesis writing. Nairobi: Pauline's Publication Africa.

Kumar, A.P. and Kapur, R. (1989), Discrete simulation applications scheduling staff for the emergency room: Proceedings of the 1989 Winter Simulation Conference, pp. 1112-20.

Lowery, J.C. (1996), Introduction to simulation in health care. Proceedings of the 1996 Winter Simulation Conference (J.M. Charnes, D.M. Morrice, D.T. Brunner, J.J. Swain, Editors), Institute of Electrical and Electronics Engineers, Coronado, California, USA, 8-1December, 78-84.

Lowery, J.C. (1998), Getting started in simulation healthcare. Proceedings of the \998 Winter Simulation Conference (J.D. Medeiros, E.F. Watson, J.S. Carson, M.S. Manivannan, Editors), Institute of Electrical and Electronics Engineers, Washington, D.C., USA, 13-16 December, 31-35.

Limor A.D., Ray J.P. and Anthony J.H. (1996), Management of queues in outpatient departments: The use of computer simulation, Journal of Management in Medicine, 10(6), pp. 50-58.

McGuire, F. (1994), Using simulation to reduce length of stay in emergency departments. Proceedings of the 1994 Winter Simulation Conference. Institute of Electrical and Electronics Engineers, Lake Buena Vista, Florida, USA, pp 861-867.

Minga, U.M. (1996), The rural chicken industry in Tanzania: Does it make sense? Tanzania veterinary association scientific conference.

Muhondwa, E.P.Y., Leshabari, M.T, Mwangu, M., Mbembati, N., Ezekiel, M.J. (2008), Patient satisfaction at the Muhimbili National Hospital in Dar Es Salaam, Tanzania. East African Journal of Public Health, (5)2.

Na, U.J., Chaudhuri, S.R. and Shinozuka, M. (2009), Simulation-based seismic loss estimation of seaport transportation system. *Reliability Engineering and System Safety*, 94(3): 722-731.

Nannozi, M. (2013), Reducing patients' waiting time in Mengo Hospital dental clinic. Makerere University, Uganda.

Nosek, A.R., Wislon, P. J. (2001), Queuing theory and customer satisfaction: A Review of Terminology, trends and applications to pharmacy practice, 36(3):275-279.

Obamiro, J.K. (2003), Application of queuing model in determining the optimum number of service facility in Nigerian hospitals, M. Sc. Project submitted to Department of Business Administration, University of Ilorin.

Olorunsola, S. A., Adeleke, R. A., and Ogunlade, T. O. (2014), Queueing analysis of patient flow in hospital, 10(4), 47–53.

Olshaker, J. S., N. K. Rathlev. (2006), Emergency department over-crowding and ambulance diversion: The impact and potential solutions of extended boarding of admitted patients in the emergency department. J. Emerg. Med. 30(3): 351-356.

Pavlović, I., Kern, T. and Miklavčič, D. (2009), Comparison of paper-based and electronic data collection process in clinical trials: Costs simulation study. Contemporary Clinical Trials, 30(4): p. 300-316.

Render, B. Stair, R.M. Jr, and Hanna, M.E. (2006), Quantitative Analysis for Management, 9th Edition. Upper Saddle: Pearson Prentice Hall.

Rising, E., Baron, R. and Averill, B. (1973), A systems analysis of a university health service outpatient clinic, Operations Research, 21, pp. 1030-47.

Ritondo, M and Freedman, RW. (1993), The effects of procedure scheduling on emergency room throughput time: A simulation study. In: Anderson, J.G and Katzper, M (eds). 1993 SCS Western Multi conference on Simulation: Simulation in the Health Sciences and Services. Society for Computer Simulation, La Jolla, California, USA, pp 8-11.

Samuel, F., Jeffrey, H. (2007), A Survey of Queuing Theory applications in healthcare. The Institute for Systems Research.

Seila A., Ceric V. and Tadikamalla P. (2003), Applied Simulation Modeling. Belmont: Thomson Learning Inc.

Singh, V. (2007), Use of queuing models in health care, Department of Health Policy and Management, University of Arkansas for Medical Science.

Scotland, R. (1991), Customer Service: A waiting game, Marketing, pp 1-3.

Sundarapandian, V. (2009), Queueing Theory. Probability, statistics and queuing theory. PHI Learning.

Tahar, R. and Hussain, K. (2000), Simulation and analysis for the Kelang Container Terminal operations. Logistics Information Management, 13(1): 14-20.

United Republic of Tanzania. (2013), Population distribution by administrative units.

Waleed, A and Amr, A. (2013), Simulation-based framework to improve patient experience in an emergency department.

APPENDICES

Appendix I: Time Frame

Nov 30, 2015 – Dec 30 2015	Proposal planning & Proposal Reviewing
Dec 30, 2015 - Jan 30 2016	Proposal planning & Proposal Reviewing
Jan 30, 2016 – Feb 30, 2016	Submission of Research Topics
Feb 30, 2016 – March 4, 2016	Submission of concept note
March 5, 2016 – March 24, 2016	Preparation of Research Proposal
March 25, 2016	Submission of Research Proposal
March 29-31, 2016	Proposal presentations
April 1, 2016 – April 5, 2016	Pre-testing of Research Tools
April 6, 2016 – April 30, 2016	Data Collection
May 1, 2016 – May 15, 2016	Data Analysis
May 16, 2016 – May 30, 2016	Presenting the findings
June 1, 2016 – June 28, 2016	Report writing
June 30, 2016	Producing the final Dissertation
July 5, 2016 – July 08, 2016	Defending the final Dissertations
July 25, 2016	Submission of Final Dissertations

Appendix II: Data Access Letter

THE UNIVERSITY OF DODOMA

DEPUTY VICE CHANCELLOR ACADEMIC, RESEARCH & CONSULTANCY
OFFICE OF GRADUATE STUDIES

P.O. BOX 263
DODOMA, TANZANIA
TEL: +255 23 23002 FAX: +255 23 23000 EMAIL: ahmed_ame@yahoo.com

REF/UDOM/GS-ADMS/2016/202 Tuesday, July 5 2016

To Whom It May Concern:

RE: INTRODUCING MR. MNYAWAMI, YUDA.

The above named student is enrolled at the University of Dodoma for the degree of Master of Science in Information Technology (MSc.IT) with registration number HD/UDOM/127/T.2014.

An essential requirement of the study programme is that each candidate is required to submit a dissertation report on a project undertaken within industry and supervised by a member of the University's academic staff. Where possible this project should relate to a practical situation in an organisation or firm selected by the candidate. Students are expected to use their own initiative to identify a possible project and negotiate access with a local firm or organization. The area of study is **"TESTING THE PANTIENT APPOINTMENTS QUEUING MODEL BY USING COMPUTER SIMULATION: A CASE OF IRINGA REFERRAL HOSPITAL".**

The work may take the form of a survey, ethnography, case studies, etc. Where the report may contain confidential information and its publication could be harmful to the organization, confidentiality is assured by the University. Such reports will be seen only by the Supervisor and Examiner for examination purposes.

I would be grateful if you would provide the student with this opportunity to further his studies while at the same time gaining some useful input for your own organization through the results of the project report.

Sincerely,

Abdallah waziri
For: Director for Graduate Studies