QUEUE MANAGEMENT BY SIMULATION MODELING: A CASE STUDY OF AGA KHAN UNIVERSITY HOSPITAL

BY

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DECLARATION

This Research project is my original work and has not been submitted for a degree in any other university or Institution.

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Declaration by Supervisor

I have supervised the work contained herein and confirm that it is to the required standards

Signed.......................... Date: . . . V 3 . 1 . H /2012 ....

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DEDICATION

This work is dedicated to my father Mr.Wanjangi Murigu for inculcating in me a great desire to better the conditions of mankind and for sacrificing any form luxury or leisure to see me and my siblings through our education.

ACKNOWLEDGEMENT

First and foremost I would like to offer my sincere gratitude to my kind supervisor, Mr. Ernest 0. Akelo, who supported me though out the research project with his patience and knowledge. I attribute the level of my Masters degree to his encouragement and effort and without him this project would not have been completed. One simply could not wish for a better supervisor.

I would like to thank my family members, especially my wife, Gladys Nduta, and my two sons, Gil Wanjangi and Roy Nduati for supporting and encouraging me to pursue this important degree program .Without my dear family's encouragement, I would not have finished the degree.

I acknowledge the valuable time and technical assistance received from Gerald Mbuthia of Aga Khan University Hospital research office and Felistas Ngunjiri, manager Aga Khan University Hospital A&E department.

Finally I am greatly indebted to the Almighty God for his Grace and Mercy in my academic and professional journey.

ABSTRACT

Using computer simulation, a model of Accident and Emergency care process in a hospital was developed and the effect of some proposed changes to improve patient throughput times studied. The project was based upon a case study conducted at the hospital and historical (secondary data) from the hospital records were used to simulate the accident and emergency process. ARENA simulation software was used to run the model. The simulation results demonstrate that some proposed changes can shorten patient throughput times in the emergency care process. The proposed changes involve adding one more doctor to man an extra consultation room. The simulation results show that computer simulation can be an effective decision support tool in modeling hospital emergency care process and evaluating the effects of changes in the process. The results would be useful to the hospital management who are considering improving the service delivery through reducing the patient throughput time.

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TABLE OF CONTENTS

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LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS/ACRONYMS

Accident and Emergency Department

Aga Khan University Hospital

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Government and private health investors in Kenya, provide medical services to diverse groups of people. Demand of health services has been growing in recent years due to increase of both preventable and communicative diseases. In the absence of enough hospitals, health personnel and efficient appointment system, patients especially in government hospitals spend excessively long times waiting for treatment. As a result the hospitals and clinics are congested, leaving patients dissatisfied.

As hospitals raise their technical quality, patients will lay more emphasis on the quality of services they receive. In order to survive, most of hospitals are making efforts to improve their service quality to satisfy their patients. In the out-patient service for example, the main indicator of quality assurance for patients is waiting itself; patients should be attended within an acceptable time. Several studies (e.g. Cayirli et al, 2008; Kujala et al, 2006 Zhu et al, 2009) suggest that hospital managers and policy-makers are becoming more and more concerned with patient waiting time because it is a measure of organizational efficiency. The waiting time is particularly important for a hospital, since the customers are patients who are human beings. Waiting for treatment can be frustrating given that time is unproductively spent and according to Katzman (1999) people are impatient and do not want to wait to be attended to. As Bielen and Demoulin (2007) observe, the literature on service quality indicates that waiting experiences are typically negative and have been shown to affect overall satisfaction of consumers with the service

Generally, analysts use the simulation approach either because optimization techniques are unavailable or because the assumptions required by an optimizing technique are not reasonably satisfied in a given situation (Stevenson, 2002). Queuing problems are a good example of the latter reason. Although waiting-line problems are pervasive, the rather restrictive assumptions of arrival and service distributions in many cases are simply not met. Very often, analysts will then turn to simulation as a reasonable alternative for obtaining descriptive information about the system in question.

Healthcare has attracted attention from the discrete-event simulation modeling community. Jun et al (1999) conducted an extensive review of the literature in 1999, and Fletcher and Worthington (2009) and Brailsford et al (2009) provide more recent reviews of the literature. Simulation models range from being relatively simple and accessible e.g. Kumar and Shim (2007); Hoot et al (2008) to being highly complex according to Duguay and Chetouane (2007).

1.1.1 Simulation

Anderson et al (2001), defines simulation as a method of learning about a real system by experimenting with a model that represents the system. According to Render et al (2006), 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 mathematical/logical model of a physical system that portrays state changes at precise points in simulated time.

Discrete Event Simulation has been widely applied in many hospital sections including outpatient clinic (Harper and Gamlin, 2003; Klassen and Rohleder, 1996; Zhu et al., 2009), emergency department (Connelly and Bair, 2004; Su and Shih, 2003; White et al., 1992) etc. Discrete Event Simulation models are carried out on individual objects (entities) as they move through a system, participate in different processes, and consume material, financial and personal resources. In discrete-event simulation, the operation of a system is represented as a chronological sequence of events. Each event occurs at an instant in time and marks a change of state in the system. This study will use discrete event simulation modeling.

1.1.2 Queuing Systems

In the early 1900s A.K Erlang, a Danish telephone engineer, began a study of the congestion and waiting times occurring in the completion of telephone calls. Since then, queuing theory has grown far more sophisticated and has been applied to a wide variety of waiting line situations. The operating characteristics that are important in describing a queuing system are: probability that no units are in the system, the average number of units in the waiting line, the average number of units in the system, the average time a unit spends in the waiting line, the average time a unit spends in the system and the probability that an arriving unit has to wait for service (Anderson et al; 2001). The various characteristics of a queuing model are identified using Kendal notation. According to Kendal notation (Tulsian and Vishal, 2002) a general queuing system is denoted by (a/b/c): d/e, where

a= probability distribution of the inter-arrival time.

b = probability distribution of the service time.

c = number of servers in the system,

d = maximum number of customers allowed in the system,

e = queue discipline.

Thus M/M/l: (oo/FIFO) indicates a queuing system when the inter-arrival times and service times are exponentially distributed having one server in the system with first in first out discipline and the number on units allowed in the system can be infinite.

1.1.3 Objectives of Queuing

The ultimate objective of the analysis of queuing systems is to understand the behavior of their underlying processes so that informed and intelligent decisions can be~made in their management. The study of behavioral problems of queuing systems is intended to understand how it behaves under various conditions. The bulk of results in queuing theory are based on research on behavioral problems. Another objective of queuing model is to find out the optimum service rate and the number of servers so that the average cost of being in the queuing system and the cost of service are minimized (Tulsian and Vishal, 2002).

1.1.4 Health Sector in Kenya

In 1994, the Government of Kenya approved the Kenya Health Policy Framework as a blueprint for developing and managing health services. It spells out the long-term strategic imperatives and the agenda for Kenya's health sector. To operationalize the document, the Ministry of Health developed the Kenya Health Policy Framework Implementation Action Plan and established the Health Sector Reform Secretariat in 1996 under a Ministerial Reform Committee in 1997 to spearhead and oversee the implementation process. A rationalization program within the Ministry of Health was also initiated. The above policy initiatives aimed at responding to the following constraints: decline in health sector expenditure, inefficient utilization of resources, centralized decision making, inequitable management information systems, outdated health laws, inadequate management skills at the district level, worsening poverty levels, increasing burden of disease, and rapid population growth.

The health sector comprises the public system, with major players including the Ministry of Health and the private sector. The public health system consists of the following levels of health facilities: national referral hospitals, provincial general hospitals, district hospitals, health centers, and dispensaries. National referral hospitals are a* the apex of the health care system, providing sophisticated diagnostic, therapeutic, and rehabilitative services. The equivalent private referral hospitals are Nairobi Hospital and Aga Khan Hospital in Nairobi. Provincial hospitals act as referral hospitals to their district hospitals. They also provide very specialized care. The provincial level acts as an intermediary between the national central level and the districts. Similar private hospitals at the provincial level include Aga Khan Hospitals in Kisumu and Mombasa.

District hospitals concentrate on the delivery of health care services and generate their own expenditure plans and budget requirements based on guidelines from headquarters through the provinces. Health centers generally offer preventive and curative services, mostly adapted to local needs. Dispensaries are meant to be the system's first line of contact with patients. The government health service is supplemented by privately owned and operated hospitals and clinics and faith-based organizations' hospitals and clinics, which together provide between 30 and 40 percent of the hospital beds in Kenya.

The population and housing census carried out 2009 established that the Kenya population stood at over 38 million people against a total of 6,696 health institutions and 100, 301 registered health personnel (Government of Kenya, 2009). This translates to 17 health institutions to every 100, 000 population and 265 health personnel to every 100,000 population. This statistics clears indicates that the health providers are over stretched which explains why queues would form in the health facilities.

1.1.5 Aga Khan University Hospital

The Aga Khan University Hospital, Nairobi is part of the Aga Khan Health Services (AKHS). Established in 1958, the hospital is a 254-bed long-term care facility offering quality general medical services, specialist clinics and high-tech diagnostic services. It is a premier provider of ambulatory care and quality inpatient services, including critical care. In 2005, the Aga Khan University Hospital, Nairobi, was created as a teaching hospital. The Hospital's aim is to be a premier tertiary care facility for Eastern Africa. Since becoming a University teaching hospital in 2005, the Aga Khan University Hospital, Nairobi, has increased its clinical capacity and made significant improvements to its facilities. In collaboration with Aga Khan Health Service, Kenya, the hospital has developed a health management information system at the district level. The hospital has launched an ophthalmology program, and planning is continuing for the development of international standard tertiary care facilities in cardiology and oncology. The Hospital aims to develop strong research capabilities in relevant research, focusing on regional issues.

1.1.6 Aga Khan University Hospital A&E Queuing System

Some patients arrive at the A&E department by ambulance, while others present as "walk-in" patients who have referred themselves. A patient who arrives by ambulance may have provided their details in the ambulance, or may be in too serious a condition, and will therefore bypass the reception and be directed to the most appropriate area - usually the resuscitation unit. When a walk-in patient arrives in the department they see the receptionist, who records their arrival time and takes their biometric details. Patients then proceeds to the triage where they wait to be seen by one of the two triage nurse. After the triage the walk-in patients then proceeds to the consultation rooms where they are attended in one of the four consultant doctors. On the recommendation of the consulting doctor, a patient will either be admitted or discharged. A patient who is to be discharged goes through the payment desk where he is billed and pays for the service rendered before proceeding to the discharge desk.

1.2 Statement of the Problem

A great deal of research has shown that waiting time is a source of dissatisfaction in patients (Uehira and Kay, 2009; Bielen and Demoulin, 2007; Kujala et al., 2006; Barlow, 2002; Hart, 1996; Gupta et al., 1993; McKinnon et al., 1998). Hart (1996) argues that waiting to be treated is the one consistent feature of dissatisfaction that has been expressed with outpatient service. There is a dearth of research on hospital waiting times with very few studies focusing on methods to improve the situation. There are several situations in hospital waiting times that cannot be presented by standard mathematical formulae. This is because of the stochastic nature of the problem, the complexity involved in formulating the problem and the complexity of interactions needed to adequately describe the problem being studied. Assumptions that allow deriving most queuing formulas are not always valid for many healthcare processes. For example, several patients sometimes arrive in Emergency Department at the same time (several people injured in the same auto accident), and/or the probability of new patient arrivals could depend on the previous arrivals when Emergency Department is close to its capacity. For these reasons, the only tool that might be used is simulation.

Attempts to improve patient waiting time by adjusting appointment schedules have been reported previously, but these studies described highly specific clinic settings (Jennings, 1991; Marshall, 1986). John et al (1997) used a computer program which simulated patient throughput time in a hospital. Githendu (2008) carried out a study on the use of simulation in inventory management. He found that simulation modeling can conveniently be used in stock management. However very little appear to have been done in Kenya in the use of simulation in queue management. Given the centrality of queue management as key success factor in patient satisfaction, it should be studied and documented.

Models are not universally valid, but are designed for specific purposes (Law and Keton 1991). Identifying a suitable queuing model for a particular waiting line is not an easy task due to the stochastic nature of arrival times and service rates. Different researchers studying different queue systems have come up with different models that best fits the situation being studied. The proposed study intends to develop a simulation model that can effectively be used to solve queue management problems in Accident and Emergency department in a hospital.

1.3 Research Questions

1) How can a simulation model be used to determine an optimal throughput time?
2) How does the number of health care personnel affect the patient throughput time?

1.4 Research Objective

The overall objective is to develop a simulation model that will help in reducing throughput time in Accident and Emergency department.

1.5 Specific Objectives.

1) To determine the current status of the queuing system that is currently in use in AKUH A&E department.
2) Develop a queuing model for AKUH A&E department using simulation.
3) Determine what staffing levels should be used in AKUH A&E department within the budget constraints in order to reduce overall through put time.

1.6 Value of the study

The study shall be significant in the following ways: First it will guide hospital management in formulating policies that will result in enhanced patient service in the Accident and Emergency department. Second, serve as a basis of further research on use of simulation in other sectors of the economy. Third, it will add to the already existing knowledge on the use of simulation in business.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

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. Kumar and Kapur (1989) describe using simulation for scheduling staff for emergency room. This chapter covers various studies that have been carried out to simulate queues systems in hospitals.

2.2 Waiting Lines (Queuing)

Queuing can be defined as waiting to be served. Waiting lines form because people or things arrive at the servicing function, or server, faster than they can be served. Waiting lines result because customers do not arrive at a constant rate, nor are they served in an equal amount of time. Decisions and management of waiting lines are based on average customers arrivals and service times. According to Roberta and Bernard *(T000)* waiting line processes are generally categorized into four basic structures, according to the nature of the service facilities: single-channel, single-phase; single-channel, multiple-phase; multiple-channel, single-phase; and multiple-channel, multiple-phase.

Waiting to be attended to is undesirable. Models have been developed to help managers understand and make better decisions concerning the operation of waiting lines. Efficiency and effectiveness of outpatient services have many dimensions, but an important aspect is excessive waiting time, which is a major complaint of patients

(Clague et al., 1997). Waiting time in outpatient clinics has been documented to be a source of dissatisfaction among patients (Uehira and Kay, (2009); Bielen and Demoulin, (2007); Kujala et al., (2006); Barlow, (2002); Hart, (1996); Gupta et al., (1993); McKinnon et al., (1998). Hart (1996) argues that this is the one consistent feature of dissatisfaction that has been expressed with outpatient service.

The realization that patient waiting time is directly related to service quality prompted a large number of studies to focus on how to reduce this time (Gandhi et al., 2003; Lane et al., 2000; Gonzalez et al., 1997; Braly, 1995). These and other studies used Accident and Emergency simulation models to evaluate the impact operational changes such as staffing levels and schedules (Evans et al., 1996; Rossetti et al., 1999) have on Accident and Emergency department performance measures. A more general study analyzed patient time delays in six major hospitals in Dublin (Regan, 2000). The study identified inappropriate staffing levels of nurses and physicians, confusing medical staff role definitions, long distances to adjacent facilities and inappropriate Accident and Emergency layout structures as the primary causes for patient delays.

While increased waiting time is a problem in Kenya, the phenomenon is worldwide. A five-country hospital survey by Blendon et al. (2004) found that Canada, Britain and the USA reported average wait of two hours or more. In Hong Kong public hospitals, Aharonson et al. (1996) found that the longest time that patients spent at the clinic was in waiting for consultation where 82 per cent of total visit time is spent in the waiting room. Heckerling (1984) conducted a study in Illinois and found that 84 percent of the patients had already been examined by a physician an hour after arrival. In Britain, the official and publicized waiting time according to the Patient's Charter is 30 minutes, although the reality may be quite different.

2.2.1 Arrival Rate

This is the rate at which customers arrive at the service facility during a specified period of time. This rate can be estimated from empirical data derived from studying the system or a similar system, or it can be an average of these empirical data. Whenever customers arrive at a rate that exceeds the processing system rate, a line or queue will form. Arrivals may come in singly or in batches; they may come in consistently spaced or in a completely random manner. A potential customer can also leave if, on arrival, he or she finds the line too long. Arrivals at a service are assumed to conform to some probability distribution.

On arrival, patients need to be placed in an appropriate queue. Patient flow Management stresses the possibility of segmenting the customers in different queues if appropriate, rather than entering all customers in the same queue. The most common segmentation is based on customer needs, e.g. separate queues for separate services. Customers with more complex service requirements can then be managed separately, which reduces the risk of blocking other customers with a negative impact on their service experience.

2.2.2 Service Rate

The queuing theory arrivals are described in terms of a rate and service in terms of time. Service times in a queuing process may be any of a large number of different probability distributions. Usually we assume that the service times are independent and identically distributed, and that they are independent of the inter-arrival times. For example, the service times can be deterministic or exponentially distributed. It can also occur that service times are dependent of the queue length. The distribution commonly assumed for service times is the negative exponential distribution. Empirical research has shown that the assumption of negative exponentially distributed service times is not valid nearly as often as is the assumption of Poisson-distributed arrivals. The service mechanism describes how the customer is served. It includes the number of servers and the duration of the service time, both of which may vary greatly and in a random fashion. The service time may be similar for each job or it could vary greatly.

2.2.3 Queue Discipline

The queue discipline is the order in which waiting customers are served. The most common type of queue discipline is first come, first served (FIFO). Other queue disciplines are possible. Often customers are scheduled for service according to a predetermined appointment, such as patients in a dentist's clinic or arrive randomly to the service system.

2.4 Characteristics of Queuing Models

A queuing system can be described as customers arriving for service, waitint^for service and leaving the system after being served. A queuing system is characterized by arrival pattern of those requiring service, service pattern of servers, queue discipline, system capacity, number of service channels, and number of service stages. A queuing analysis is based on set of assumptions, namely, that only single individuals are coming to a system and that there are no bulk arrivals. Lengths of the intervals between arrivals are independently and identically distributed and described by a continuous density function. It is assumed that inter-arrival times and service times follow the exponential distribution or equivalently that the arrival rate and service rate follow a Poisson distribution. Queue discipline refers to the manner in which waiting patients are selected for service when a queue is formed which could be either first-in and first-out (FIFO) or some other specified priority order.

Different queuing characteristics used include mean waiting time, incidence of excessive waiting rather than mean waiting time, average queue length, and expected number of busy and idle servers, probability that those requiring service will not have to wait at all, probability that those needing service may not be served at all, etc. Considering that healthcare is by far most important factor to control, any resource planning in healthcare context should be based on limiting values of queuing characteristics rather than only average values. With the limiting value it is intended to imply that desired patient waiting times should be zero or near zero, probability that patients will not have to wait should be unity or near one, probability that patients will not be served due to laxity of servers should be zero or near zero, expected queue length of patients should be minimal or very small, and expected number of idle servers should not be allowed to increase inordinately.

2.5 Scheduling Systems

There are two scheduling systems in outpatient departments: the patient and staff. Appointment scheduling and staff scheduling are the two aspects that determine the waiting time in the outpatient departments. These schedules should be organized according to the types of patients and consultation categories.

2.5.1 Patient Scheduling

In patient scheduling, the types of appointment systems range from single-block appointments on the one extreme to individual appointments on the other. Most of the appointment systems have concentrated on modifying and combining these two systems into different forms. Any combination in the appointment interval, block size, and initial block create an appointment schedule rule.

The single-block system assigns all patients to arrive in a block at the beginning of the clinic session, allocating a "date" rather than a specific appointment time (Babes and Sarma 1991). Such a system was used in the past by most hospitals. The single-block system creates long waiting time for patients but shortens idle time for doctors.

The individual-block/fixed-interval system gives unique appointment times for patients staggered evenly over the clinical session (Klassen and Rohleder 1996). The individual-block/fixed-interval with an initial block system is similar, but the number of patients assigned to the initial block is greater than one. Bailey (1952) introduced this rule to the appointment schedules literature, and Ho and Lau (1992) added some amendments.

Following an analytical approach, Soriano (1966) advocated the multiple-block/fixed-interval rule to the appointment schedules literature recommending patients be schedule two at a time with an interval of twice the consultation time. Cox, Birchall, and Wong (1985) investigated the multiple-block/fixed-interval with an initial block rule, introducing an initial block to the above rule.

The Individual-block/variable-interval rule calls patients individually with unequal appointment intervals. Introducing this rule to the literature, Ho and Lau (1992) concluded that a variable-interval appointment-scheduling system designed to reduce patient waiting time performs well in most environmental conditions.

2.5.2 Staff Scheduling

A number of studies have addressed the queuing problem from the point of staff scheduling. From this aspect, the staff is scheduled to meet patient demand while setting patient arrival as unchanged. Alessandra et al. (1978) studied both staffing levels and patient arrivals to identify the bottleneck and improve patient throughput time, where they proposed that the morning appointment patients to be distributed to the afternoon shift. Ho and Lau (1992) identified an alternative which reduced average patient waiting time and average patient time in a system in an Accident and Emergency department.

2.6 Queue Simulation Modeling.

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

Fenghueih and Mong, (1996) carried 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 which recommended that extra sessions be added in the afternoons. The result 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) carried out a study in a government clinic outpatient in Hong Kong. The method used in the study included a site appraisal and a time and motion study, first for achieving an understanding of the system under study and the process taking place, and then for 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 they showed that under these conditions not only the queues forming are long, but also that doctors will 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.

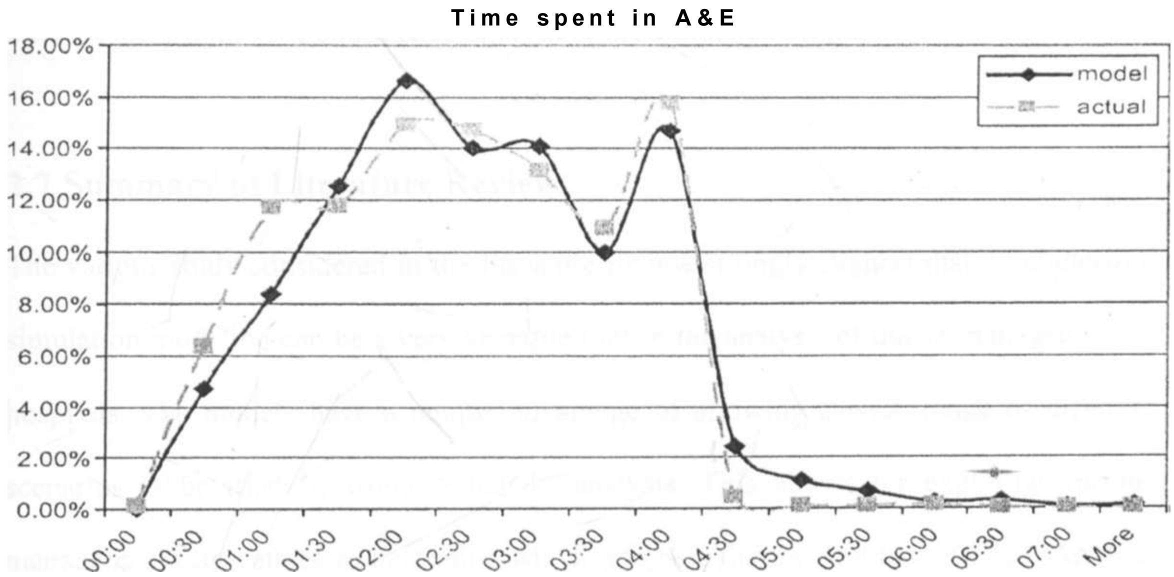
Garcia et al (1995) analyzed the effects of using a fast track lane to reduce waiting times of low priority patients in an Accident and Emergency room. Emergency rooms were prioritized according to the condition of the patient which means that the jow priority patients wait longer than those who arc in serious condition. A fast track lane is dedicated to serving non-urgent patients. They found that a fast track lane that uses a minimal amount of resources could greatly reduce patient waiting times.

McGuire (1994) used a simulation model to determine how to reduce the length of stay for patients in an Accident and Emergency department in Sun Health hospital. From the simulation study results, several alternatives were recommended which included adding a holding area for waiting patients, adding an additional clerk during peak hours and using physicians instead of residents in the fast track area. Blake and Carter (1996) analyzed an Accident and Emergency department at the Children's Hospital of Eastern Ontario. Based on their simulation results, a fast track lane for treating patients with minor injuries was implemented. Ritondo and Freedman (1993) showed the procedure policy in the triage results in a decrease in patient waiting times in the Accident and Emergency room and an increase in patient throughput time.

Alessandra et al (1978) studied the staffing levels and patient arrival rates to ease bottlenecks and to improve patient throughput time. They analyzed eight alternatives that involved varying the staffing pattern and the patient scheduling scheme. They found that the best alternative was to keep the staffing and arrival rate the same, but to distribute the current morning appointment patients to afternoon shift. Draeger (1992) simulated nurse workload in an emergency room and its effect on the average number of patients, average time in system, average number of patients waiting and average patient waiting time. Comparing the current schedule's performance to those of two alternative staffing schedules, they found an alternative that could reduce both the average patient time in the system and average patient waiting time without increasing costs. Evans et al (1996) developed a model that reduced the patient's length of stay by finding the optimal number of nurses and technicians that should be on duty during four shift periods in an Accident and Emergency room.

A well developed simulation model can be a good approximation of the real situation. Julie et al., (2011) used discrete-event simulation to model a waiting line in the A&Edepartment at a UK hospital. They collectcd three different weeks of data from the hospital which was used as input data for the model. The result of the model showed that the mean service rate was almost identical to the mean service rate of actual data that were collected as illustrated in figure 2.1 below. This implies that a well constructed simulation model can be a very good approximation of the real situation on the ground.

Figure 2.1 Comparison of actual (dashed line) and model (solid line) for length of stay in A&E department.



John et al. (1997) used a computer program which simulated patient throughput time in a clinic. The model used was developed using data from the medical outpatient clinics. Using the model they were able to assess the consequences of changes in the clinic structure and the influence on clinic performance. The computer simulation and appointment scheduler they developed confirmed the finding of a previous report on the reduction of the waiting time made possible by placing new patient appointments in the middle of the clinic.

Sung and Arun (2010), simulated the A&E department where they classified emergency patients into four categories. Any patient coming into the department first stops over the screening. After the screening, the patient registers at the registration station, and then based upon the screening result; a nurse triages the patient at the triage station. The patient then waits to see a doctor, who determines and provides the appropriate treatment for the patient. When the patient is discharged after the treatment, the patient arranges payment at the payment station before leaving the A&E department. They results of the simulation showed that the actual average patient wait times at the registration and triage stations are within 95% confidence interval of the simulated estimates.

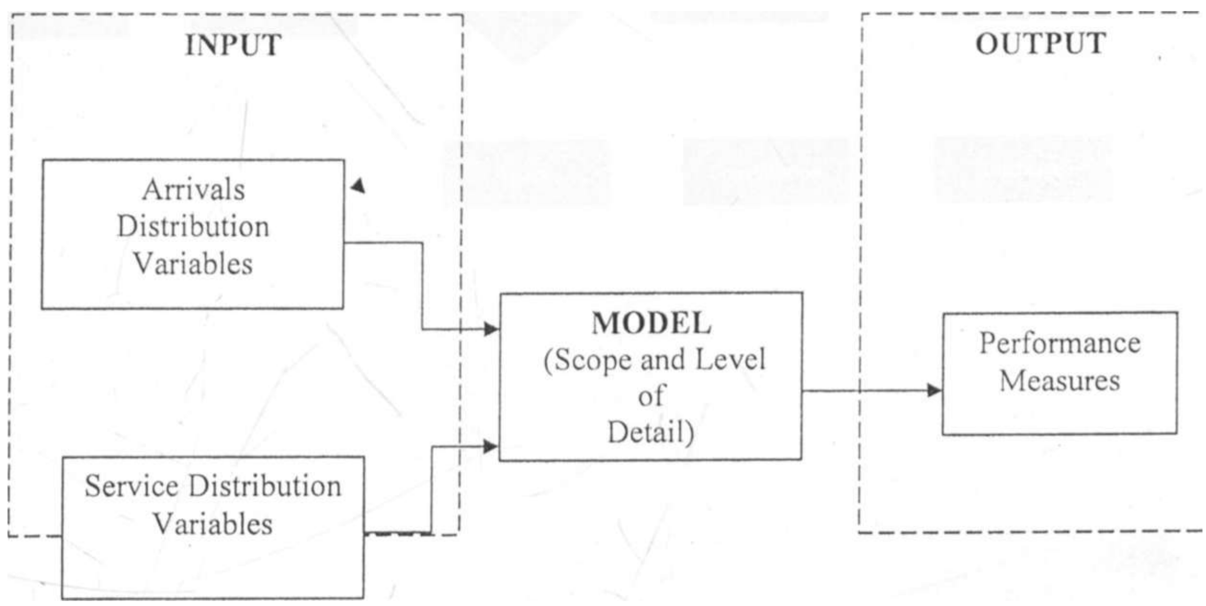
2.7 Summary of Literature Review

The various study considered in the literature review strongly suggest that computerized simulation modeling can be a very versatile tool in the analysis of queue management in hospitals. The models have a unique advantage of allowing a wide range of different scenarios to be tried by using "what if' analysis. This allows for exploring various management alternatives to determine which one best fits the problem at H3nd. Another benefit of simulation modeling that strongly comes out of the literature review is that the process of modeling is participative which allows the hospital management to be part of the solution. In the Kenyan context, there has been no empirical evidence of the study on using simulation modeling on hospital queue management. This study attempted to fill this gap.

2.8 Conceptual Framework

The conceptual framework is presented as shown below. It shows the input variables on the left side, intervening variables (model) in the middle and the dependent variable on the right side.

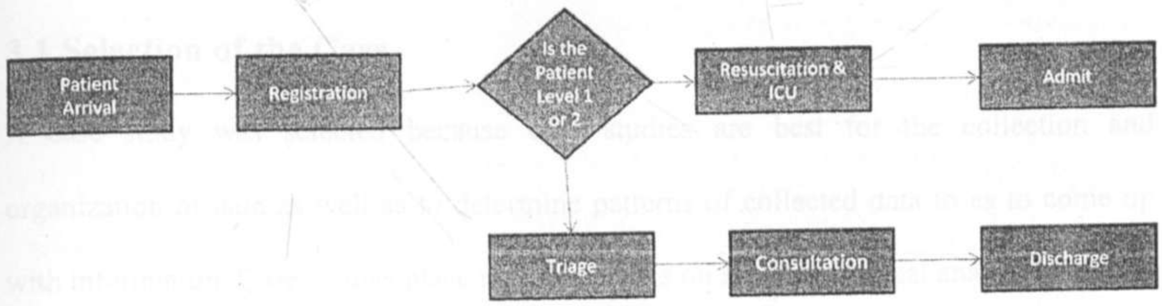
Figure 2.2: Conceptual Framework



2.9 Description of the Model

In the Accident and Emergency department patients arrive either as walk in patients who have been referred by their general practitioner or in ambulances. When a walk-in patient arrives in the department they are registered before going through the triage where their basic observation e.g. blood pressure, weight, pause etc., are taken and the severity of their illness assessed. The Patients are then are then directed to the appropriate area within the A&E department as shown in figure 2.3.

Figure 2.3 Overview of the Model



CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Selection of the Case

A case study was selected because case studies are best for the collection and organization of data as well as to determine patterns of collected data to as to come up with information. Case studies place more emphasis on a full contextual analysis of fewer events or conditions and their interrelations (Donald and Pamela, 2006). Aga Khan University hospital was chosen since it has a well established record system where most of the secondary data was obtained from and is also one of the major private hospitals in Kenya.

3.2 Research Design

The study was based on a case study of Aga Khan University Hospital Accident and Emergency department. Yin (1994) defines the case study as an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. Research design constitutes the blueprint for the collection, measurement, and analysis of data. The study used descriptive design. Descriptive research determines and reports the way things are (Mugenda and Mugenda, 2003).

3.3 Research Methodology

The purpose of the study was to develop a queuing simulation model that would help to determine the operating parameters that would reduce patient throughput time in the AKUH A&E department. To accomplish this, the study began by defining the current state of patient flow through the A&E department. Next, it was important to ensure that the simulation model worked correctly and that it accurately depicted the AKUH A&E department. Lastly "what if' questions were answered using the model to determine ways in which the patient throughput time could be improved.

Any walk-in patient coming to A&E department first goes to the registration desk before proceeding to the triage. If the patient condition is clearly critical (level land2), the patient goes directly for the resuscitation. After going through the triage the patient waits to see a doctor, who provides the appropriate treatment for the patient. A patient may be admitted or discharged. A discharged patient pays for the service received at the payment clerk desk. At each workstation is a queue of patients waiting to be served. Patients are entities that the simulation model processes, and work stations are locations where entities are routed for processing. Each work station is attended and serviced hospital personnel. The personnel are resources that the simulation model uses for servicing entities. The changes that the A&E department management considers in order to improve patient throughput time is adding one extra workforce who should either be a registration clerk, a triage nurse or a payment clerk but only one of each. The A&E department may also consider adding one consultation room which will be manned by one extra doctor.

3.4 Data collection and Analysis

The study used secondary from the Enterprise Resource Planning (ERP) System and other databases that were kept in the hospital. To gain a comprehensive understudying of the patient throughput time at AK.UH A&E department, an analysis was performed on patient data distributions. The A&E manager was interviewed to understand the layout and the processes that take place in the department.

A simulation analysis was conducted using ARENA Simulation software. ARENA 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 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; capacity of each work station; and number of health care personnel available at each workstation for the January 2012 to September 2012 was obtained. The acuity levels were classified as 1 and 2 patients (critical patients) and level 3, 4 and 5 (non-critical patients).

3.5 Testing the Simulation Model

The simulation model was tested to ensure that it was functional and accurate. Two major test stages were conducted - verification and validation. First verification of the model was carried out to debug the model and ensure that it performed its purpose. The validation of the model was performed to ensure it represented what would happen in real life and that it accurately represented the patient flow at the AKUH A&E department. This was done by ensuring the patient How order, entrance to the system, times in queue and service times was in conformity with model.

To validate the model, the simulation results were compared to real-life data. This was done by using two metrics:-the patient times from point of entry to discharge from the emergency department and the number of patients through the system in a given amount of time. The A&E manager was asked questions to validate that the model was an accurate representation of their emergency department. Absolute validation is usually impossible because the simulation is at best an approximation of the real system, and the most definitive method is to compare the output data from the simulation with the actual data from existing system using formal statistical analysis such as confidence intervals (Son, 1993). In validating the simulation model of this study, the confidence intervals of the simulation output were calculated at 95% level of confidence.

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSION

4.1 Data Analysis

The three stages of the methodology - data collection, simulation model building and experimentation, were completed in sequential order with objective of improving patient throughput 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 payment clerks. The scenario with an extra doctor was also tested.

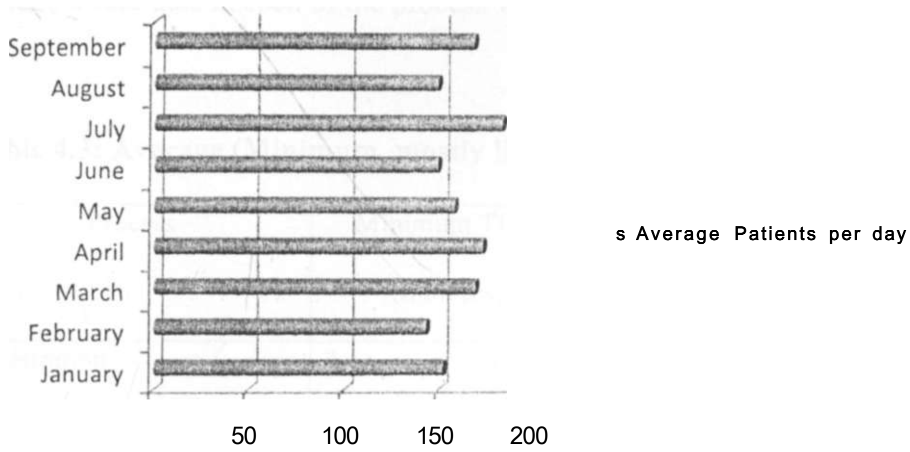
On average 160 patients visited the A&E department per day. The data for January to September for the year 2012 is shown in table 4.1 below and represented in graphical form in figure 4.1.

Table 4.1: Average patients per day by month

Month	Average Patients per day
January	152
February	143
March	169
April	173
May	158
June	149
July	183
August	149
September	168

Source: AKUH patient data base

Figure 4.1: Average patients per day



Source: AKUH patient data base

4.2 Current Status of the AKUH A&E queuing system

The number of personnel in each of the work station before the change in shown in table 4.2 below.

Tabic 4.2: Personnel at each workstation before change

Work Station	Personnel	No. of Personnel in the work station
Registration	Registration Clerk	1
Triage	Triage Nurse	2
Consultation Room	Doctor	4
Admission/Discharge	Discharge Clerk	1
Resuscitation	Doctor	1
ICU	Team	-
Pharmacy	Pharmacist	1

Source: AKUH patient data base

From the A&E records, the minimum, the most likely time and the maximum time a patient would take in each of the process was obtained as summarized in table 4.3 below.

Table 4.3: Average (Minimum, mostly likely and maximum time) in each process

Process	Minimum Time (minutes)	Mostly Likely (minutes)	Maximum (minutes)
Registration	4	7	10
Triage	5	10	15
Doctor Consultation	10	25	40
Payment	5	10	15
Discharge& Admission	8	10	15

Source: AKUH patient data base

A

After running the patient inter-arrival data using ARENA probability distribution analyzer, it was established that the average patient inter-arrival time is exponentially distributed with an average of 9 minutes.

Currently the registration desk is manned by one clerk, there are two operational triages and a third one is available in case the number of patient goes beyond a certain level. There are four operational consultations room each manned by a doctor and a fifth one is available in case the number of patients goes beyond a certain level. There is one payment counter manned by one clerk and the admission/discharge desk in also manned by one clerk. It was established that approximately 5% of the patients need to be resuscitated and may eventually proceed to ICU.

4.3 Results of the study

The simulation model was run in two different scenarios: "before" and "after" the changes in the emergency care process. Both scenarios are built on a common foundation or base model in which the variables are held constant. The simulation modrf-was run for 50 independent replications for six months. The simulation results presented are based on the average results of the 50 independent replications.

4.3.1 Simulated patient waiting time before the changes

Table 4.4 shows the simulation results on patient wait time at each station in the emergency care process before the changes.

Table 4.4: Simulated patient waiting time at the workstations (in minutes)

Process	Average	Half Width	95% Confidence Interval	
			Lower Limit	*Upper Limit*
Registration	12.7	0.16	12.45	12.86
Consultation Room 1	25.0	0.51	24.49	25.51
Consultation Room 2	23.6	0.41	23.49	24.01
Consultation Room 3	23.8	0.42	23.38	24.22
Consultation Room 4	23.6	0.41	23.19	24.01
Triage 1	3.1	0.03	3.07	3.13
Triage 2	3.2	0.04	3.16	3.24
Payment	9.2	0.12	9.08	9.32

Before the changes- patients experience the longest wait times at the consultation rooms (an average of 24 minutes). The actual average at the consultation room is 25 minutes. This shows that the results are within the 95% confidence interval. The next longest stay is at the registration desk (12.7 minutes) followed by the payment station (9.2 minutes).

4.3.2 Simulated patient through put time before the changes

Table 4.5 shows the simulation results on patient through put time in the emergency care process before the changes. The simulated average throughput time is very close to the actual average throughput time which stands at two hours (120 minutes). The hospital management target is to have the average throughput time reduced to one hour and forty five minutes (105 minutes)

Table 4.5: Simulated patient through put time before changes (minutes)

Through time	Half width	95% Confidence Interval	
		Lower Limit	Upper Limit
118.74	0.48	1 17.26	119.26

The results show that the average simulated through put time before any changes in the operating parameters is 119 minutes.

4.3.3 Simulated patient throughput time after adding one registration clerk

Table 4.6 shows the simulation results on patient through put time in the emergency care process after adding one registration clerk.

Table 4.6: Simulated patient through put time after adding one registration clerk (minutes)

Through time	Half width	95% Confidence Interval	
		Lower Limit	Upper Limit
111.94	0.50	111.44	112.44

The results shows that on average, the through put time would be reduced by (118.74 - 11 1.94) 6.80 minutes.

4.3.4 Simulated patient throughput time after adding one triage nurse

Table 4.7 shows the simulation results on patient through put time in the emergency care process after adding one more triage nurse.

Table 4.7: Simulated patient through put time after adding one triage nurse (minutes)

Throughput time	Half width	95% Confidence Interval	
		Lower Limit	Upper Limit
J 16.81	0.49	1 15.32	117.30

The results shows that on average, the through put time would be reduced by (118.74 - 116.81) 1.93 minutes.

4.3.5 Simulated patient throughput time after adding one doctor

Table 4.8 shows the simulation results on patient through put time in the emergency care process after adding one more triage nurse.

Table 4.8: Simulated patient through put time after adding one doctor (minutes)

Throughput time	Half width	95% Confidence Interval	
		Lower Limit	Upper Limit
108.71	0.42	108.29	109.13

The results shows that on average, the through put time would be reduced by (118.74 - 108.71) 10.03 minutes.

4.3.6 Simulated patient throughput time after adding one payment clerk

Table 4.9 shows the simulation results on patient through put time in the emergency care process after adding one more triage nurse.

Table 4.9: Simulated patient throughput time after adding one payment clerk (minutes)

Throughput time	Half width	95% Confidence Interval	
		Lower Limit	Upper Limit
- 117.73	0.55	117.18	118.28

The results shows that on average, the through put time would be reduced by (118.74 - 117.73) 1.01 minutes.

The alternative for adding one more doctor (consultation room) yield the highest reduction in throughput time 10 minutes, which was followed by adding one more registration clerk reduces the throughput time by approximately 7 minutes. In contrast adding an extra payment clerk reduces the throughput time by only 1 minute. Since the hospital objective is to reduce the average throughput time from the current average of two hours (120 minutes) to one hour and forty five minutes (105) minutes, the best alternative would be to add one more consultation room doctor since this reduces the throughput time to 109 minutes.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

Aga Khan University Hospital is addressing issues within the emergency department as a means to improve efficiency, safety, and both patient and staff satisfaction. The hospital is evaluating the current operations of its Emergency Department in an effort to improve the though put time and general patient satisfaction. The objectives of this project were to use the simulation model to define the current state and identify ways to improve patient throughput while enhancing patient satisfaction. To do this, we analyzed data and conducted interviews to establish a comprehensive understanding of the hospital's emergency department.

5.2 Conclusion

A detailed and validated model of A&E department of Aga Khan University hospital is reported. In the process of developing the model, important aspects of formal and informal processes have been identified. Most of the formal processes have been incorporated within the model, but informal processes have proven difficult to capture and include. It is assumed their effect does not significantly affect the results of the simulation model. Using computer simulation the study modeled the A&E department 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. The 95% confidence intervals of the simulation outputs include the actual values, indicating that simulation model is capable of reproducing the emergency care process in the hospital with respect to patient throughput time. The simulation results demonstrate that adding one more consulting doctor can shorten the throughput times in the emergency care process, and shows that computer simulation can be an effective decision support tool in modeling the emergency care 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.

5.3 Recommendation

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 four to five the throughput time decreased substantially. It is there recommended that one more doctor be engaged. Periodic evaluation of staffing in the A&E should be carried out to identify the areas where more staff is needed in order to continually reduce the throughput times within the budgetary constraints. The other recommendation is 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. This is important because data on the time taken by a patient to move from one workstation to the other was missing.

5.4 Limitations of the study

Although I confident in this work and recommendations, I do recognize that they may not perfectly reflect the conditions in the Emergency Department at AKUH A&E department. There are a couple of limitations that were encountered. One limitation of the simulation model, and subsequently the testing and experimentation, is that in simulating the throughput times I did not categorize the data into various acuity level. This was because there was a lot of data overlap of the patients in the acuity levels. Thus level 1 and 2 patients were categorized in the same group while level 3, 4 and 5 patients were categorized in the same group. The other limitation encountered was that a doctor could be helped by an intern or a nurse and hence it was difficult to estimate the time he takes to attend the patient.

5,5 Areas of further study

More simulation studies should be conducted on effect of changing the layout of the A&E and incorporating transfer times on the throughput times. Further simulation studies should also 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 model. Simulation studies which include other departments which share resources with A&E should also be carried out.

REFERENCES

Aharonson, D.L., Paul, R.J. and Hedley, A.J. (1996), "Management of queues in outpatient departments: the use of computer simulation", Journal of Management in Medicine, Vol. 10 No. 6, pp. 50-8.

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

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

Babes, M. and G. V. Sarma. 1991. "Out-patient queues at the Ibn-Rochd health center". Journal of the Operational Research Society, Vol. 42 No. 10, pp. 845-855.

Baily, N. T. J. 1952. "A study of queues and appointment systems in hospital out-patient departments, with special reference to waiting-times". Journal of the Rtryal Statistical Society Vol. 14 No. 2, pp. 185-199.

Barlow, G.L. (2002), "Auditing hospital queuing", Managerial Auditing Journal, Vol. 17 No. 7, pp. 397-403.

Bielen, F. and Demoulin, N. (2007), "Waiting time influence on the satisfaction loyalty relationship in services", Managing Service Quality, Vol. 17 No. 2, pp. 174-93.

Blake JT and Carter MW (1996). Analyses of emergency room wait time via computer simulation. INFOR 34: 263-272.

Blendon, R.J., Schoen, C. and DesRoches, C.M. (2004), "Confronting competing demands to improve quality: a five-country hospital survey", Health Affairs, Vol. 23 No. 3, pp. 119-35.

Brailsford, S., Harper, P., Patel, B. and Pitt, M. (2009), "An analysis of the academic literature on simulation and modelling in health care", Journal of Simulation, Vol. 3 No. 3, pp. 130-40.

Braly, D. (1995), "Seek alternatives via simulation software", Health Management Technology, Vol. 16 No. 13, pp. 13-15.

Cayirli, T., Veral, E. and Rosen, H. (2008), "Assessment of patient classification in appointment system design", Production and Operations Management, Vol. 17 No. 3, pp. 338-53

Clague, J.E., Reed, P.G., Barlow, J., Rada, R., Clarke, M. and Edwards, R.H.T. (1997), "Improving outpatient clinic efficiency using computer simulation", International Journal of Healthcare Quality Assurance, Vol. 10 No. 5, pp. 197-201.

Cox, T. F., J. F. Birchall, and H. Wong. 1985. "Optimizing the queuing system for an ear, nose and throat outpatient clinic". Journal of Applied Statistics Vol. 12 No. 3, pp.113-126.

Donald R.C. and Pamela S.S. (2006). Business Research Methods, 9th edition. McGraw-Hill.

Draeger MA (1992). An emergency department simulation model used to evaluate alternative nurse staffing and patient population scenarios. In: Swain JJ, Goldsman D, Crain RC and Wilson JR (eds). Proceedings of the 1992 Winter Simulation Conference. Institute of Electrical and Electronics Engineers, Arlington, Virginia, USA, 13-16 December, pp 1057-1064.

Duguay, C. and Chetouane, F. (2007), "Modeling and improving emergency department systems using discrete event simulation", Simulation, Vol. 83 No. 4, pp. 311-20.

Evans GW, Gor TB 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, 8-11 December, pp 1205-1209.

Evans, G.W., Unger, E. and Gor, T.B. (1996), "A simulation model for evaluating personnel schedules in a hospital emergency department", Proceedings of the 96 Winter Simulation Conference, pp. 1205-9.

Fenghueih, H. and Mong, H.L. (1996), "Using Simulation in out-patient queues: A case study", International Journal of Healthcare Quality Assurance, Vol. 9 No. 6, pp. 21-25.

Fletcher, A. and Worthington, D. (2009), "What is a 'generic' hospital model? A comparison of 'generic' and 'specific' hospital models of emergency patient flows", Health Care Management Science, Vol. 12 No. 4, pp. 374-91.

Gandhi, T., Nagarkar, K., DcGennaro, M. and Srihari, K. (2003), "Reducing patient turnaround time in an emergency room", Proceedings of the International Conference on Production Research. —

Garcia ML, Centeno MA, Rivera C and DeCario N (1995). Reducing time in an emergency room via a fast-track. In: Alexopoulos C, Kang K, Lilegdon WR, Goldsman D . Proceedings of the 1995 Winter Simulation Conference. Institute of Electrical and Electronics Engineers, Washington DC, USA, 3-6 December, pp 1048-1053.

Githendu, D. 2008. Inventory Management by Simulation Analysis: A Case Study of Davis & Shirtliff Company Limited. University of Nairobi, unpublished MBA dissertation.

Gonzalez, C.J., Gonzalez, M. and Rios, N.M. (1997), "Improving the quality of service in an emergency room using simulation-animation and total quality management", Computer and Industrial Engineering., Vol. 33 No. 1-2, pp. 87-100.

Government of Kenya, 2009. Economic Survey

Gupta, P.C., Witty, J. and Wright, N. (1993), "An approach to consumer feedback in an outpatient specialty service", International Journal of Health Care Quality Assurance, Vol. 6 No. 5, pp. 13-16.

Hart, M. (1996), "Improving the quality of out-patient services in NHS hospitals: some policy considerations", International Journal of Health Care Quality Assurance, Vol. 9 No. 7, pp. 28-38.

Ho, C. and H. Lau. 1992. "Minimizing total cost in scheduling outpatient appointments". Journal of Management Science Vol. 38 No. 2, pp. 1750-1764.

Hoot, N.R., LeBlanc, L.J., Jones, I., Levin, S.R., Zhou, C., Gadd, C.S. and Aronsky, D. (2008), "Forecasting emergency department crowding: a discrete event simulation", Annals of Emergency Medicine, Vol. 52 No. 2, pp. 116-25.

Jennings M., "Audit of a new appointment system in a hospital outpatient clinic", British Medical Journal, Vol. 302, 1991, pp. 148-9.

John E. Clague, Patrick G. Reed, Judith Barlow, Roy Rada, Margaret Clarke, Richard H.T. Edwards, (1997),"Improving outpatient clinic efficiency using computer simulation", International Journal of Health Care Quality Assurance, Vol. 10 Iss: 5 pp. 197-201

Julie E., Malcolm C., Claire P. and Terry Y. (2011)," Meeting the four-hour deadline in an A&E department", Journal of Health Organization and Management Vol. 25 No. 6, pp. 606-624.

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, Vol. 50 No. 2, pp. 109-23.

Katzman, C.N. (1999), "New Jersey hospital works to satisfy customers", Modern Healthcare, Vol.29 No. 51, p. 48.

Klassen, K. J. and T. R. Rohleder. 1996. "Scheduling outpatient appointments in a dynamic environment". Journal of Operations Management Vol. 14 No. 2, pp. 83-101.

Kujala, J., Lillrank, P., Kronstrom, V. and Peltokorpi, A. (2006), "Time-based management of patient processes", Journal of Health Organisation and Management, Vol.20 No. 6, pp. 512-24.

Kumar, A. and Shim, S.J. (2007), "Eliminating emergency department wait by BPR implementation", Proceedings of the 2007 IEEE International Conference on Industrial Engineering and Engineering Management, pp. 1679-83.

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.

Lane, D.C., Monefeldt, C. and Rosenhcad, J.V. (2000), "Looking in the wrong palace for healthcare improvements: a system dynamics study on an A&E Department", Journal of the Operations Research Society, Vol. 51, pp. 518-31.

Limor A.D., Ray J.P. and Anthony J.H. (1996), "Management of queues in out-patient departments: The use of computer simulation", Journal of management in Medine, Vol. 10 No. 6, pp. 50-58.

Marshall, E.I., "Waiting for doctor', British Medical Journal, Vol. 297, 1986, pp. 993-5.

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, 11-14 December, pp 861-867.

McKinnon, K., Champion, P.D. and Edwards, R.H.T. (1998), "The outpatient experience: results of a patient feedback survey", International Journal of Health Care Quality Assurance, Vol. 11 No. 5, pp. 156-60.

Mugenda, O.M., & Mugenda, A. G. (2003). Research methods: quantitative and qualitative approaches. Revised edition. Nairobi: ACTS Press.

Proctor, T. (1996), "Simulation in healthcare", Health Manpower Management, Vol. 22 No. 5, pp. 40-4.

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

Rising, E.J., Baron, R. and Averill, B. (1973), "A systems analysis of a university-health-service outpatient clinic", Operations Research, Vol. 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 JG 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, 17-20 January, pp 8-11.

Roberta S.R., Bernard W.T. (2000). Operations Management. Prentice Hall, New Jersey.

Rossetti, M., Trzeinski, G. and Syerud, S. (1999), "Emergency department simulation and determination of optimal attending physician staffing schedules", Proceedings of the 99 Winter Simulation Conference, pp. 1532-40.

Son, Y.K. (1993), "Simulation-based manufacturing accounting for modern management", Journal of Manufacturing Systems, Vol. 12 No. 5, pp. 417-27.

Soriano, A. 1966. "Comparison of two scheduling systems". Operations Research Vol. 14 No.3, pp. 388-397.

Stevenson, W.J. (2009). Operations Management. Boston: McGraw-Hill

Tulsian P.C., .R. and Vishal P. (2002). Quantitative Techniques Theory and Problems. Pearson's Education Publishing.

Uehira, T. and Kay, C. (2009), "Using design thinking to improve patient experiences in Japanese hospitals: a case study", Journal of Business Strategy, Vol. 30 Nos. 2/3, pp. 6-12.

Yin, R.K. (1994) Case Study Research: Design and Methods, 2nd edition. Thousand Oaks, CA: Sage.

Zhu, Z.C., Hen, B.H. and Teow, K.L. (2009), "Simulation study of the optimal appointment number for outpatient clinics", International Journal~oT Simulation Modeling, Vol. 8 No. 3, pp. 156-65.

APPENDIX

1: Observation Form

1) What is the size of AKUH in terms of bed size?
2) What is the average number of patients are treated in A&E per day or week?
3) What is the room capacity of the A&E department?
4) How long does each process take?
    (a) Is the process time consistent from patient to patient?
    (b) If it is not consistent, what causes variability in this process?
5) How does the staffing model change throughout the week (day by day)?
    (a) What is the physician-to-nurse ratio?
    (b) What is the nurse to patient ratio?
6) What is distribution of patients of each acuity level?
7) How do you determine whether patients go back to waiting room after triage or straight to exam room?
8) How long does it take for a patient to go through the triage?
    (a) Is the process time consistent from patient to patient? Does it differ depending on the acuity level? Does the time differ even among different types of patients within the same acuity? If there are any differences, what causes the differences?
    (b) How many triage nurses are there? Does this number change (e.g. according to time of the day, day of the week, weekend vs. weekday
9) How many triage rooms are there?
    (a) If there are multiple rooms, are all the rooms staffed?
    (b) Are the rooms fully staffed during certain days/times but unstaffed at other times?
10) How many registration clerks do you have?
    How long does it take for a patient to be registered?
11) What is the average number of patients in each level per day fbt-January to September period?

Level	1	2	3	4	5	Total
Mean Daily number of Patients						

12) Does the flow of Patients depend on

a) Seasonal illness (weather related)

b) Days of the week

c) Time of the day

d) Time of the month

13) Average Patients Per Day by Month

Month	Average Patients per day
January	
February	
March	
April	
May	
June	
July	
August	
September	

14) Average time taken by a Physician to attend to a Patient

Patient Type	Average Treatment Time (minutes)
Level 1 and 2	
Level 3, 4 and 5	

15) Average Total time in A&E as measured from Arrival to Discharge/Admission,

Patient Type	Average Total Time (minutes)
Level 1 and 2	
Level 3 ,4 and 5	

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Figure 6.1 A&E Department Overview

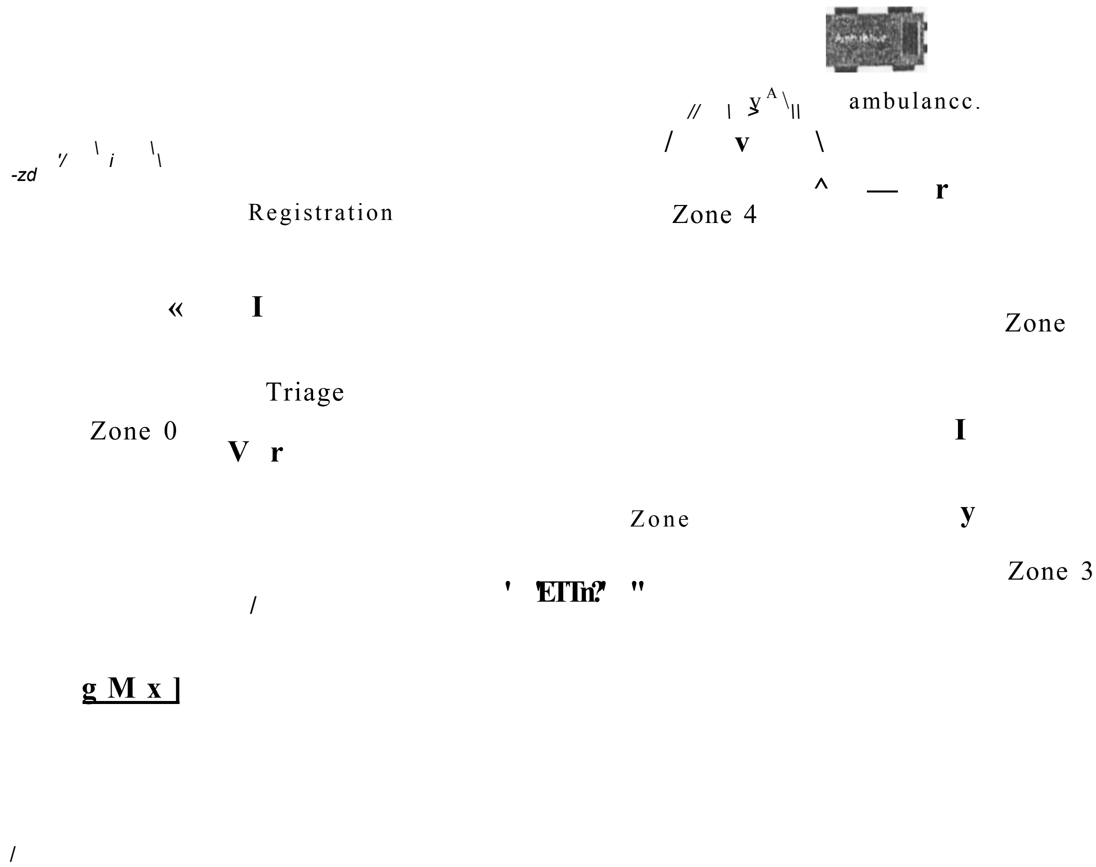
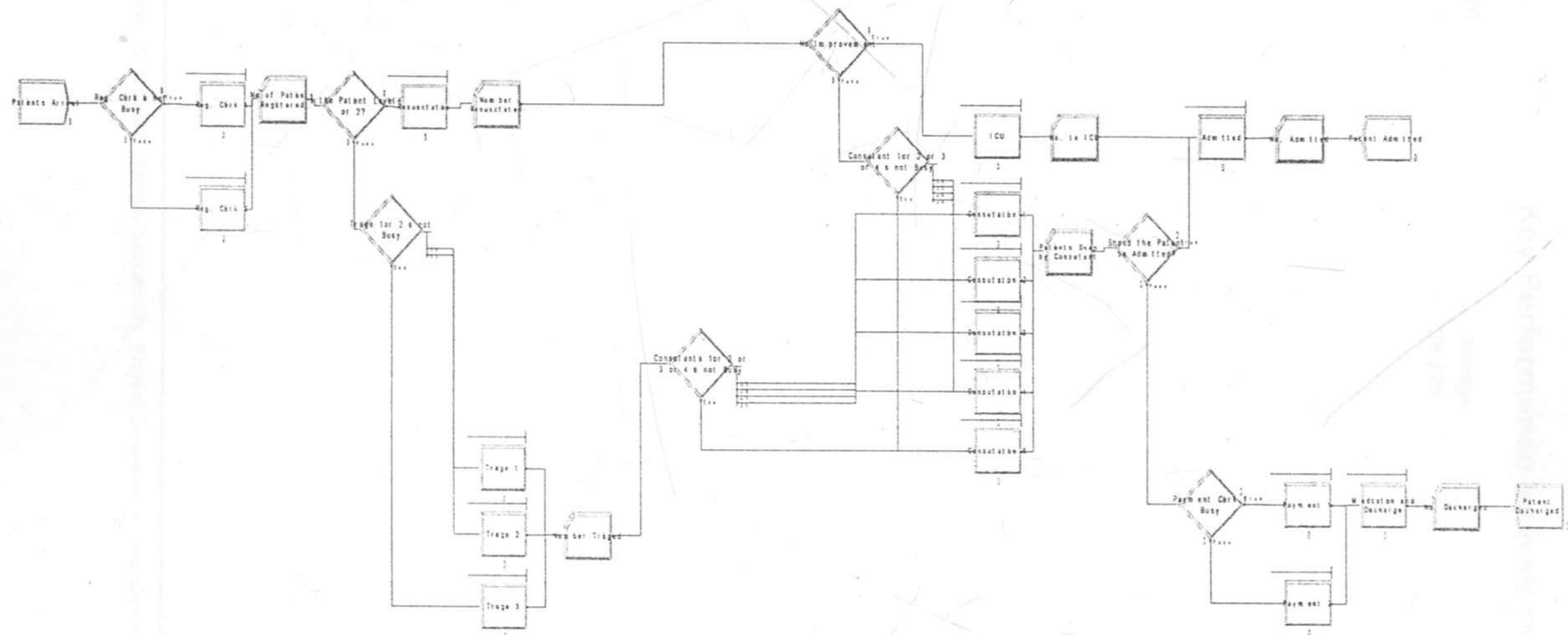


Figure 6.2: The Simulation Model Flow Chart



Values Across All Replications

(UH AE Queue Simulation

Replications: 50 Time Units: Minutes

Key Performance Indicators

System	Average
Number Out	28,795

/

(UH AE Queue Simulation

Replications: 50 Time Units: Minutes

itity

"ime

/A Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
itient	62.2201	0.01	62.1259	62.3131	29.6258	125.59

slVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
itient	0.00	0.00	0.00	0.00	0.00	0.00

A/ait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
atient	56.5171	0.48	52.5762	60.0302	0.00	567.33

rransferTime	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
atient	0.00	0.00	0.00	0.00	0.00	0.00

Dther Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
atient	0.00	0.00	0.00	0.00	0.00	0.00

rotal Time /	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
atient	118.74	0.48	114.77	122.29	32.4834	628.59

Dther

Number In	Average	Half Width	Minimum Average	Maximum Average
atient	28808.00	49.97	28499.00	29163.00

Mumber Out	Average	Half Width	Minimum Average	Maximum Average
atient	28795.32	50.28	28487.00	29155.00

/VIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
atient	13.1950	0.07	12.6544	13.6645	0.00	49.0000

KUH AE Queue Simulation

Replications: 50 Time Units: Minutes

w

rocess

fime per Entity

VA Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Emitted	16.6683	0.01	16.5900	16.7685	10.0048	24.9752
:onsultation 1	25.0230	0.03	24.7615	25.1959	10.0223	39.9841
onsultation 2	25.0053	0.02	24.8237	25.1606	10.0360	39.9733
onsultation 3	24.9988	0.02	24.8527	25.1891	10.0231	39.9752
onsultation 4	25.0055	0.02	24.8398	25.2189	10.0295	39.9582
onsultation 5	25.1118	0.18	23.4195	26.2309	10.1117	39.6325
;u	53.2961	0.09	52.5127	53.9138	30.1702	89.7708
ledication and Discharge	10.9997	0.00	10.9815	11.0229	8.0048	14.9935
ayment 1	9.9997	0.00	9.9707	10.0291	5.0070	14.9952
eg. Clerk 1	6.9999	0.00	6.9794	7.0155	4.0039	9.9980
esuscitation	2.6676	0.01	2.6154	2.7095	1.0112	4.9896
riage 1	10.0005	0.01	9.9354	10.0834	0.00	28.0000
riage 2	9.9987	0.01	9.9236	10.0759	0.00	29.0000

Wait Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
dmitted	9.7723	0.13	8.8040	10.6961	0.00	177.99
onsultation 1	25.0453	0.51	21.1348	28.2069	0.00	449 69
onsultation 2	23.5595	0.41	21.0437	26.0802	0.00	367.79
onsultation 3	23.8219	0.42	21.3420	27.7073	0.00	357.15
onsultation 4	23.5546	0.41	20.3316	26.1411	0.00	327.86
onsultation 5	0.1146	0.05	0.00	0.8265	0.00	34.3931
;u	8.3017	0.27	5.8999	10.1568	0.00	290.67
ledication and Discharge	9.9056	0.24	8.1288	11.6532	0.00	218.54
ayment 1	9.2162	0.12	8.3172	10.0817	0.00	150.44
eg. Clerk 1	12.7088	0.16	11.7625	14.0378	0.00	189.15
esuscitation	27.0376	0.46	22.3488	30.8900	0.00	421.78
riage 1	3.1297	0.03	2.9350	3.4825	0.00	81.2048
riage 2	3.1585	0.04	2.8554	3.4292	0.00	72.1164

AKUH AE Queue Simulation

Replications: 50 **Time Units:** Minutes

process

Time per Entity

Total Time Per Entity	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
"Admitted	26.4406	0.13	25.5095	27.4008	10.0196	193.22
Consultation 1	50.0683	0.52	46.2066	53.1394	10.0223	478.26
Consultation 2	48.5649	0.41	45.9159	51.1359	10.0682	391.79
Consultation 3	48.8207	0.42	46.1947	52.7612	10.0406	379.31
Consultation 4	48.5602	0.42	45.2976	51.1099	10.0414	348.93
Consultation 5	25.2264	0.19	23.4195	26.5663	10.1117	58.7524
;cu	61.5978	0.30	59.1042	63.5994	30.1702	339.05
Medication and Discharge	20.9052	0.24	19.1295	22.6725	8.0159	228.71
Payment 1	19.2158	0.12	18.3176	20.0997	5.0070	157.61
Reg. Clerk 1	19.7087	0.16	18.7690	21.0407	4.0039	195.14
Resuscitation	29.7052	0.46	25.0126	33.5977	1.0177	423.48
Triage 1	13.1302	0.04	12.9103	13.4568	0.00	88.7517
Triage 2	13.1572	0.04	12.8148	13.4889	0.00	86.1164

Accumulated Time

/

Values Across All Replications

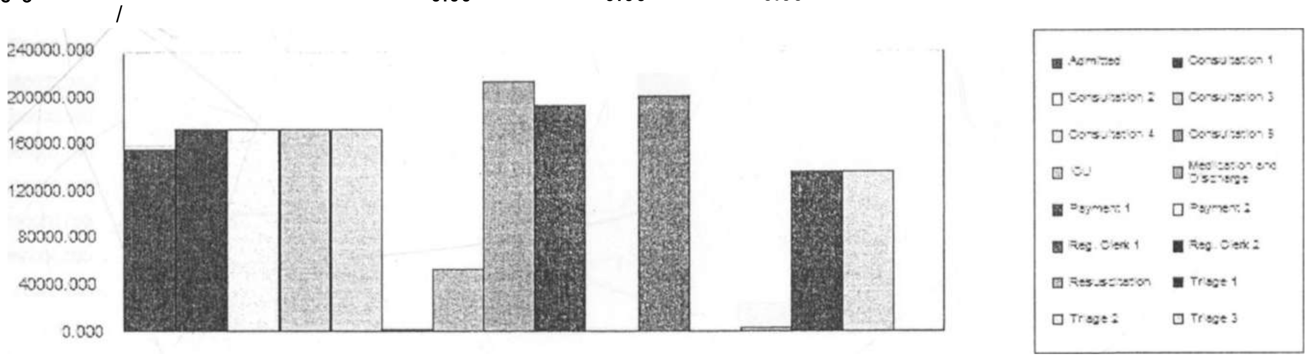
AKUH AE Queue Simulation

Replications: 50 **Time Units:** Minutes

process

Accumulated Time

Accum VA Time	Average	Half Width	Minimum Average	Maximum Average
Admitted	155661.92	464.21	153110.90	160121.87
Consultation 1	173892.42	564.78	170355.52	178638.66
Consultation 2	172924.66	634.23	167773.56	177049.94
Consultation 3	172974.60	621.45	169369.35	178860.24
Consultation 4	173284.15	594.20	168607.57	177660.75
Consultation 5	2165.87	65.07	1740.77	2658.74
ICU	53235.12	565.12	49586.39	57976.84
Medication and Discharge	214014.68	429.41	210229.16	217532.70
Payment 1	194573.14	415.10	190959.69	197924.44
Payment 2	0.00	0.00	0.00	0.00
Reg. Clerk 1	201637.19	351.58	199505.47	204377.21
Reg. Clerk 2	0.00	0.00	0.00	0.00
Resuscitation	3811.78	34.72	3605.42	4076.22
Triage 1	136913.04	362.85	134804.00	140813.00
Triage 2	136830.90	373.45	133350.00	139258.00
Triage 3	0.00	0.00	0.00	0.00



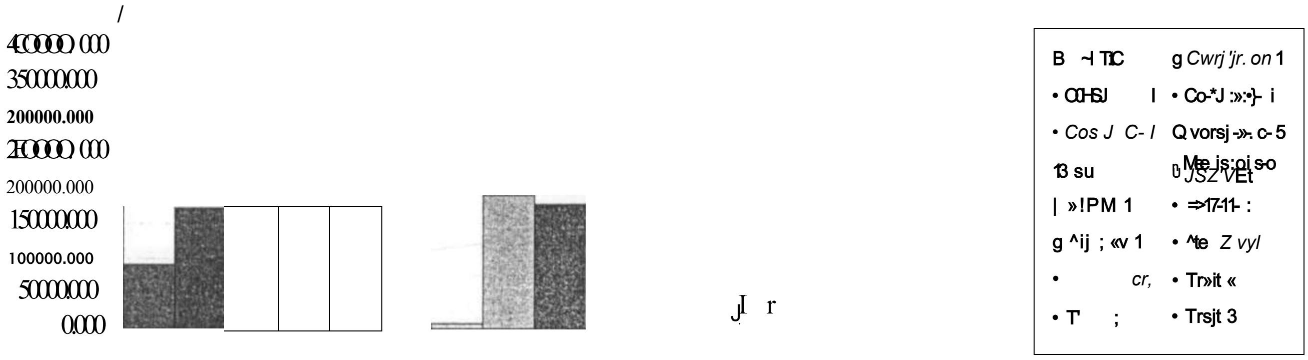
AKUH AE Queue Simulation

Replications: 50 **Time Units:** Minutes

process

Accumulated Time

Accum Wait Time	Average	Half Width	Minimum Average	Maximum Average
Admitted	91285.05	1,397.95	81499.06	100243.48
Consultation 1	174121.45	3,896.75	145597.32	200071.56
Consultation 2	162986.30	3,164.38	143056.32	183083.25
Consultation 3	164893.79	3,237.56	147131.67	197802.28
Consultation 4	163289.00	3,163.90	139653.13	183598.68
Consultation 5	9.9021	4.56	0.00	71.0759
ICU	8306.35	313.62	5498.74	10745.95
Medication and Discharge	192788.10	4,962.30	155896.39	225723.02
Payment 1	179368.37	2,672.31	159478.27	198054.09
Payment 2	0.00	0.00	0.00	0.00
Reg. Clerk 1	366141.30	4,988.29	335208.34	407138.16
Reg. Clerk 2	0.00	0.00	0.00	0.00
Resuscitation	38632.84	739.26	33101.26	45072.98
Triage 1	42853.48	498.93	39957.16	48114.35
Triage 2	43230.08	553.02	38876.20	47425.69
Triage 3	0.00	0.00	0.00	0.00



Other

Category Overview

Values Across All Replications

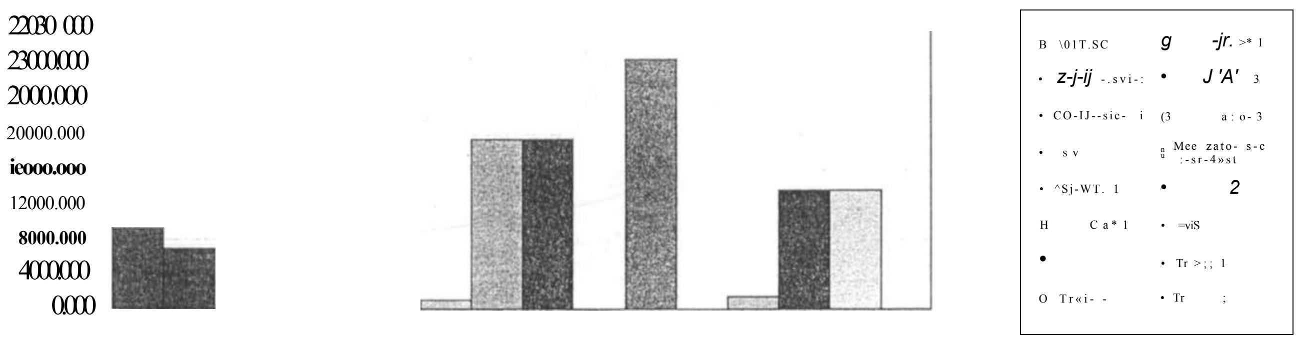
AKUH AE Queue Simulation

Replications: 50 **Time Units:** Minutes

Process

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
Admitted	9339.74	28.04	9165.00	9590.00
Consultation 1	6950.36	21.15	6825.00	7141.00
Consultation 2	6916.76	25.47	6701.00	7078.00
Consultation 3	6920.52	24.11	6764.00	7141.00
Consultation 4	6931.28	21.94	6735.00	7089.00
Consultation 5	86.3200	2.64	68.0000	104.00
ICU	999.16	10.47	932.00	1087.00
Medication and Discharge	19457.96	40.02	19128.00	19794.00
Payment 1	19459.38	39.95	19128.00	19795.00
Payment 2	0.00	0.00	0.00	0.00
Reg. Clerk 1	28808.00	49.97	28499.00	29163.00
Reg. Clerk 2	0.00	0.00	0.00	0.00
Resuscitation	1429.04	12.96	1347.00	1534.00
Triage 1	13691.00	31.89	13502.00	14006.00
Triage 2	13685.72	35.36	13321.00	13967.00
Triage 3	0.00	0.00	0.00	0.00



Values Across All Replications

AKUH AE Queue Simulation

Replications: 50 Time Units: Minutes

Process

Other

Number Out	Average	Half Width	Minimum Average	Maximum Average
Admitted	9338.82	28.09	9164.00	9590.00
Consultation 1	6949.30	21.22	6824.00	7140.00
Consultation 2	6915.54	25.41	6701.00	7078.00
Consultation 3	6919.32	24.11	6764.00	7139.00
Consultation 4	6929.80	21.98	6732.00	7088.00
Consultation 5	86.3000	2.65	63.0000	104.00
ICU	998.86	10.48	932.00	1087.00
Medication and Discharge	19456.50	40.12	19127.00	19794.00
Payment 1	19457.96	40.02	19128.00	19794.00
Payment 2	0.00	0.00	0.00	0.00
Reg. Clerk 1	28805.76	50.12	28498.00	29162.00
Reg. Clerk 2	0.00	0.00	0.00	0.00
Resuscitation	1428.96	12.95	1347.00	1534.00
Triage 1	13690.56	31.88	13502.00	14006.00
Triage 2	13684.88	35.35	13321.00	13965.00
Triage 3	0.00	0.00	0.00	0.00

Values Across All Replications

AKUH AE Queue Simulation

Replications: 50 Time Units: Minutes

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Admitted.Queue	9.7722	0.13	8.8040	10.6957	0.00	177.99
Consultation 1.Queue	25.0447	0.51	21.1348	28.2096	0.00	449.69
Consultation 2.Queue	23.5606	0.41	21.0437	26.0802	0.00	367.79
Consultation 3.Queue	23.8220	0.42	21.3420	27.7098	0.00	357.15
Consultation 4.Queue	23.5543	0.41	20.3314	26.1396	0.00	327.86
Consultation 5.Queue	0.1146	0.05	0.00	0.8265	0.00	34.3931
ICU.Queue	8.3026	0.27	5.8999	10.1473	0.00	290.67
Medication and Discharge.Queue	9.9056	0.24	8.1285	11.6527	0.00	218.54
Payment 1 .Queue	9.2162	0.12	8.3168	10.0811	0.00	150.44
Reg.Clerk 1.Queue	12.7087	0.16	11.7625	14.0381	0.00	189.15
Resuscitation.Queue	27.0379	0.46	22.3488	30.8900	0.00	421.78
Triage 1 .Queue	3.1297	0.03	2.9350	3.4823	0.00	81.2048
Triage 2.Queue	3.1585	0.04	2.8552	3.4295	0.00	72.1164

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Admitted.Queue	0.3522	0.01	0.3144	0.3868	0.00	11.0000
Consultation 1.Queue	0.6719	0.02	0.5617	0.7721	0.00	17.0000
Consultation 2.Queue	0.6290	0.01	0.5523	0.7063	0.00	16.0000
Consultation 3.Queue	0.6363	0.01	0.5676	0.7633	0.00	13.0000
Consultation 4.Queue	0.6301	0.01	0.5388	0.7083	0.00	13.0000
Consultation 5.Queue	0.00003820	0.00	0.00	0.00027421	0.00	1.0000
ICU.Queue	0.03206287	0.00	0.02121426	0.04145812	0.00	5.0000
Medication and Discharge.Queue	0.7439	0.02	0.6015	0.8708	0.00	20.0000
Payment 1.Queue	0.6921	0.01	0.6154	0.7641	0.00	16.0000
Payment 2.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Reg.Clerk 1.Queue	1.4127	0.02	1.2933	1.5709	0.00	26.0000
Reg.Clerk 2.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Resuscitation.Queue	0.1491	0.00	0.1277	0.1739	0.00	6.0000
page 1.Queue	0.1653	0.00	0.1542	0.1856	0.00	8.0000
Triage 2.Queue	0.1668	0.00	0.1500	0.1830	0.00	7.0000
[riage 3.Queue	0.00	0.00	0.00	0.00	0.00	0.00

Values Across All Replications

AKUH AE Queue Simulation

Replications: 50 Time Units: Minutes

Resource

Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Admitting Clerk	0.6006	0.00	0.5907	0.6178	0.00	1.0000
Doctor 1	0.6856	0.00	0.6727	0.7049	0.00	1.0000
Doctor 2	0.6672	0.00	0.6473	0.6831	0.00	1.0000
Doctor 3	0.6674	0.00	0.6534	0.6901	0.00	1.0000
Doctor 4	0.6686	0.00	0.6505	0.6854	0.00	1.0000
Doctor 5	0.00835729	0.00	0.00671594	0.01025750	0.00	1.0000
ICU Medical Team	0.2054	0.00	0.1913	0.2237	0.00	1.0000
Medication Clerk	0.8257	0.00	0.8111	0.8392	0.00	1.0000
Payment Clerk 1	0.7507	0.00	0.7367	0.7636	0.00	1.0000
Payment Clerk 2	0.00	0.00	0.00	0.00	0.00	0.00
Registration Clerk 1	0.7779	0.00	0.7697	0.7885	0.00	1.0000
Registration Clerk 2	0.00	0.00	0.00	0.00	0.00	0.00
Triage Nurse 1	0.5282	0.00	0.5201	0.5433	0.00	1.0000
Triage Nurse 2	0.5279	0.00	0.5145	0.5373	0.00	1.0000
Triage Nurse 3	0.00	0.00	0.00	0.00	0.00	0.00

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Admitting Clerk	0.6006	0.00	0.5907	0.6178	0.00	1.0000
Doctor 1	0.6856	0.00	0.6727	0.7049	0.00	1.0000
Doctor 2	0.6672	0.00	0.6473	0.6831	0.00	1.0000
Doctor 3	0.6674	0.00	0.6534	0.6901	0.00	1.0000
Doctor 4	0.6686	0.00	0.6505	0.6854	0.00	1.0000
Doctor 5	0.00835729	0.00	0.00671594	0.01025750	0.00	1.0000
ICU Medical Team	0.2054	0.00	0.1913	0.2237	0.00	1.0000
Medication Clerk	0.8257	0.00	0.8111	0.8392	0.00	1.0000
Payment Clerk 1	0.7507	0.00	0.7367	0.7636	0.00	1.0000
Payment Clerk 2	0.00	0.00	0.00	0.00	0.00	0.00
Registration Clerk 1	0.7779	0.00	0.7697	0.7885	0.00	1.0000
Registration Clerk 2	0.00	0.00	0.00	0.00	0.00	0.00
Triage Nurse 1	0.5282	0.00	0.5201	0.5433	0.00	1.0000
Triage Nurse 2	0.5279	0.00	0.5145	0.5373	0.00	1.0000
Triage Nurse 3	0.00	0.00	0.00	0.00	0.00	0.00

AKUH AE Queue Simulation

Replications: 50 **Time Units:** Minutes

Resource

Usage

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Admitting Clerk	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Doctor 1	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Doctor 2	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Doctor 3	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Doctor 4	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Doctor 5	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
ICU Medical Team	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Medication Clerk	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Payment Clerk 1	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Payment Clerk 2	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Registration Clerk 1	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Registration Clerk 2	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Triage Nurse 1	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Triage Nurse 2	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Triage Nurse 3	1.0000	0.00	1.0000	1.0000	1.0000	1.0000

11:49:09AM

Category Overview

Values Across All Replications

October 24, 2012

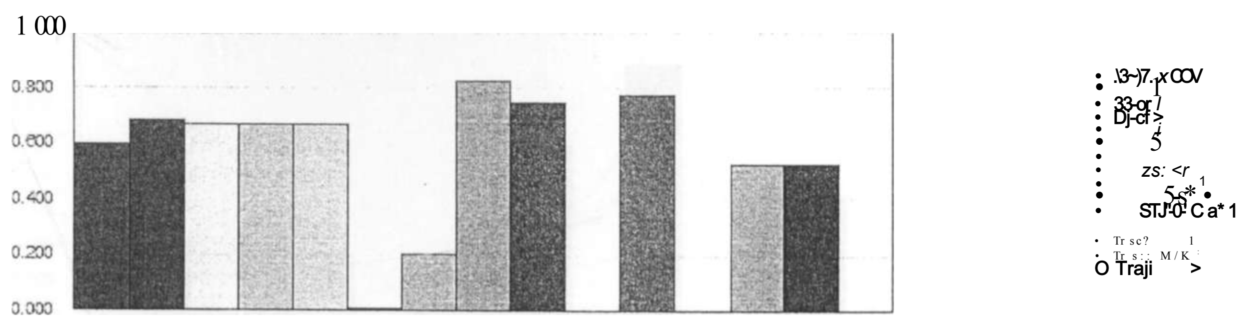
AKUH AE Queue Simulation

Replications: 50 Time Units: Minutes

Resource

Usage

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Admitting Clerk	0.6006	0.00	0.5907	0.6178
Doctor 1	0.6856	0.00	0.6727	0.7049
Doctor 2	0.6672	0.00	0.6473	0.6831
Doctor 3	0.6674	0.00	0.6534	0.6901
Doctor 4	0.6686	0.00	0.6505	0.6854
Doctor 5	0.00835729	0.00	0.00671594	0.01025750
ICU Medical Team	0.2054	0.00	0.1913	0.2237
Medication Clerk	0.8257	0.00	0.8111	0.8392
Payment Clerk 1	0.7507	0.00	0.7367	0.7636
Payment Clerk 2	0.00	0.00	0.00	0.00
Registration Clerk 1	0.7779	0.00	0.7697	0.7885
Registration Clerk 2	0.00	0.00	0.00	0.00
Triage Nurse 1	0.5282	0.00	0.5201	0.5433
Triage Nurse 2	0.5279	0.00	0.5145	0.5373
Triage Nurse 3	0.00	0.00	0.00	0.00



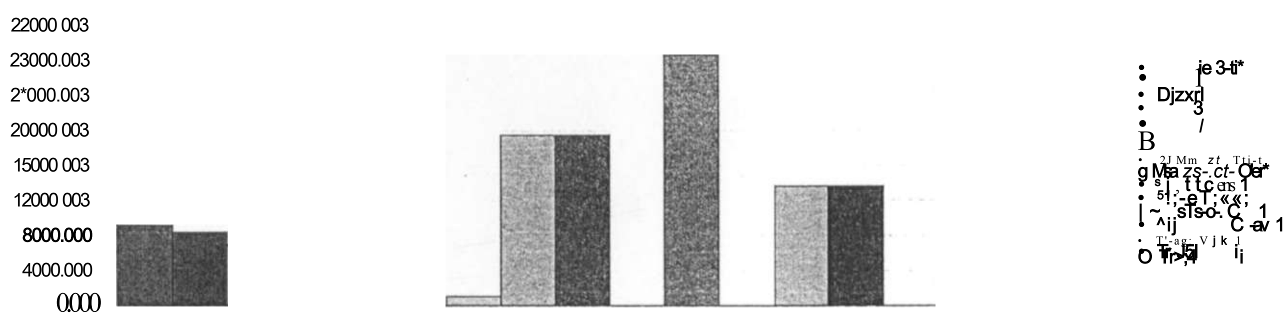
AKUH AE Queue Simulation

Replications: 50 **Time Units:** Minutes

Resource

Usage

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Admitting Clerk	9339.46	28.08	9165.00	9590.00
Doctor 1	8378.90	26.34	8172.00	8626.00
Doctor 2	6916.08	25.42	6701.00	7078.00
Doctor 3	6919.96	24.12	6764.00	7140.00
Doctor 4	6930.62	21.97	6733.00	7089.00
Doctor 5	86.3200	2.64	68.0000	104.00
ICU Medical Team	999.06	10.49	932.00	1087.00
Medication Clerk	19457.28	40.07	19128.00	19794.00
Payment Clerk 1	19458.76	40.03	19128.00	19795.00
Payment Clerk 2	0.00	0.00	0.00	0.00
Registration Clerk 1	28806.52	50.10	28499.00	29162.00
Registration Clerk 2	0.00	0.00	0.00	0.00
Triage Nurse 1	13690.98	31.89	13502.00	14006.00
Triage Nurse 2	13685.52	35.34	13321.00	13966.00
Triage Nurse 3	0.00	0.00	0.00	0.00



AKUH AE Queue Simulation

Replications: 50 Time Units: Minutes C \Users\G Wamae\Desktop\My_Project\Simulation Project\

User Specified

Counter

Count	Average	Half Width	Minimum Average	Maximum Average
No of Patients Registered	28805.76	50.12	28498.00	29162.00
No. Admitted	9338.82	28.09	9164.00	9590.00
No. Discharged	19456.50	40.12	19127.00	19794.00
No. to ICU	998.86	10.48	932.00	1087.00
Number Resuscitated	1428.96	12.95	1347.00	1534.00
Number Triaged	27375.44	46.07	27091.00	27742.00
Patients Seen by Consultant	27800.26	48.00	27495.00	28189.00