PROCESS IMPROVEMENT IN AN EAR-NOSE-THROAT OUTPATIENT DEPARTMENT: A HOSPITAL CASE STUDY

By

SOPIDA TEPPRATOOM

A Final Report of the Six-Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment of the Requrirements for the Degree of
MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

Martin de Tours School of Management
Assumption University
Bangkok, Thailand

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Master of Science in Supply Chain Management

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ABSTRACT

Long waiting time has become one of the critical problems in health care service which is difficult to solve. Long waiting time not only affects patients' scheduled but also reduces service level of the hospital. There are many causes of this waiting time problem such as inadequate number of doctors to deal with many patients, bad contribution of patients' appointment time, bad room layout and so on. Thus, simulation is used as a tool to analyze the patients' flow, to determine the causes of problem and to improve the process.

The purpose of this research is to reduce total cycle time of patients by reducing the waiting time for each activity. Simulation was applied to simulate and validate the as-is process and also to determine the to-be scenario. The Excel Microsoft solver was used to find the optimal number of doctors and resident doctors. Then the optimized number of doctors and resident doctors and adapted batch size in front of the endoscope room were used to determine and verify total cycle time and waiting time.

The result of simulation showed that after the new process was implemented, the average total cycle time was reduced from 41.28 minutes to 29.92 minutes which was a 27 percent reduction in waiting and cycle time.

ACKNOWLEDGEMENT

Completing of this project, I would like give thanks to all the persons who made this success.

First of all, I am heartily thankful to my advisor, Dr. Athisarn Wayuparb, his encouragement, guidance, and support in ideas throughout the project. He also inspired me to work in this project. Without his support and inspiration, my project might not have been completed.

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CHAPTER I

GENERALITIES OF THE STUDY

Nowadays, competition in the healthcare business is increasing rapidly resulting in the improvement of service quality of each healthcare center in order to attract and satisfy their customers. The waiting time of patients which affects patients' schedule day by day is now an indicator of the service quality and also is one of the problems which healthcare centers normally encounter. Many healthcare centers try to solve this problem in many ways such as rescheduling the appointment time, increasing the doctor/nurse, re-layout the area to improve the flow of patients, improving the working procedures, etc. Also supply chain management now plays an important role and is an important key in every business including the healthcare business. Many healthcare centers apply the supply chain strategy and lean strategy to improve their patients' flow by reducing bottleneck points in the process resulting in decrement of patient's waiting time and increment of their income. This study focuses on how to improve patients' flow and how to reduce total process time of the outpatient department (OPD) in a government hospital in Bangkok, Thailand. The simulation model is conducted based on the collected data, and then the improvement process is developed.

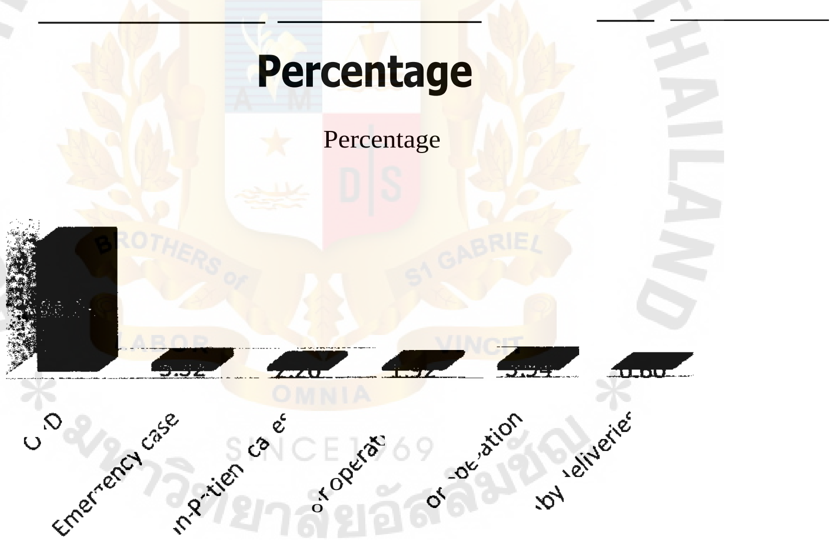
Supply Chain Management and Lean Concept

Supply chain management has become increasingly important in recent years and many companies use supply chain management as a tool to achieve the advantage over their competitors. The objective of supply chain management is to produce and distribute the right products, right quantities, right time and deliver to the right place. It is not only supply chain management that has become an important strategic but, lean concept is also a vital strategic these days. Lean concept is widely applied to many businesses. The core of lean concept is to identify and remove wastes in the process. However, prior to applying the lean concept, all processes and all work contribution have to be clarified and understood in order to develop the process safely. The value-added activities and non value-added activities have to be determined in order to reduce "waste activities".

1.1 Background of the Study

The ABC hospital was established in 1965. It is the large size hospital that consists of 1,118 total hospital beds. At present, the contribution of patient cases consist of 86.03 percent for outpatients, 5.32 percent for emergencies, 3.94 percent for minor operations, 2.20 percent for in-patients, 1.92 percent for major operations and 0.60 percent for baby deliveries. (Presentation IQC of ABC hospital, 2008)

Figure 1.1: Contribution of Patient Cases in 2008



The ABC hospital is divided into eleven service departments consisting of Pediatrics, Ophthalmology, Psychiatry, Family medicine, Rehabilitation medicine, Surgery, Obstetrics and Gynecology, Otolaryngology or Ear-Nose-Throat, Orthopedics, Skin clinic and Premium clinic. The project will be studying the patient flow in the Outpatient Ear Nose and Throat department.

As indicated in Figure 1.1, the outpatient department (OPD) takes on the largest amount of cases, and the most important section in OPD is the Ear-Nose-Throat section because most of patients have a disease related to ear, nose, or throat. Thus, the OPD-ENT of ABC hospital is facing a problem because patients spend a long total process time when they come to see the doctor. The details of the problem will be shown as a problem statement.

OPD-ENT (Outpatient department – Ear-Nose-Throat)

OPD- ENT is a department for curing a patient who has ear, a nose or a throat problem. The operation time is 9.00 a.m. to 12.00 a.m. from Monday to Friday and 1.00 p.m. to 4.00 p.m. from Monday to Friday is for the specific clinic.

At present there are 33 doctors, 16 nurse assistants, 3 nurses and 2 clerks.

1. There is one doctor for each diagnosis room; there are two kinds of doctors. First is a doctor who graduated as a general doctor and working in a specific department which is ear, nose and throat, called "resident" doctor. The resident doctor must study for 3 years to treat the ear-nose-throat. The second is a doctor who has already finished studying specific patients' ear-nose-throat with problems.
2. There is one doctor as a consultant for resident doctors only.
3. There are 2 nurse assistants at the registered station. One of them contacts customers at the window to get the queue number. Another one calls a patient for waiting in front of the diagnosis room.
4. There is one nurse assistant preparing for medical document and assigning patients to the doctors.

5. There are seven nurse assistants for helping the doctor in the diagnosis room. One nurse assistant helps two doctors.

6. There is one nurse assistant in the treatment room.

7. There is one nurse assistant in the endoscopy room.

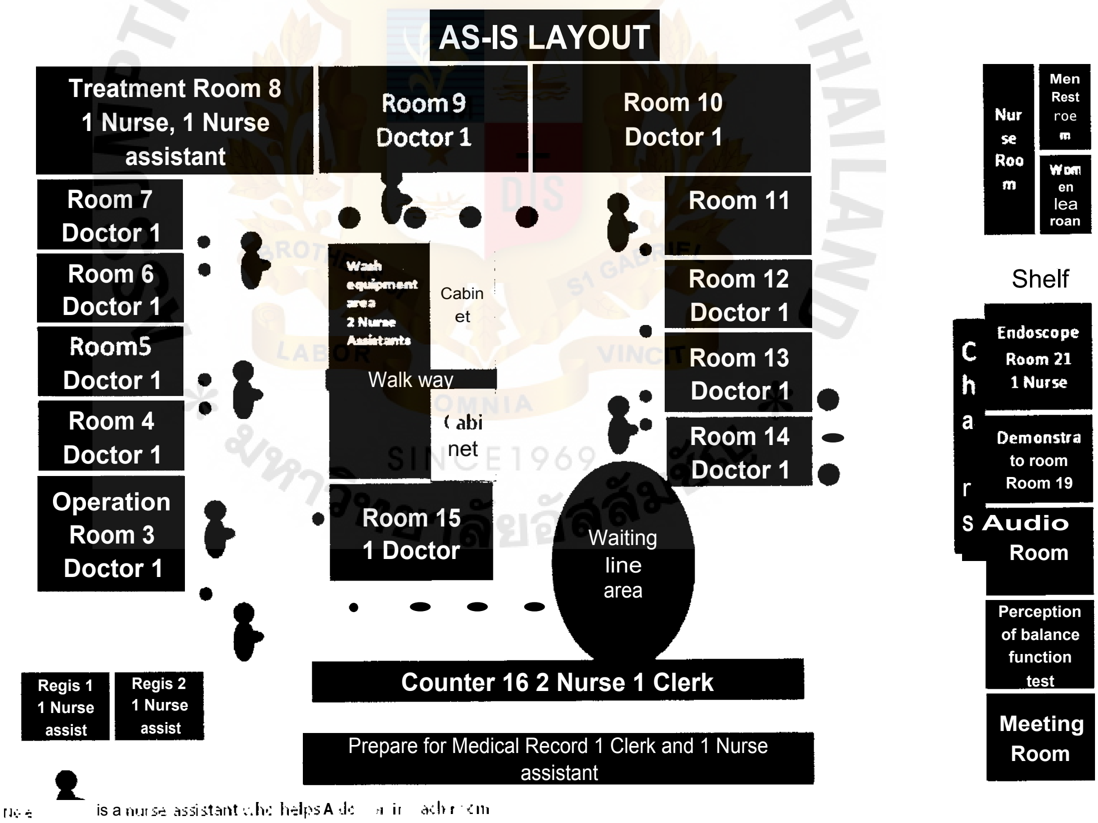
8. There is one nurse assistant in the demonstration room.

9. There are two nurse assistants for preparing and cleaning utensils.

10. There are one nurse assistant and one clerk for station 16 for the next appointment.

11. There is one nurse at the station 16 for taking care of operations or serious cases.

Figure 1.2: AS-IS Layout of OPD-ENT



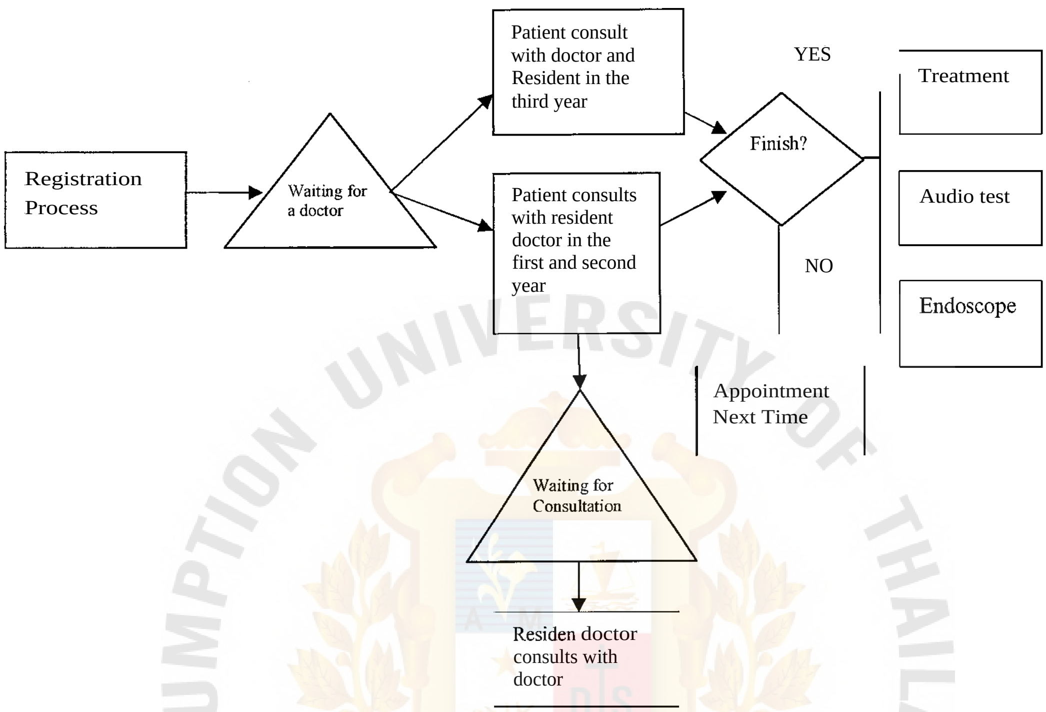
The current layout (SEE Figure 1.2) consists of 11 diagnose rooms for diagnoses. The room number 3 is for operations only. One room for diagnose is assigned for doctor who provides counseling services to resident doctors. There is one treatment room for patients who need treatment such as ear treatment, checking body temperature of body and so on. Room 21 is for endoscopy. Moreover, there is one audio room for patients who need their ears checked.

1.2 Statement of the Problem

Due to a large number of patients in the outpatient department in the government hospital namely ABC, the patients normally encounter a long waiting time. Some patients have to wait for half a day, thus waste their time and make schedule changes Last but not the least, they experience bad emotion.

The ABC hospital now opens on Monday to Friday from 9.00 – 12.00 a.m. like OPD Ear-Nose-Throat clinic, which is the scope of this study open from 1.00-4.00 p.m. However, all the OPD ENT in the morning, doctors cannot finish consultation within 12.00 a.m. due to the work overload and lack of experiences of first and second year resident doctors, thus the bottleneck on the process occurs at this point.

Figure 1.3: Bottle Neck of Patients' Process Flow



According to the data collection and observation for eleven days in the ABC hospital waiting time became a problem in the OPD-ENT department. The staff got the letters of complaints from patients about long waiting time. There are many causes for this problem. One of the most important factors is doctors. From the data collection and interview, one of the bottle necks of the process is from the case of resident doctors who are in the first or second year, the average waiting time for consultation with a doctor. Moreover, the cases of patients who need to do the endoscopy require a doctor from the consultation room. The doctor does not come to the endoscopy room one by one. He is awaiting the batch size of 5 people because he must walk from his diagnosis room. This also causes long waiting time. The first patient who needs to do endoscopy must wait until total number of patients on five. Then a doctor will start to do the endoscopy for the patients. Another bottle neck is at the treatment room become the number of rooms is not enough for patients.

The entire factors above are what have a negative effect for both the Outpatient Ear-Nose-Throat department and patients and also affects to the afternoon clinic opened for special cases such as operation and cancer. The doctors of the afternoon period have to wait until the morning clinic has finished their jobs. If the morning clinic finishes late, the afternoon clinic will also finish late. Patients are also affected with their schedules and waste their time. Some patients are rejected by limited capacity so they have to come again on the next day. This case not only waste patients' time but also waste their money such as transportation cost and so on.

1.2 Research Objectives

The objective will focus on using simulation to validate the alternative scenarios for reducing waiting time. They are as follows;

1.3.1 To determine the process flow behavior of OPD-ENT.

1.3.2 To reduce total time of the process because the current process of OPD-ENT is not finished within 12.00 am.

1.3.3 To improve the process by reducing non-value added time or patients' waiting time.

1.3.4 To use simulation as a tool to validate the solution

1.4 Scope of the Research

Figure 1.4: Scope of the Research

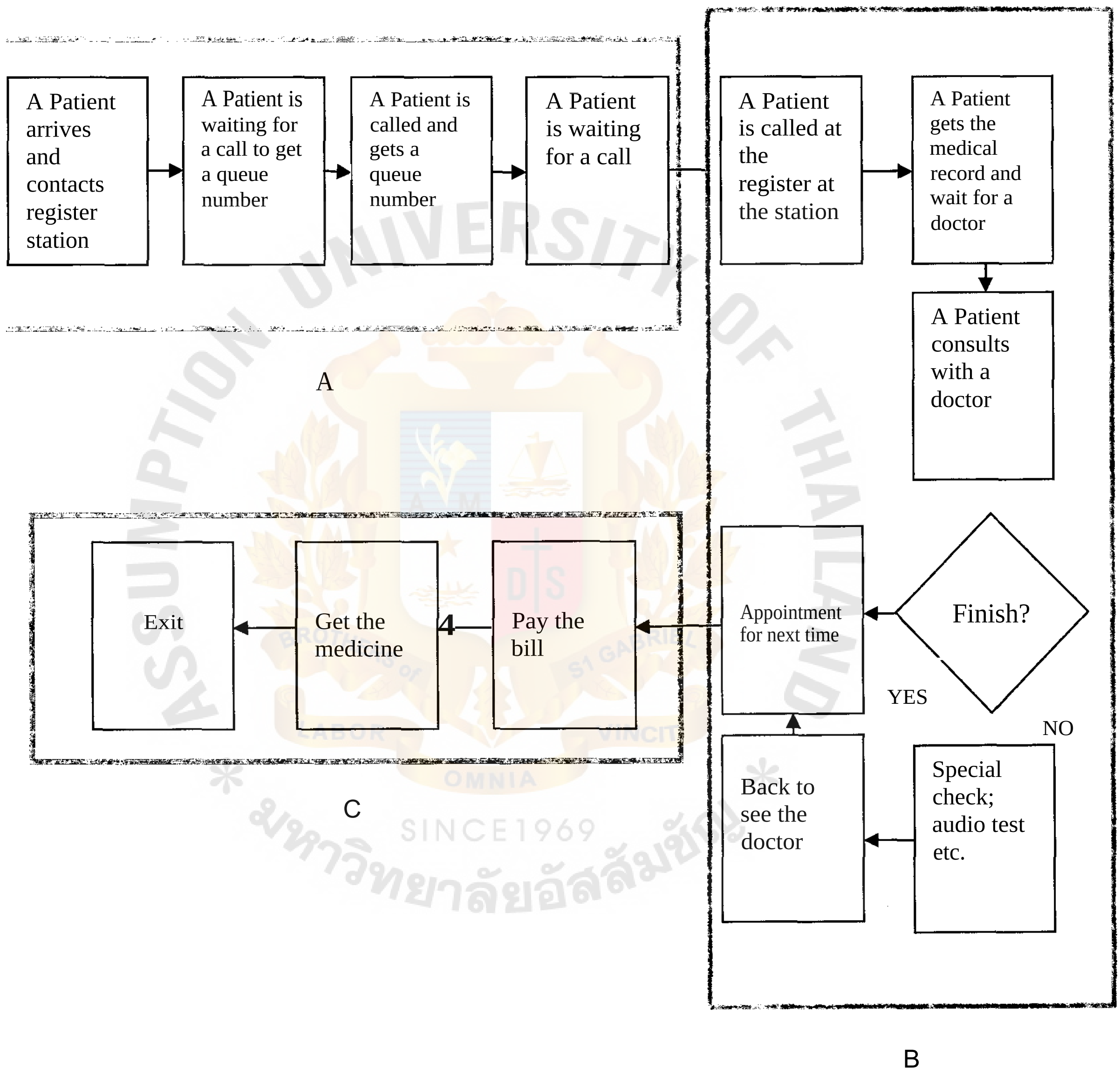


Figure 1.4, indicates that the study focuses on the process improvement for Outpatient Department of Ear- Nose- Throat by using simulation validated by collecting data before making a decision for process development. The scope of study concentrates on the OPD-ENT department area which is show in section B. However, the section A and section C are not covered in the scope of this project. For section A, the data is

difficult to collect because the patients come too early in the morning and they just drop the appointment card. Then they go somewhere else in order to finish their jobs, so it is difficult to follow them. Section B, it is involved with other departments such as Financial and Pharmacy department.

1.5 Limitation of the Research

1.5.1 Because of limited time for data collection, the sample size of data is only 63 patients.

1.5.2 The simulation specifies doctors into a group, not individually.

1.5.3 The project focuses on the Outpatient Ear-Nose-Throat department area, so it does not cover other processes.

1.5.4 Data was collected by following the patients one by one and not by referring to record documents.

1.6 Significance of the Study

The goal of research is to reduce the total process time of Outpatient Department of Ear-Nose-Throat in the ABC hospital by using simulation. The expected result is decrement of total process time and patients' waiting time, in order to finish consultation within 12.00 a.m. The study will benefit hospitals, and patients as follows:

1.6.1 Hospital

1.6.1.1 Satisfy their customers and get higher service level

1.6.1.2 OPD-ENT will finish consultation before 12.00 a.m.

1.6.2 **Patients**

1.6.2.1 Reduce waiting time of OPD-ENT patients.

1.6.2.2 Reduce total process time of patients

1.7 Definition of Terms

OPD – ENT	Out Patient Department Ear-Nose-Throat
Resident doctor	A student doctor who was has a general degree in medicine doctor and who is now studying in specific branch.
Endoscopy	An instrument for visually examining the interior of a bodily canal or a hollow organ such as the colon, bladder, or stomach.
Process time	The time it takes to complete a prescribed procedure
Resource	The percentage of resource creates working
Total Cycle time	Total cycle time is the sum of value-added processing time and total non value-added time.
Non value added Time	Non value-added time is waste time such as waiting time.

CHAPTER II

LITERATURE REVIEW

In this chapter, literature review will be presented in 3 parts which are follows:

2.1 Discrete Event simulation

2.2 Simulation techniques applied in healthcare

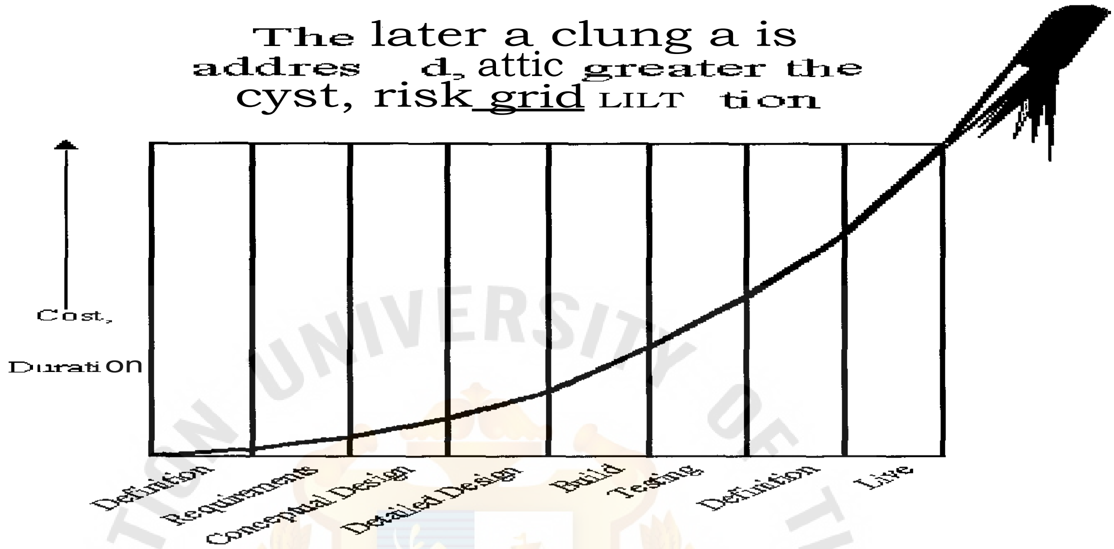
2.3 Benefits of simulation techniques

2.4 Previous study of simulation in healthcare

2.5 Arena software for simulation

As the result of rapid growth and increasing demands, long waiting time in the outpatient section becomes a big problem of healthcare throughout the world (Aharonson-Daniel, Paul, & Hedley, 1996; Babes & Sarma, 1991; Hashim, Tahar, & Muhammad, 2003; Huarng & Lee, 1996; Khurma, Gheorghe, & Zbigniew, 2008; Lehaney, Kogetsidis, & Clarke, 1996; Swenson & Deflitch, 2008; Wijewickrama, 2006). Many outpatient sections of Japan face the problem by getting many complaints from patients about long waiting time but have a short consultation with the doctors (Wijewickrama, 2006). This problem is also a big issue of healthcare business in Thailand. Thus, there are many researchers who try to improve the outpatient process in various ways such as change of patients' schedule, layout and also optimization of resources (See figure 2.2). However, change of management system is not easy to do especially in healthcare service which is a complex and complicated system. There are many issues to consider about process improvement especially where the result is worth it enough to investing (See figure 2.1). Hence, a computer simulation is one of the techniques that will help to analyze the outpatient process with minimum risk.

Figure 2.1: The Phases of Process Changes that Affect Cost, Risk and Time.



Source: Adapted from http://www.epmbook.com/scope.htm

2.1 Discrete Event Simulation

The discrete event simulation is operated by a sequence of events. The basic structure of discrete event simulation consists of entities, activities, event, resources, global variables, a random number of generator, a calendar system state variable and statistic collectors. The discrete event simulation is a useful for analyzing the results and monitoring the specific areas (Ingalls, 2001; Jenkins, Deshpande, & Davision, 1998; Takakuwa & Wijewickrama, 2008). It is widely used in the healthcare section to analyze waiting time and, scheduling management. Moreover, discrete simulation is also applied in logistic and operation in construction to analyze the inspection process and job shop scheduling (Kuljis, Paul, & Stergioulas, 2007).

2.2 Simulation Techniques Applied in Healthcare System

In the past, simulation techniques in the healthcare industry have not been widely used compared with other industries such as manufacturing and logistics which was used in 1997. At that time, the simulation in healthcare service was categorized by the winter simulation conference as a general simulation, but in 1998, it was categorized separately namely 'health care simulation'. Moreover, the website also shows that there is 5 percent representing healthcare category from 32 categories of the past.

Actually, the simulation in healthcare industry started since the early 1960's when Fetter and Thompson (1965) used simulation as a tool to study the process behavior of a motherhood suite production, an outpatient clinic, and a surgical pavilion. Then Robinson, Wing and Devis applied simulation technique for patients' scheduling and other healthcare process in 1968.

Simulation became an important tool for the process analysis of healthcare systems which mostly emphasized on capacity planning and scheduling (Hashim, et al., 2003). Moreover, Jun el al (1999) had identified the two main areas of using simulation related to the management of customers flows and resource allocation (Eldabi & Paul, 2001).

2.3 Benefits of Simulation

There are many reasons that simulation has been chosen to use in healthcare service. Firstly, simulation is a powerful tool which can be used for process improvement in many industries (See table 2.1).

Table 2.1: The Application of Simulation to Develop the Process Improvement in Each Area.

Technique	Industry Sector	Purpose of application
Discrete Event Simulation	Iron&Steel	Improvement in production process, inventory management , new product development
	Automobil	Improvement in production process
	Construction	Losgistics and operations construction scheduling
Continous simulation	Iron&Steel	Improvement in production process,new product development
	Pharmacology	Improvement in production process, inventory management , new product development
	Process industry	Improvement in production process
System Dynamics	Construction	Training real-time planning, resource allocation
	Energy	Asset management
	Automobil	Decision making
Montecario simulation	Construction	Incentives and disincentive based contracting, construction scheduling, risk modeling
	Energy	power trading, market place simulation, competitive strategy, expansion planning
	Biotechnology	Growth projection
Multi-agent simulation	Construction Energy	Supply chain simulation
	Energy	Emergency planning, energy pricing, Power trading, market place simulation, competitive strategy.
Technique	**Industry Sector**	**Purpose of application**
Virtual reality/3-D simulation	Iron&Steel	Training
	Automobil	New Product development
	Construction	Training, improve communication and conveying of concepts.
Artificial Intelligence	Automobil	Improvement in production process
	Construction	Construction scheduling, risk modeling
	Energy	Expansion planning, market place simulation, power trading, financial analysis

Source : Adopted from Kuljis (2007) , p.1450

Secondly, simulation is an excellent tool to analyze the complex process or situation like a healthcare system, and also extract many results in detail such as resource utilization, queuing, waiting time etc. Thirdly, the animation of simulation which illustrates the process flow as a motion picture can help the user to understand the process clearly (Brady, 2000; Eldabi & Paul, 2001; Hashim, et al., 2003; Jenkins, et al., 1998; Lehaney, et al., 1996; Proctor, 1996; Takakuwa & Wijewickrama, 2008). Moreover, the discrete simulation can focus in specific areas to have a better understanding in the areas to be concentrated (Deshpande, 1998; Khurma, et al., 2008; Sanchez & Ferrin, 2000; Sharma, Abel, Al-Hussein, Pfrunder, & Lennerts, 2007). In addition, simulation can help the user to make a decision for process implementation. The simulation model can be built into many scenarios or can be conducted into various experiments in order to find the best solution (Badri & Hollingsworth, 1992; Brady, 2000; Eldabi & Paul, 2001; Hashim, et al., 2003; Jenkins, et al., 1998; Proctor, 1996; Sanchez & Ferrin, 2000). Finally, simulation is a good tool to evaluate the performance of the process. (Badri & Hollingsworth, 1992; Clague, et al., 1997; Hashim, et al., 2003; Sanchez & Ferrin, 2000)

Table 2.2: Previous Studying of Simulation in Healthcare

Authors	Queue Management; Patient appointment systems, Patient scheduling, Patient arrival process	Re layout; Lean, Reassignment, Balance workload, Six sigma	Optimization of Resources and Facility; Staff and doctor scheduling, Staff capacity
Badri andHollingsworth(1992)			
Huarng and Lee (1996)	X		
Limor and team (1996)	X		
Clague and team (1997)	X		X
Sepulveda and Cahoon (1999)	X		
Ramis and team			X
Hashim and team (2003)	X		
Wiinamaki andDronzek (2003)		X	X
Abdullah (2005)		X	
Sharma (2007)			X
Khurma and team (2008)		X	
Medeiros andDeflitch (2008)			
Takakuwa andWijewickrama(2008)			X

Table 2.2 shows the conclusion of previous studies using simulation for the process improvement in healthcare. There are three methods for developing the process in healthcare which are queue management, Re-layout and optimization of resources and facilities.

2.4 Previous Studying of Simulation in Healthcare

There are numerous studies related to process improvement in healthcare business. The methods used to improve the process can be classified as shown in Table 2.2.

Many of them use the method of rescheduling of patients. The rescheduling of patients' arrival time can control the number of patients in the system which affect patients' waiting time directly. Normally, the patients' uncertain arrival time can be interrupted or slow down the patients' flow. A well-distributed appointment time is needed to improve the process flow and also to reduce patients' waiting time.

According to Huarng and Lee (1996), many hospitals in Taiwan encountered the problem of patients' long waiting time. They suggested two ways to reduce patient waiting time such as change the arrival process and change the service process. The result showed that when number of appointed patients increased, that means the arrival time was controlled, the patients' waiting time decreased because the waste time of waiting for non-appointed patient is eliminated (Huarng & Lee, 1996). Also Limor, Paul and Hedley (1996) studied about the queues management in an outpatient department in Hong Kong which faced the problem of patients' long waiting time. They realized that the appointment system was an important factor affecting to patients' waiting time. After implementation of new appointment system, the patients' waiting time decreased while the workload of doctors was still in normal condition (Limor et a1,1996). The result of the previous study is in line with Jose A. Sepulveda's and his team's (1999) who studied about the process improvement of a cancer treatment center using simulation. They analyzed the patients' flow based on the change of floor layout and different patients' appointment schedule and found that the appointment scheduling was a factor helping the clinic to increase patient capacity

(Sepulveda & Cahoon, 1999). In addition, Saleh Hashim and his team (2003) studied about improving patient treatment services in Malaysia by changing patient scheduling while keeping the total number of patients as the same and found that after the new scheduling was applied, the patient waiting time was reduced significantly (Hashim, et al., 2003)

Next is the re-layout of areas to improve the patients' flow and also the resource's flow that can reduce the waste time from transportation. This method is in line with Lean concept to reduce non-value added time in the process. Nancy and team (2008) studied the process improvement of an emergency room in 2008. The research focused on process improvement by re-layout, re-assignment and balance of work load. It was found that the patients' waiting time, cost and triage nurse workload could be reduced.(Khurma, et al., 2008) However, the re-layout method cannot guarantee that the transportation time will decrease due to unpredictable behavior of human such as walking route(Sepulveda & Cahoon, 1999) .

Lastly methods to improve processes are optimization of resources such as staff, number of rooms, number of beds etc. Sometimes the utilization of resources is poorly distributed, leading to poor patients' flow. The optimization of resources can be done in many ways such as rescheduling of resources with the existing amount of resources or rescheduling with additional resources. The results of many studies showed that after increasing/scheduling of resources, patients' waiting time is reduced. In 1992, the operations process of the emergency room of the Rashid Hospital in the United Arab Emirates was studied by A. Badri and J. Hollingsworth. They studied about the changes in scheduling practices such as the number of limited resources and changes in the patient demand pattern and found that the number of doctors mainly affected the performance of the emergency room system (Badri & Hollingsworth, 1992). This study is in line with the one in 1997 by John E. Clague and his team who studied about the improvement of outpatient clinic. They found that staffing size and patient arrival time affected both patient and doctor waiting times (Clague, et al., 1997). However, in 2001, Ramis, Palma and Baesler studied in process improvement of ambulatory surgery center at J. J. Aguirre Hospital of Universidad de Chile in Chile. They used the optimization of the room usage instead of optimization of staff by changing the number of the rooms for each activity such as the preparation room and recovery room and found that the patient capacity is increased without changes for a closing time (Ramis, Palma, & Baesler, 2001). In addition, simulation was used again to examine congestions and doctor schedules in the outpatient ward of the Nagoya University hospital (Takakuwa & Wijewickrama, 2008). The process was improved by changing contribution of doctor in each department to find the optimized solution. The result showed that contribution of doctor to each department quite affected to patient waiting time and due to this the doctor's utilization was improved.

2.5 Arena software for simulation

The study conducted by Judy Rathmell in 2002 describes about three types of arena software and also provides the benefits of arena. The first is the Basic Edition which focuses on business and other simulation system such as manufacturing and service industries. The second is Arena Standard Edition that is suitable for entire model flexibility. And the last is Arena Professional Edition which consists of functions; real structures, including expressions, process logic, performance metrics and animation (Rathmell, 2002).

There are many advantages of Arena software which are as follow:

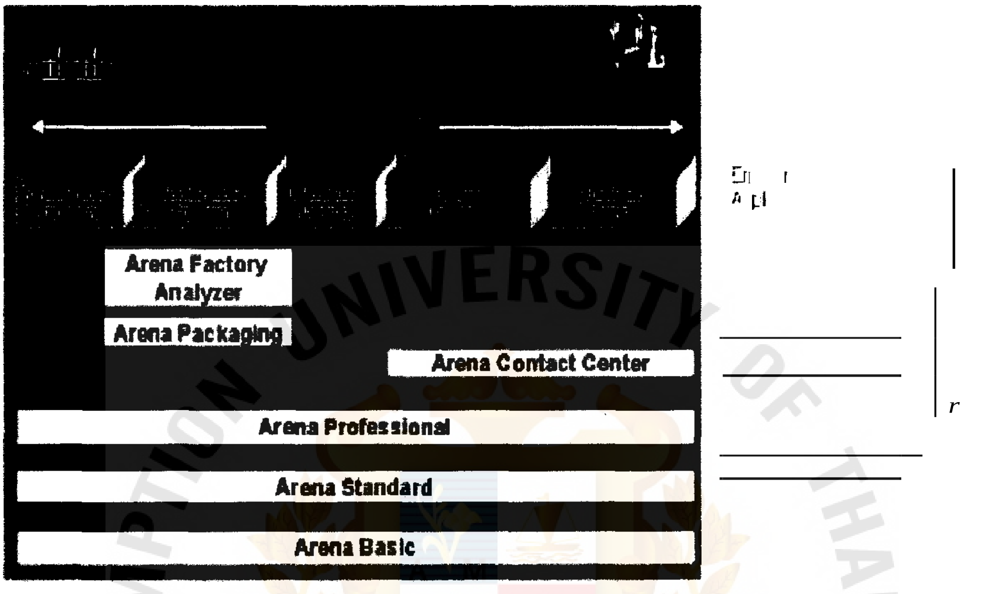
2.5.1 Arena software can be applied throughout many companies from upstream to downstream.

2.5.2 Arena software supports the high level analysis such as discrete event simulation and continuous simulation.

2.5.3 Arena programs can be integrated with other programs such as excel spreadsheet and Visual Basic (Rathmell, 2002; Seppanen & Kumar, 2002).

2.5.4 Arena Architecture is used to support many customers' application. Arena also has a power to create a complex model. Moreover, in Arena program, the data can be imported into the model directly from Microsoft Excel or Access.

Figure2.2: Arena Software Architecture



Source: Adapted from Judy & David, 2002

2.5.5 The basic templates or modules of arena can support all types of modeling application. Moreover, Arena programs also provide stand features which are resources, queuing, system data and process logic or expression.

2.5.6 Animation modules in Arena software is easy to construct and also shows the standard graphics which are queues, resource status, etc (Rathmell, 2002).

Figure2.3: Arena Animation

Source: Adapted from Judy & David, 2002

2.5.7 There are input analyzer tools which help the user to fit the correct distribution of data.

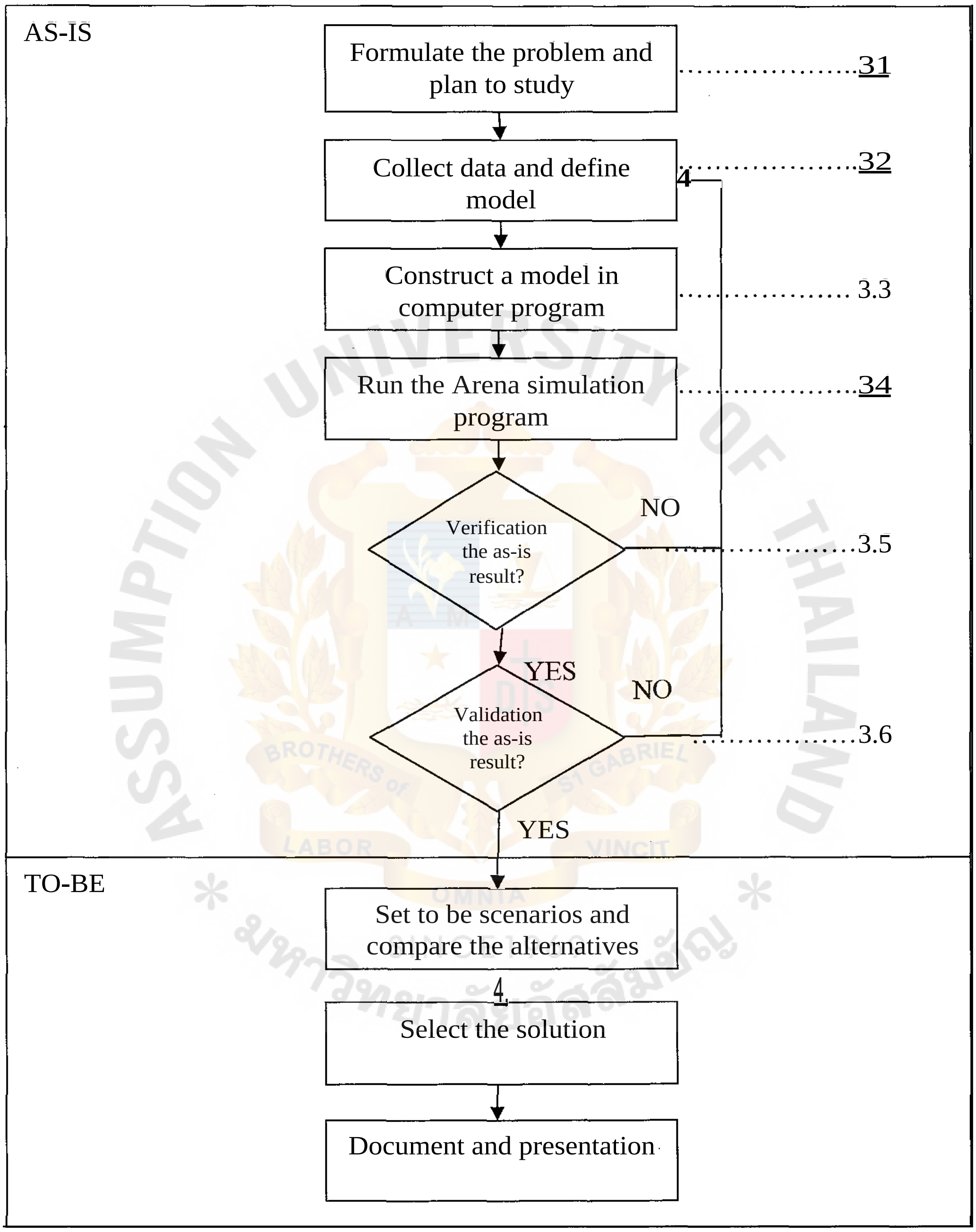
2.5.8 The Process and Output Analyzer of Arena are given the automation of comparison among scenarios to find the best solution (Hashim, et al., 2003; Rathmell, 2002; Seppanen & Kumar, 2002).

CHAPTER III

RESEARCH METHODOLOGY

This chapter will present research methodology. The research methodology is divided into two parts. The first section is "as-is" simulation. The first step of as-is simulation is to formulate the problem and to plan the study that will describe about the observation and staff interview. The next step is the data collection that will explain how to collect the data and the period of data collecting. Then the model of patients' flow process is defined and described in Section 3.2. After that process model is constructed in arena software it will be shown in Section 3.3. The model construction step will illustrate the overall processes, resources and input parameters. The forth step of the as-is simulation is to run the model in arena software that explains how to set up analysis parameters before running the model. After getting the as-is result from running the simulation step, verification of model is conducted. The model verification is to validate the input parameters whether the model is corrected or not. The last step for as-is part is to validate the output result of simulation and actual data collected. Another part of the "to-be" simulation that the selective model will be constructed based on many scenarios, and the best one will be chosen.

Figure3.1: Research Methodology Framework



3.1 Formulation of Problems and Plan to Study

The first step of the framework is to formulate the problem and plan of the study. The scope of the study of this project is limited to the area of Eye-Nose-Throat of outpatient department (OPD-ENT). In order to understand the outpatient process, the walk-through process and staff interview is also needed. The walk through process helps for observing the layout and studying the route of patients' walking. The observation finds that patients walk scattered ways. The next step, problem formulation, hence the chief of nurses is interviewed about the overall process flow, problems, causes of problems and job's details for each function such as patients' appointment (See table 3.1 and 3.2). Moreover, in this step a video is recorded to observe the details of each process. The video record is captured at the same place for long time (30 minutes). Thus, it is showed the details of job functions. Like the case of a doctor who teaches the real case of sickness to student doctors in the diagnosis room. Sometimes available space is not enough and blocks the traffic. Thereafter, the process flow chart is drawn. After gathering the information from the observation and staff interview, the final step is to create the data collection sheet. The sheet will contain all data such as waiting time, process time and groups of doctors (See appendix B).

Table 3.1: Problems and Causes of Problem

Problems	Causes of problems
Problem of resources	• Resident doctors in the first and second year that lack experience • Staff (nurses, nurse assistants, doctors) are not enough to serve patients
Problem of Layout	• The space for waiting for a doctor is limited. Thus, the patients are sometimes blocked in traffic
Problem of equipment and rooms	• Equipment and rooms are not sufficient. For example, The treatment room is not enough to serve the patients.

Table 3.2: Job description of Staff in the ABC hospital

Position	Job description
Nurse Assistant	• A nurse assistant at the registration station is calling a patients' queue number • A nurse assistant at the treatment room helps a nurse and a doctor in that room • A nurse assistant cleans equipment. • A nurse assistant assists doctors in the diagnosis room. • A nurse assistant at endoscopy room assists a doctor in that room.
Nurse	• A nurse at the appointment station explains the arrangement of the next appointment for the operation patients • A nurse at the treatment room helps a doctor in that room.
Clerk	• A clerk at the next appointment station does the administration job such as printing the card for the next appointment

3.2 Data Collection

The sample data is randomly collected from 64 patients. The duration of data collection is 11 days which is divided into two periods because of the limitation of available time since the clinic opens from 9.00 a.m. until 12.00 a.m. Data collected is by tracking each patient from the beginning through the end of the process. Base on the data collected, an average patient's transaction took about 40 minutes. Thus, the data collected the first week is 21 patients by one team. Due to permission from the hospital limit for data collection is only two weeks. The data-collection team was doubled in size in order to track more samples during the second week. Therefore, the total sample data the second week is 43. The first data collection period was February 2nd to 6th. Then the second period of collecting data is from March 17th to 20th and March 23rd to 24th in 2009. The result can be classified as follows:

3.2.1 Patients arrival time: mentioned in the part of limitations and scope of the project it is difficult to collect the actual arrival time, so the arrival time is collected at the register station as soon as patients are called by a nurse assistant.

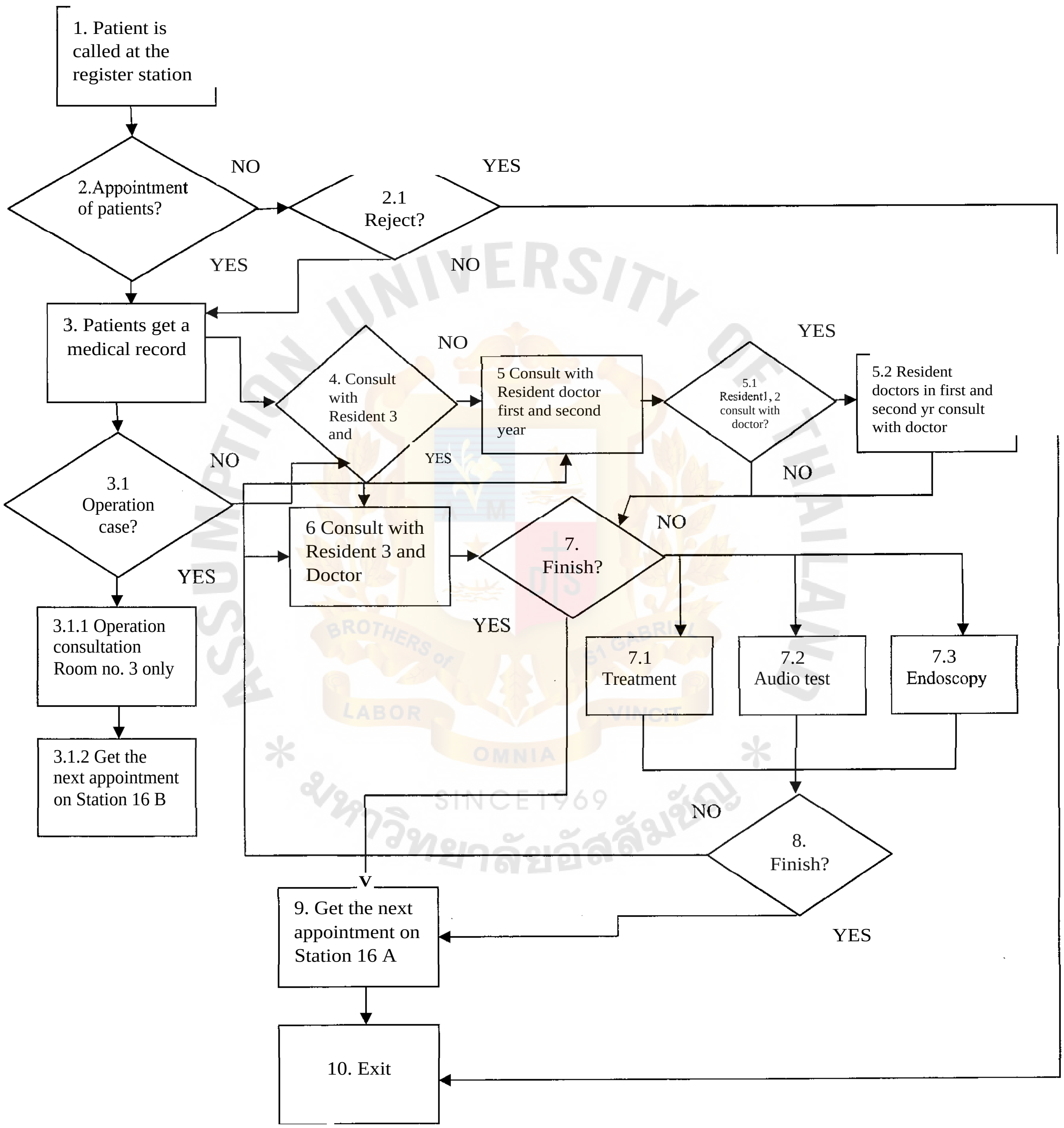
3.2.1.1 The numbers of patients for each day are extracted from the monthly record of the hospital.

3.2.1.2 The total numbers of patients in the treatment room are extracted from monthly record of the hospital.

3.2.1.3 The total numbers of patients consulting each doctor is obtained from a nurse's record.

3.2.1.4 The doctors' process time is obtained from random observation. It starts since a patient enters to the diagnosis room until patient leaves.

Figure3.2: Patients' Process Flow of OPD-ENT



As shown in Figure 3.2, patients are divided in two categories, those who are appointed and non-appointed. The process of both groups starts with a nurse assistant calling the name following by the queue number.

In case of the non-appointment patients who are not in critical condition, the nurse may request to come another day since there is overcrowding and the doctors are limited. They may come back at some future date.

Appointment patients are separated into 2 groups consulting with a doctor/a third-year resident doctor and the first-year resident doctor/the second-year resident doctor. They are both called by the same nurse assistant and get the medical record at the registration station. The top of a medical record sheet shows different colors that specify the room number and a doctor.

First group consulting with a doctor/a third-year resident doctor will be screened to specify the serious of the case, such as cancer. The patients with serious symptoms will be arranged to consult with a doctor who is a chief resident doctor at room number 3. However, chief resident doctors will be rotated every week. For the regular symptom case, patients must wait in front of the consultation room until the room is available. After consulting with a doctor, the doctor will evaluate if a patient needs to do an extra treatment such as audio test, endoscopy and treatment, they have to go to the special room. However, the regular case patients who do not need a special treatment will go to the next station called "station 16" to get the next appointment.

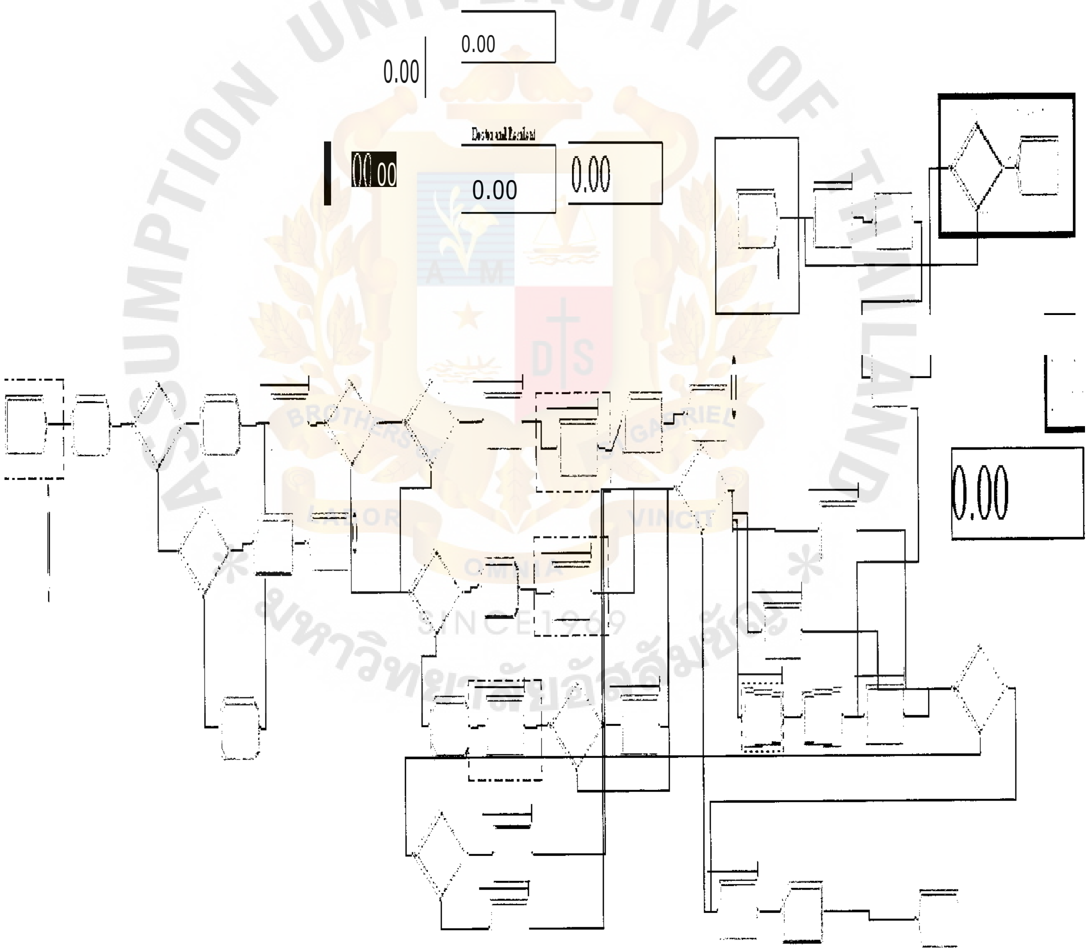
The last group is patients who have an appointment with the first or second year resident doctor. He/she has to wait until the room is available before consulting with his/her resident doctor. Since resident doctors have a limited experience in diagnosis, sometime they have to discuss the case with their supervisors (Consultant doctors) before finalizing the diagnosis results. Then, the patients will be able to go to station 16 in order to get the next appointment

3.3 Construct model in Arena software

After the model is defined and all data is all collected, the model is constructed in Arena software as the following figure;

3.3.1 Process Flow of Patients' OPD-ENT

Figure3.3: Patients' process flow of OPD-ENT in Arena software



3.3.2 Resources

Figure3.4: The resources input of OPD-ENT in Arena software

	Hanle	Type	Capacity	Busy lice,	Idle Hour	Per U	ateSet Hame	Failu es	Report Statistics
	e endoscope	Fixed Capacity		0.0	0.0				
2	Darter arid dent 3	Fixed Capacity		0.0	0.0	.0.0		rows	☑
	Resident year 1 and2	Fixed Capacity		0.0	0.0	0.0		0 rows	
4	Nurse assist register	Fixed Capacity		0.0	0.0	0.0		0 rows	
5	Nurse assist medical record	Fixed Capacity	1	OO		0.0		0 rows	☑
6	Resident 3 room 3	Fixed Capacity		0.0	0.0	0.0		0 rows	
7	Doctor consult	Fixed Capacity			0.0	.0.0		o rows	
8	Nurse assist counter 16	Fixed Capacity			0.0	0.0		rows	
9	Nurse Counter 16	Fixed Capacity		0.0	0.0	0		0 rows	☑
	Nurse treatment	Fixed Capacity			0.0	o 0		rows	☑
	Nurse assist audio	Fixed Capacity			OO	OO		0 rows	
2	Doctor	Fixed Capacity			0.0	OO		rows	
3	Clerk at station 16	Fixed Capacity			0.0	0.0		0 rows	
4	Nurse Appointment	Fixed Capacity		0.0	0.0	0.0		0 rows	
	Resident A	Fixed Capacity		0.0	0.0	OO		0 rows	☑
16	Resident B	Fixed Capacity	1	0.0	0.0	'OO		0 rows	☑
7	Resident C	Fixed Capacity	1	0.0	0.0	0.0		o row,	☑
8	Resident D	Fixed Capacity	1	OO	0.0	OO		o row	
	Doctor A	Fixed Capacity	1	0.0	0.0	0.0		0 rows	☑
20	Doctor E	Fixed Capacity	1	0.0	0.0	0.0		0 rows	
2	Doctor D	Fixed Capacity	1	OO	0.0	0.0		0 rows	
22	Doctor C	Fixed Capacity	1	0.0	0.0	0.0		0 rows	☑
23	Doctor B	Fixed Capacity	1	0.0	0.0	OO		o rows	

From the interview's result, doctors can be divided into two groups according to the agreement and policy of workload. The first group is resident doctors in the 1st year and 2nd year. The second group is resident doctors in the 3rd year and doctors. In order to group the doctors into two groups as mentioned above, the normality test of consultation time is conducted in Minitab. The test result is shown below;

3.3.3 Test of Normality:

If the Kolmogorov-Smirnov Z test yields a significance level of more (>) than 0.05, it means that the distribution is normal.

3.3.3.1 Test of the average consulting time

3.3.3.1.1 Testing a Statistical Hypothesis between Resident 1 and Resident 2

Assumption:

H_o: $\mu R1 = \mu R2$ (The average consultation time of Resident doctors in the first year is equal to Resident doctors in the second year)

H_1: $\mu R1 \neq \mu R2$ (The average consultation time of Resident1 is not equal to Resident2)

Significant Level: $\alpha = 0.05$

The data collection was analyzed in MINITAB 14, which the statistic testing is t-test. The results are shown below in Figure 3.5 to Figure 3.7.

Figure3.5: Normality Plot of Resident Doctor1

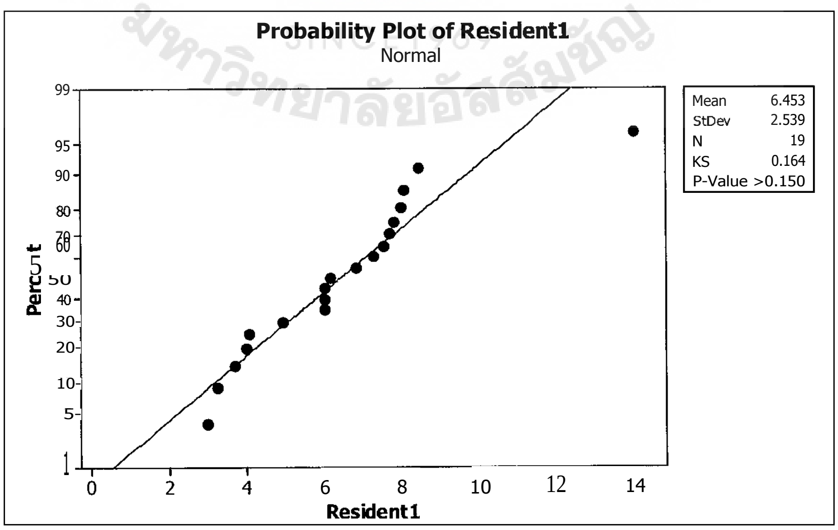


Figure3.6: Normality Plot of Resident Doctor 2

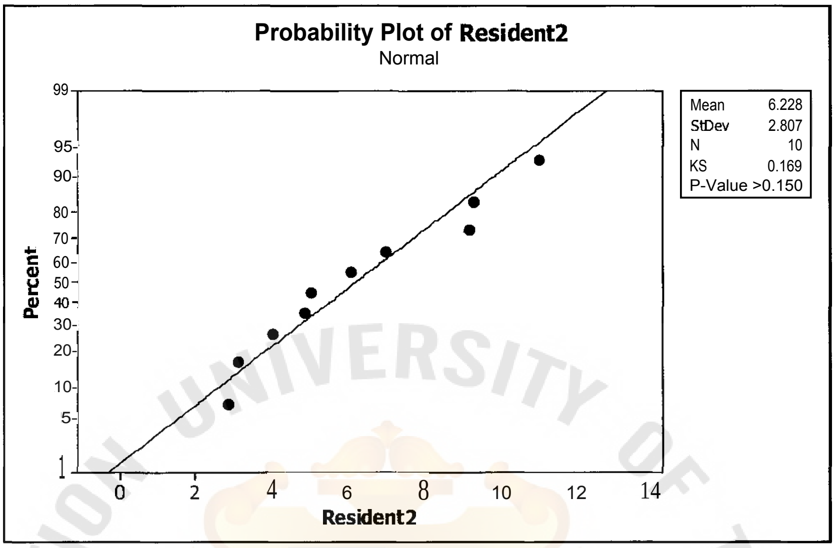


Figure 3.7: Two-Sample t-test and CI: Resident Doctor1, Resident Doctor 2

	N	Mean	StDev	SE Mean
Resident 1	19	6.46	2.54	0.58
Resident 2	10	6.23	2.81	0.89

Difference = μ (Resident1) - μ (Resident2)

Estimate for difference: 0.235158

95% CI for difference: (-2.015398, 2.485713)

t-test of difference: H0= 0, H1= not equal to 0

t-value = 0.22, P-Value = 0.828, DF = 16

The obtained value of t-test is equal to 0.22 and Sig. (p-value) =0.828. Since, it is the two-tailed test so Sig. (p-value) is equal to 0.828/2= 0.414. Thus, this value is more than 0.05 level of significance or a =0.05 hence, HO cannot be rejected. Thus, the average consultation time of Resident1 is equal to Resident2.

3.3.3.2 Testing a Statistical Hypothesis between Resident 3 and the other Doctor

Assumption:

H_{o}: $\mu R3 = \mu D$ (The average consultation time of Resident doctor in the third year is equal to the other Doctor)

H_{i}: $\mu R3 \neq \mu D$ (The average consultation time of Resident doctor in the third year is not equal to the other Doctor)

Significant Level: $\alpha = 0.05$

The data collection was analyzed in MINITAB 14, which the statistic testing is t-test. The results are below in Figure 3.8 to Figure 3.10.

Figure3.8: Normality Plot of Resident Doctor 3

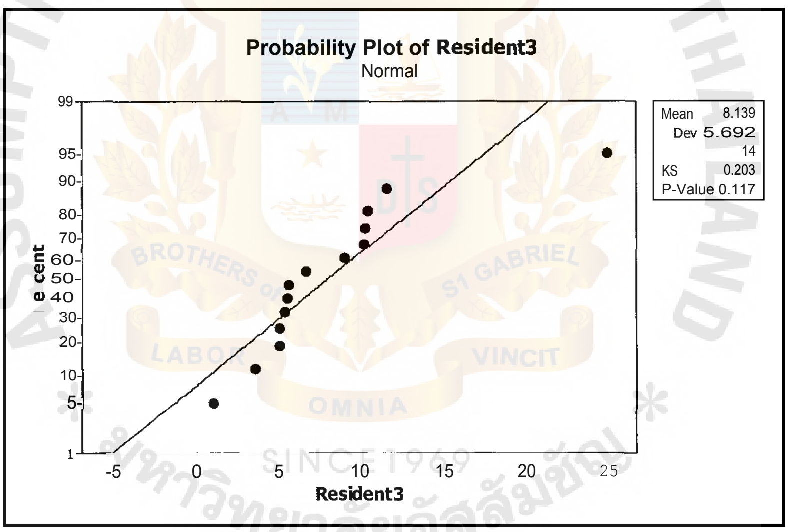


Figure3.9: Normality Plot of Doctor

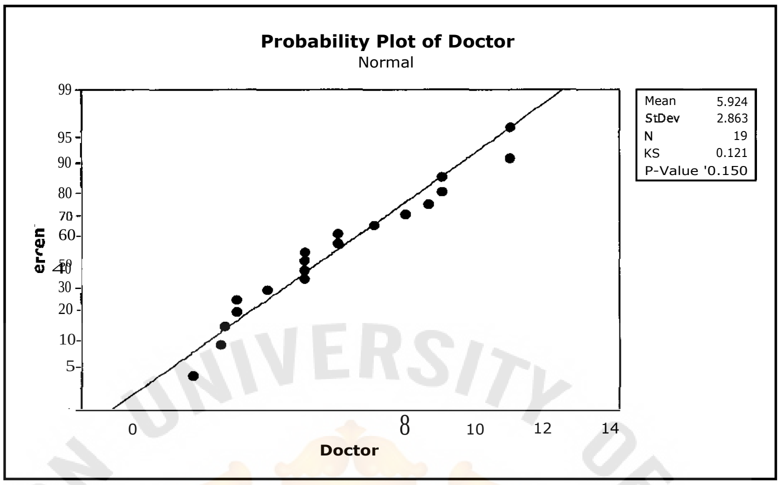


Figure 3.10: Two-Sample t-test and CI: Resident Doctor 3, Doctor

	N	Mean	St Dev	SE Mean
Resident 3	14	8.14	5.69	1.5
Doctor	19	5.92	2.86	0.66

Difference = t (Resident3) - μ (Doctor)

Estimate for difference: 2.21560

95% CI for difference: (-1.28017, 5.71137)

t-test of difference: HO = 0, H1 = not equal to 0

t-value = 1.34 P-Value = 0.199 DF = 17

As the result showed that t-test is equal to 1.34 and Sig. (p-value) =0.199. Since, it is the two-tailed test so Sig. (p-value) is equal to 0.199/2= 0.0995. Thus, this value is more than 0.05 level of significance or a =0.05 so, HO cannot be rejected. Thus, the average consultation time of Resident3 is equal to the other Doctor

3.3.4 Process time

The process time was set in the input analyzer program as figure 3.11 indicate.

Figure 3.11: The Example of Setting of Process Time in the Input Analyzer Program (Patients consulting with doctors and 3rd year resident doctors)

Figure 3.11 is an example of distribution process time which is the result of the input analyzer in Arena program. According to the data input of process is less than 50 so, the Kolmogorov-Smirnov test is considered. P-Value must more than 0.05 which means that the distribution cannot reject. All input activities throughout the process are also analyzed from this input analyzer tool (See all process distribution time in table 3.3).

Table 3.3: Process Time of Each Activity from the Input Analyzer

Processes	**Time(mins)**
Audio test	TRIA(4.39,7.23,9.48)
Doctor and resident 3 consult	0.999 + 11 * BETA(1.19, 1.3)
Doctor and resident 3 consult again	EXPO(1.05)
Endoscope	TRIA(5.36,14.56,23)
Get medical Record	0.12 + LOGN(0.307, 0.207)
Next appointment Counter 16	EXPO(0.75)
Next appointment counter 16 on	EXPO(0.75)
Operation consult Room no.3	4 + GAMM(8.83, 0.551)
Resident 1 2 consult	2 + 9 * BETA(1.47, 1.8)
Resident 1 2 consult again	EXPO(1.10)
Resident 1 2 consult with doctor	TRIA(3,5,8)
Treatment	TRIA(4.13,8,18)

Table 3.3 is indicates all of the distribution of process time that is set from input analyzer function in arena software.

3.4 Running Set up the Simulation in Arena Program

Figure 3.12: Set up before Running the Program

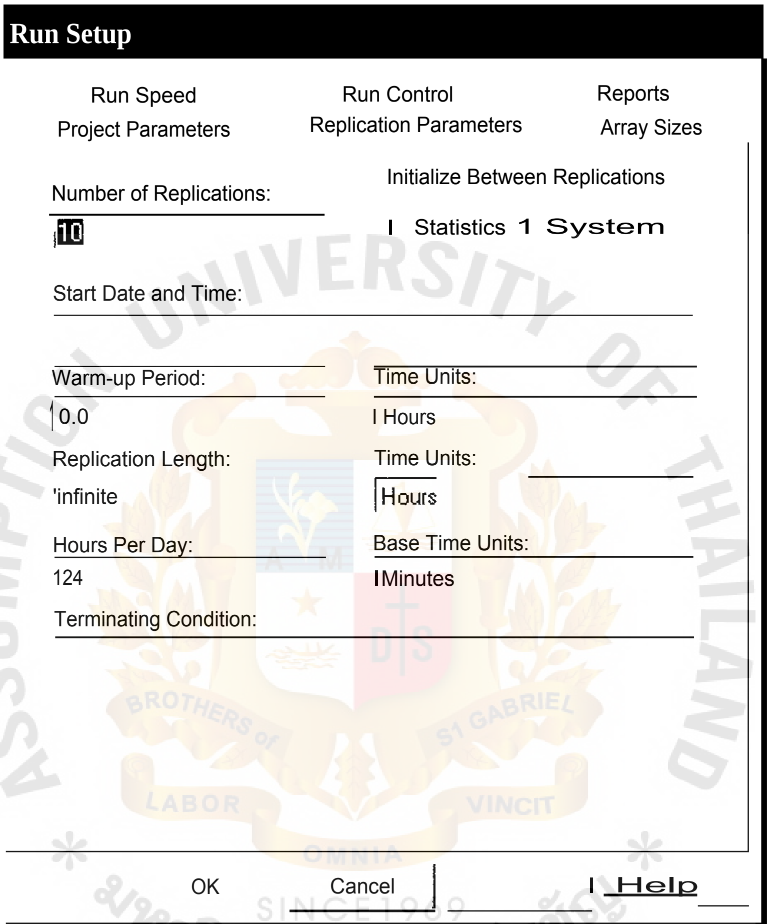


Figure 3.12 shows the set up window in which parameters need to be set before running the program. The number of replications as presents the number of runtimes of the program. The replication length is the duration per one replication. The infinite length of replication means that the replication will not end until all patients exit the process.

Figure3.13: Graph Comparing the Average of Percentage of Errors Running Replication

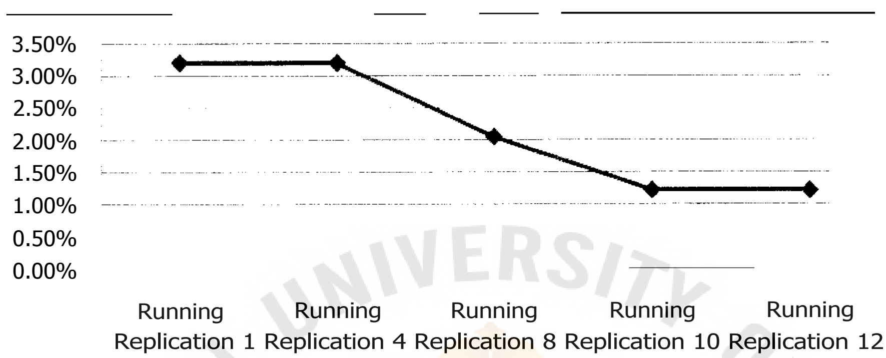


Figure 3.13 showed the comparison of errors between the different numbers of replication setting in the replication parameters. The graph is evaluated from the average percentage errors that occur in the output of process time. The one-replication running and four-replication running showed that the errors as 3.20%. The error of 8-replication running is 2.05%. The least errors occurred at replication-10 and replication-12 running which are amounts to 1.22%. Thus, the replication number of this model is set at 10 cycles.

3.5 Model Verification

The purpose of model verification is to check the input parameters and logical parameter are checked whether they are defined correctly or not. The verification is conducted separately based on interested things such as number of entities, ratios between number of appointment patients and non-appointment patients and ratio between numbers of patients treated by two groups of doctors. Then it is tested to find out if it has the right configuration. The model is verified for the three main points which are as follows:

3.5.1 Patient Input/Output:

	Key ri ance 4 cators
System	;erage
Number Out	225

The number of output of entities in the simulation model is in line with the actual number of patients, which are 225.

3.5.2 Types of Patients:

1 4 9 Appointment

Non-Appointment

Table 3.4: The Results of As-Is Simulation; Number of Patients' Types

Run Replication	Number of Appointment Patients	Number of Non-Appointment Patients
Replication 1	149	75
Replication 2	145	79
Replication 3	143	81
Replication 4	144	80
Replication 5	161	63
Replication 6	145	79
Replication 7	148	76
Replication 8	147	77
Replication 9	145	79
Replication 10	134	94
Total percentage	65.25%	34.75%

Types of patients are classified as appointment and non-appointment patients. The actual ratio between numbers of appointment patients and non-appointed patients is 64.73:35.27. However, the ratio between the numbers of two types of patients from 10-replication simulation is 65.25:34.75, that the difference between the actual and simulation is only 0.52%. Due to the agreement with the management team about the different values between actual situation and simulation which should not be more than 5%, thus hypothesis is acceptable.

3.5.3 The Group of Doctors:

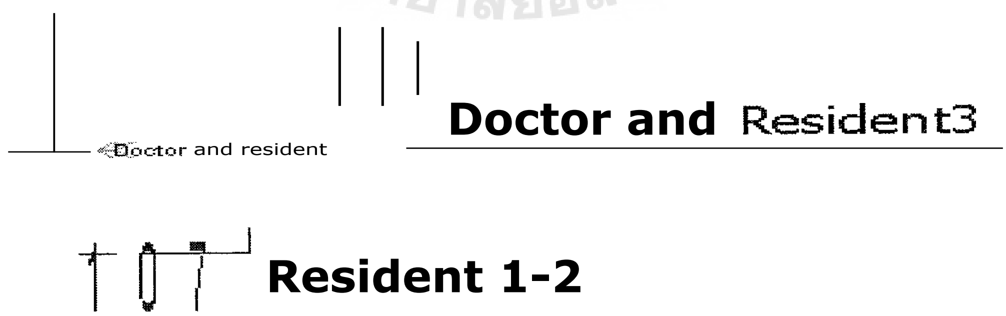


Table 3.5: The Result of As-Is Simulation; Number of Patients Treated by First Group Doctor and Second Group Doctor

Run Replication	Number of Patients treated by First and Second year Resident Doctors (Group 1)	Number of Patients treated by Third year Resident Doctors and Doctors (Group 2)
Replication 1	107	108
Replication 2	92	123
Replication 3	107	116
Replication 4	106	110
Replication 5	107	109
Replication 6	93	119
Replication 7	99	113
Replication 8	105	112
Scenario 9	98	120
Scenario 10	97	116
Total percentage	46.88%	53.12%

The doctors are categorized into two groups. The first group is the resident doctors who are studying the specialty for Ear-Nose-Throat in the first and second year. Another group is the doctors and resident doctors who are studying the specialty for Ear-Nose-Throat in the third year. The actual proportion between number of patients treated by first group doctor and second group doctor is 48.38:51.62. However, the ratio from 10-replications simulation is 46.88:53.12. Thus, the difference between actual situation and simulation is 1.5% which is acceptable. (See type of patients' verification)

3.6 Model Validation

Model validation is conducted to validate the output data or results compared with the actual data. The results to be validated consist of 3 parts as follows:

3.6.1 Total cycle time per entity (See table 3.6)

3.6.2 Process time of each activity (See table 3.7)

3.6.3 Waiting time focuses on the bottlenecks which are (See table 3.8) :

3.6.3.1 Waiting time at endoscopy process

3.6.3.2 Waiting time at diagnosis process (only for first and second year resident doctor)

3.6.3.3 Waiting time at the treatment process

The method of validation in this project is to find the difference between simulation results and the actual data collected. The percentage of errors must be based on 10 % (Hashim, et al., 2003). The formula is shown below:

$$\text{Diff (\% of error)} = \frac{\text{Actual data} - \text{Simulation result}}{\left|\text{Actual data}\right|} \times 100 \qquad \text{(Eq. 3.1)}$$

Table 3.6: Model Validation of Total Cycle Time per Entity.

	Simulation (mins)	Actual (mins)	Error
Total time per entity	41.28	40.12	-2.91%

Table 3.7: Model Validation of Process Time.

	Simulation (mins)	**Actual (mins)**	**Error**
Audio test	6.7704	7.23	6.36%
Patients consult with doctor and resident doctors in the third year. Queue	6.4992	6.66	2.41%
Doctors and resident doctors in the third year consult again after special treatment	1.0500	1.05	0.00%
Endoscopy	14.1313	14.56	2.94%
Get medical Record	0.4308	0.41	5.06%
Next appointment Counter 16 **B**	0.7491	0.75	0.12%
Operation consult Room no.3	8.8091	9.42	6.48%
Resident in first and second yr. consultation	6.0602	6.30	3.81%
Resident 1 2 consult again after special treatment	1.1461	1.10	4.19%
Resident in first and second year. consult with doctor	5.3937	5.07	-6.38%
Treatment	10.0844	10.84	6.97%

Table 3.8: Model Validation of Waiting Time.

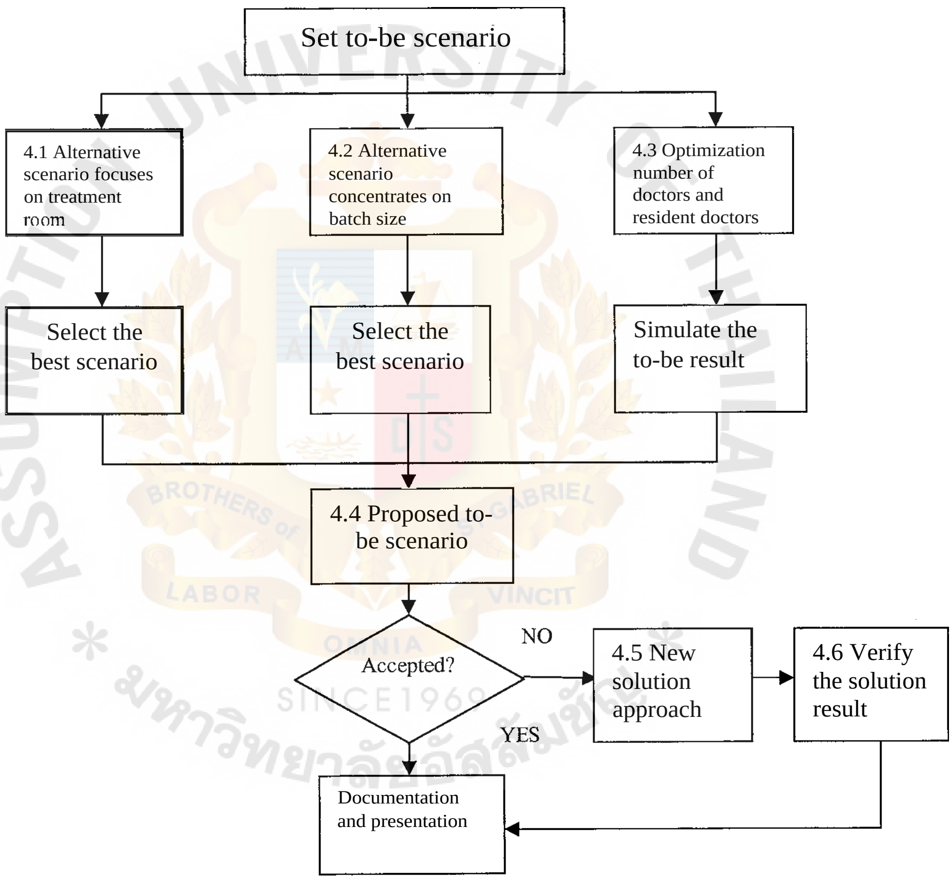
	Simulation (mins)	**Actual (mins)**	**Error**
Audio test. Queue	0.8178	0.86	4.91%
Patients consult with doctors and resident doctors in the third year. Queue	8.9063	8.11	-9.82%
Endoscope. Queue	41.4774	40.3	-2.92%
Next appointment Counter 16.B	2.8993	2.97	2.38%
Resident doctors in first and second year. consult with doctor. Queue	1.8556	2	7.22%
Patients consult with resident in first and second year. Queue	7.9010	8.67	8.87%
Treatment. Queue	74.5489	70.54	-5.68%

Table 3.6 to Table 3.8 shows the different percentages between outcome of simulation and actual data collected. The result is none of them (total time, process time, and waiting time) can be rejected because the difference is less than 10%.

CHAPTER IV

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

Figure 4.1: To-Be Modeling Procedure



From Chapter 3, the results of as-is simulation consisting of total process time and patients' waiting time were collected and validated. Thus, this chapter will describe the to-be scenarios which will be adapted to reduce patients' waiting time. The to-be models which have various scenarios will be developed from the as-is model. Simulation will be used again as a tool to find the best solution among alternative scenarios. The best to-be model will be chosen based on the objectives of the research that mainly focuses on the cycle time reduction. The alternative scenarios will be divided into three parts. Part of the scenario is based on the priority from longest waiting time per activity to the least waiting time. The first priority will be on the part of treatment room. Then will the focused will be concentrated on the reduction of waiting time at the endoscope room. The final concern part is to find the optimization of the number of doctors and resident doctors. The combination of the three above focus is the to-be result. Then the to-be scenario will be proposed with the management team. If the management team agrees with the result the next step will be the documentation and presentation. However, if the management team does not agreed with the solution, brainstorm of a new solution is needed.

4.1 Alternative Scenarios Focus in the Treatment Room

The first concern will focus on the treatment room in which the longest waiting time occurs. These will be set up to increase the treatment room. Moreover, scenarios will be selected by comparing the waiting time in front of treatment room with reduction of time and resource utilization.

Table 4.1: Alternative Scenarios for Improving Treatment Process (Part One)

Treatment 1	1	74.54	0.90	
Treatment 2	2	20.95	0.71	350,000
Treatment 3	3	10.67	0.65	700,000

Table 4.1 shows the alternative scenarios for improving treatment processes and the number of treatment rooms is different in each scenario ranging from one room to three rooms. The result focuses on the waiting time reduction. Scenario Treatment 1 is the as-is scenario where waiting time is 74.54 minutes and utilization of resource is 90 %. Then in scenario treatment 2; the number of treatment rooms were changed from one room to two rooms, therefore the waiting time is reduced by 53.59 minutes which was 71% reduction. Moreover, the utilization of resource is decreased from 90% to 71% which is 19% reduction. The third scenario (Treatment 3); one more treatment room was added from the second scenario. The waiting time for treatment activity is decreased from 20.95 minutes to 10.67 minute and utilization is also reduced from 71% to 65 %. Therefore, the estimated cost investment and resource utilization compares with waiting time reduction is all affected. The second scenario is selected as the base scenario to improve in the next part (Waiting time at endoscope room).

Figure 4.2: Waiting Time and Resource Utilization Reduction for Selected Scenario (Part one)

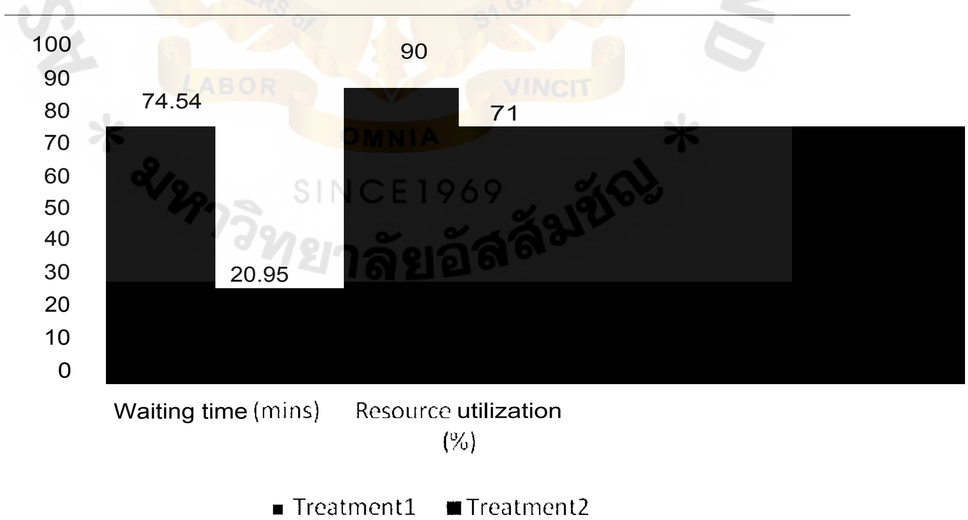


Figure 4.2 illustrates the waiting time and utilization reduction after scenario selection. The graph is used to compare the as-is situation with the selected scenario.

The graph shows that after one more treatment room is increased, the waiting time reduced by 71%. Besides, the resource utilization decreased by 19%

4.2 Alternative Scenarios Concentrate on Batch Size Reduction

The Second part is to managee the waiting time for endoscopy that occurs from batch size problem in front of the endoscopy room. The scenario will be set for five scenarios to decrease the batch size of patients. The result will be focus on the waiting time reduction of this activity.

Table 4.2: Alternative Scenarios for Improving Endoscopy Process (Part Two)

Batch 5	5	41.47	.55
Batch 4	4	34.51	.58
Batch 3	3	30.58	.60
Batch 2	2	29.77	.62
Batch 1	1	24.20	.62

Table 4.2 shows the option scenarios for improving waiting time at the endoscopy room. All scenarios concentrate on the batch size of patients' reduction in order to reduce waiting time. The first scenario is the as-is situation where 5 patients are waiting for endoscopy treatment. The waiting time for the current situation is 41.47 minutes and resource utilization is 55%. In the second scenario; the numbers in the batch size was changed from 5 patients to 4 patients. The waiting time decreases from 41.47 minutes to 34.51 minutes but, the utilization of resource is raised from 55% to 58%. Next, batch 3 scenario was also developed from the previous scenario where declined the batch size from 4 patients to 3 patients. Then the waiting time is reduced

from 34.51 minutes to 30.58 minutes but, utilization of resources increased by 2%. The forth scenario used the same method with the first, second and third scenarios where batch size was decreased. The outcome is the reduction of waiting time from 30.58 minutes to 29.77 minutes but utilization of resources increases by 2%. The last scenario has no batch size where the first patient needs to wait for another patient. He or she can get the endoscopy treatment straight away. The waiting time reduces from 29.77 minutes to 24.20 minutes but the resource utilization is still the same.

Figure 4.3: Show the Result of Changing the Batch Size at Endoscope Room.

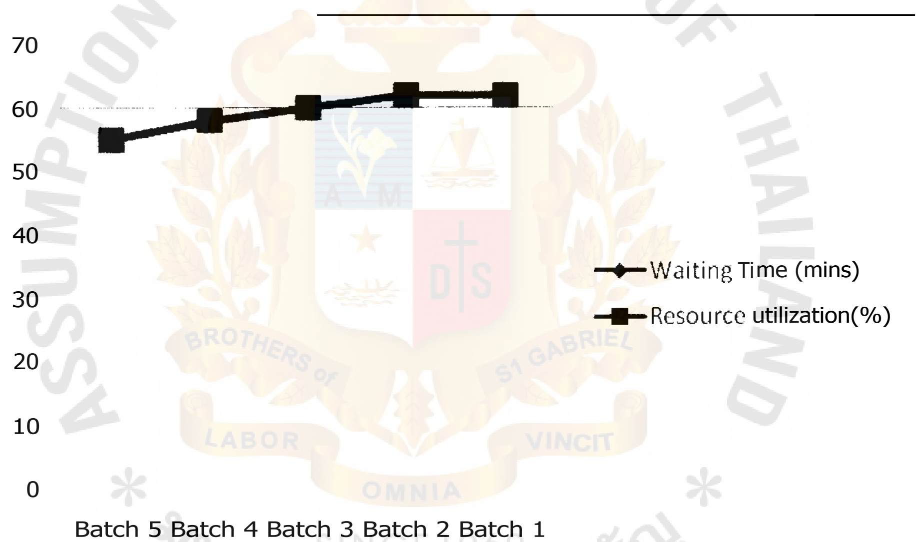


Figure 4.3 shows the results of the alternative five scenarios for improving the waiting time of endoscopy room. The blue line represents the waiting time of each scenarios. The outcome shows that the trend decreases if the batch size is reduced. If the current situations compares with the fifth scenario, the waiting time is decreased by 41 %. However, the trend of resource utilization increases when batch size is increased. Comparison between the first scenario and the fifth scenario indicates the resource utilization is increased by 11% only. Thus, the fifth scenario is the selective scenario

because it is given the best result of waiting time even though the resource utilization is raised for 11%

4.3 Optimization of the Number of Doctors and Resident Doctors

The third part of the process of improvement is to reduce the waiting time at the consultation stage. This part focuses on the optimization of number of doctors and resident doctors that will lead to total cycle time reduction. The suitable number of doctors and resident doctors will be estimating by using Microsoft Excel solver. After that, the calculated number of doctors and resident doctors will be put in Arena software, and then run the program will be seen to validate the result. The result must be in line with the objectives in order to reduce waiting and total cycle time.

The equation was created to find the optimization of the number of doctors and resident doctors as below;

Objective: $D\ (P_{NOR(D)} + P_{COM(D)}) + R_3\ (P_{NOR(R3)}\quad P_{COM(R3)})\quad R_2\ (P_{NOR(R2)}\quad P_{COM(R2)})$
$+ ^{RI}\ (P_{NOR(R1)}\quad P_{COM(R1)}) = 224$ (Eq. 4.1)

Where;

D : Number of Doctors

R_i : Number of Resident i $\quad i = 1,2,3$

NOR : Normal Cases

COM : Complicated Cases

Subject to;

D, R_i must be integer ; $\quad i = 1,2,3$

D, $\in$ (0,1) ; $\quad i = 1,2,3$

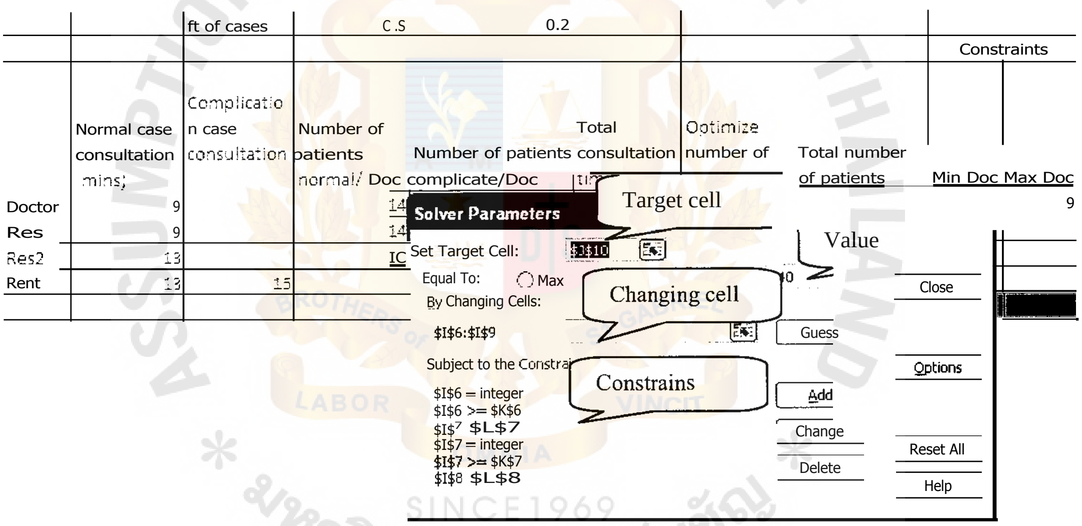
$3 \leq D \leq 9$ or $D \geq 3$ and $D \leq 9$

$2 \leq \quad \leq 5$ $\quad i = 1,2,3$

The main objective of optimization is to find the most suitable number of doctors and resident doctors that can serve 224 patients within limited time which is a fixed number. Constraints of this equation are the number of doctors and resident doctors must be integer. The number of doctors must be equal to 3 or less than 9. Moreover, the number of resident doctor must be equal to 2 or less than 5.

After the equation is formulated, the Microsoft Excel solver will solve this as figure below;

Figure 4.4: Shows the Microsoft Excel Solver (Proposed Scenario)



The Microsoft excel solver was selected as a tool with specified constrains to find the optimized number of doctors and resident doctors to serve a fixed number of 224 patients.

Table 4.3: New number of Doctors and Resident Doctors (Part Three)

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
As-Is	5	4	1	5
To-Be	9	6	2	1

The to-be scenario is developed from 4.1 (the number of treatment rooms were changed) and 4.2 (the batch size was reduced). Thus, the to-be scenario will change the number of doctors and resident doctors in the third year from 5 to 9. Besides, the numbers of resident doctors in the first and second year were also changed from 4 to 7. The result of to-be scenario is shown in Table 4.4.

Figure 4.5: Proposed Model Result (Cycle Time (mins)/ Entity)

Tally

Interval	Average
Record Arrival Time	20.2012

Figure 4.6: Graph of Total Cycle Time Reduction (Proposed Model)

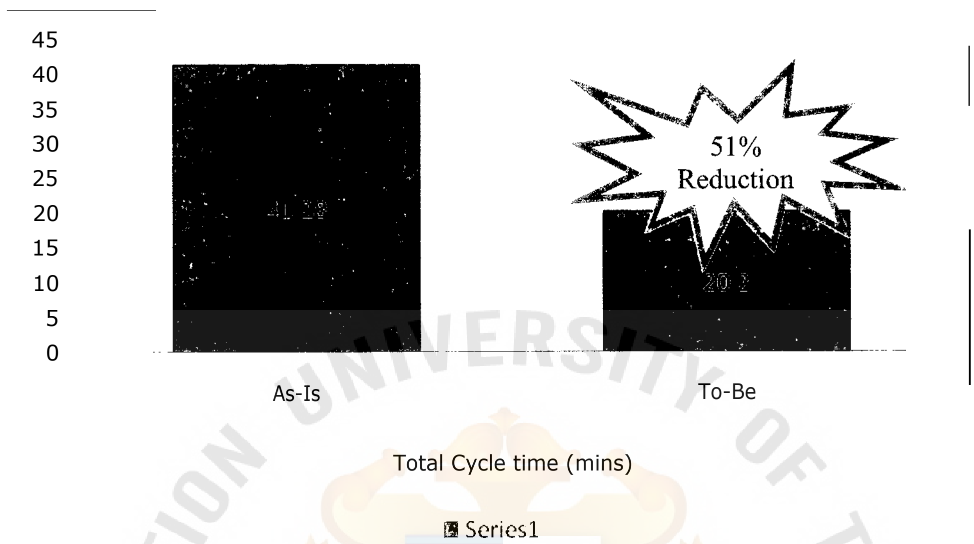


Figure 4.6 shows the compared of total cycle time reduction after the process improved (Proposed scenario). The simulation result shows that the lead time reduced by 51% if one more treatment room is added, reduced batch size from 5 to 1. Moreover, it 4 more doctors or resident doctor in the third year and 2 more resident doctor in the first and second year are needed.

4.4 Proposed Scenario to Management Team

After getting the results of the improvement, the to-be scenario was proposed to the management team in meeting. The management team is agreed with the second part (Batch size reduction) because it could be implemented immediately. However, the increasing of number of treatment rooms would be considered later because there was investment involved. Moreover, it is difficult to increase the number of doctors and resident doctors as per the proposed scenario. Thus, the meeting for new a solution approach was needed.

4.5 New Solution Approach

The new solution was discussed to discover accepted solution that can be implemented in the real situation. It was considered about shorter process time such as reducing set up time in endoscope room was considered. Thus, the required number of doctors and resident doctors was calculated from Microsoft Excel Solver again. In this case, the new lead time was put in the Microsoft Excel Solver for the calculation (See Figure 4.5). The new required number of doctors and resident doctors are shown in Table 4.4. Further more, the batch size will be removed for the new scenario too.

Figure 4.7: Microsoft Excel Solver (To-Be Model)

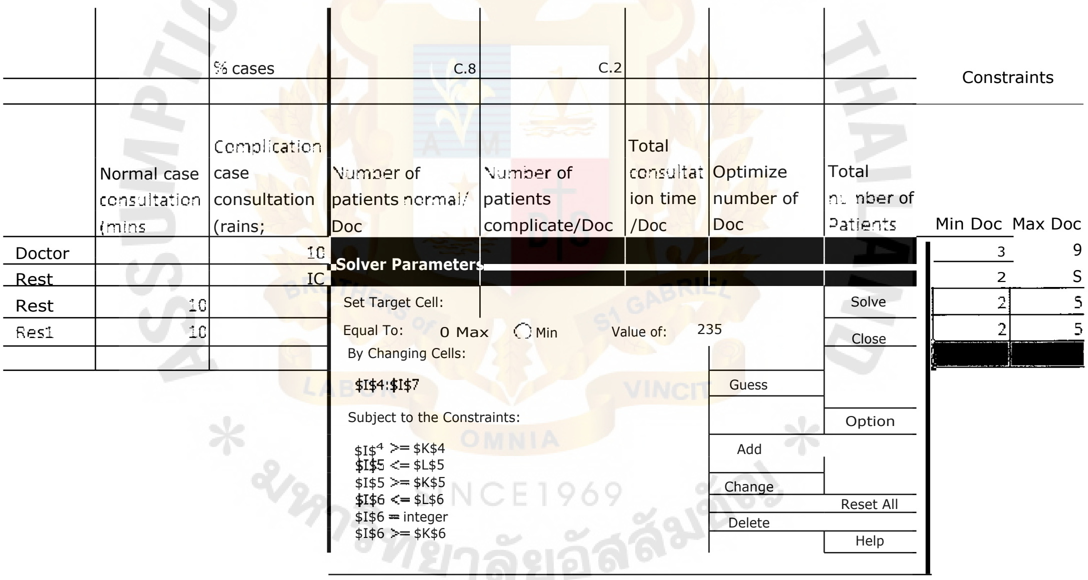


Figure 4.7 shows the Microsoft Excel Solver calculating the optimization number of doctors and resident doctors. The new lead time was put in the solver.

Table 4.4: New Number of Doctors and Resident Doctors (To-Be Model)

Scenario	Number of Doctors and Resident Doctors in the Third year	Number of Resident Doctors in the First and Second Year	Number of Treatment Room	Batch Size Quantity
As-Is	5	4	1	5
To-Be	6	6	1	1

Table 4.4 shows the new number of doctors and resident doctors calculated by the Microsoft Excel Solver. This scenario concluded because of management team meeting so; the next step was to verify the results of this scenario from simulation.

4.6 Verify the To-Be Solution

Figure 4.8: The Result of To-Be model (Cycle Time (mins)/ Entity)

Tally

Interval

	Average
&cord Arrival Time	29.9252

Figure 4.8 shows the total lead time that a patient spends in the OPD-ENT process after process improvement. The process was developed by removing batch size, optimizing the new number of doctors and resident doctors and decreasing the set-up time.

Figure 4.9: Graph of Total Cycle Time Reduction (To-Be Model)

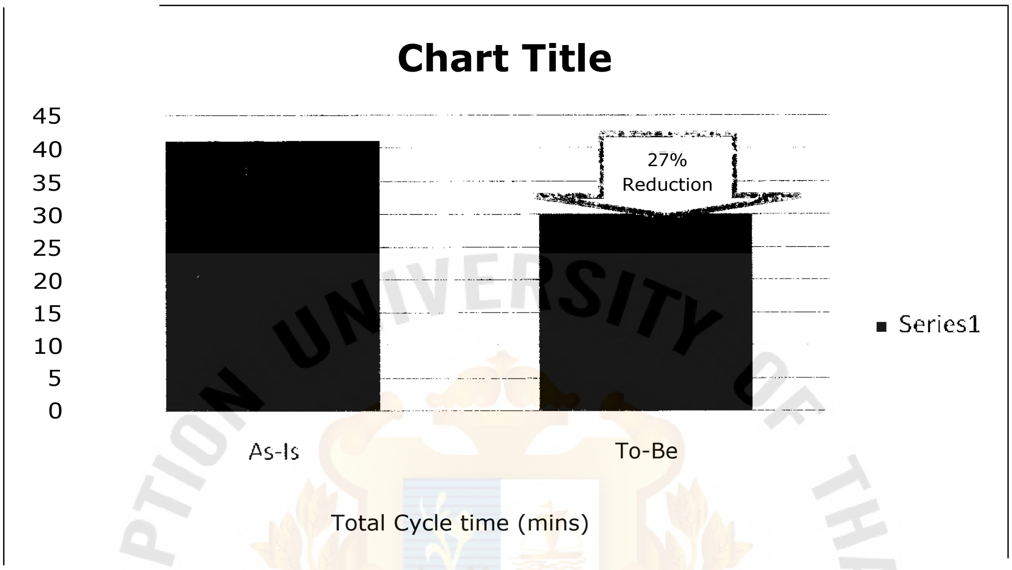


Figure 4.9 shows the comparing of total time reduction between as-is (before the improvement) and to-be (after improvement). The graph shows that after improving the process the total cycle time reduces for 27% or 11.36 minutes.

CHAPTER V

SUMMARY FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Summary of the Findings

After simulating the improvement of process for Outpatient Department Ear-Nose-Throat at the ABC hospital by running simulation with the objective to reduce total lead time of patients, the results are satisfactory. Results of To-Be model show that the total cycle time per entity is reduced for 27% from the current situation. If the result of total time is reduced, the waiting time will be decreased too. That means the service level will be increased. Moreover, the optimization technique by running Microsoft Excel solver assists to find the right number of doctors and resident doctors in the fix capacity.

Another finding is about the limitation of the application in this project. The method of process improvement in the OPD-ENT department can not apply to every department. If the management team would like to improve other departments or sections, they must analyze the departments or sections in more details because the cause of a problem for each department is different.

5.2 Conclusion

Currently, long waiting time has become a significant problem in health care service. The outpatient department ear-nose-throat of ABC hospital is also facing this problem and needs to improve it. The patients' long waiting time has mainly affected the service level of hospital. The process improvement in OPD-ENT was studied in this paper. The objective of study is to reduce non-value added time that will lead to shorter total cycle time.

The study begins with studying the current process flow of patients in OPD-ENT by observation, staff interviews and data record. Then input data was put in simulation software called Arena. After simulation was run, the outcomes of simulation results were verified and validated. The results were analyzed, and the bottle neck in the process was observed. The bottleneck is the process where patients spend the longest waiting time. Thus, the bottleneck will be eliminated the next step.

The causes of the problem were found after analyzing the results. Firstly, the number of treatment room was not sufficient to serve the patients. Secondly is the batch size in front of the endoscopy room that waiting line is too large. Lastly is the work overload of doctors and resident doctors. The number of doctors and resident doctors are not adequate to deal with 224 patients within limited time.

After the causes of the problem were analyzed, then the alternative scenarios for solving problem were set (the proposed scenario). Process improvement is focused at three points of the bottleneck. Simulation was a tool to validate the best result. The final problem was solved at the treatment room where the number of doctors is not enough to serve the patients. The result comparison focused on the waiting time reduction and resource utilization. At this point, by increasing one more treatment room, the waiting time reduced by 71 % and utilization decreased by 19%. However, the estimated cost for building a new treatment room is 350,000 baht.

The next focus was on the batch size reduction. The batch size reduction can reduce the waiting time. For this improvement, the cost of investment was not involved. The waiting time decreased by 41% but, resource utilization was increased by 11%.

The last focus is to increasing the number of doctors and resident doctors. As mentioned in the causes of problem, the number of doctors and resident doctors is not sufficient to serve 224 patients in a limited period of time. Thus, optimization for the number of doctors and resident doctors was needed. The optimized number of doctors and resident doctors was determined from Microsoft excel solver used as a tool. Then the new number of doctors and resident doctors was put in simulation software. This scenario can reduce total cycle time by 51%.

Next is the step of proposing the scenario to the management team. However, some of solutions were rejected such as increasing the number of doctors and resident doctors and adding treatment rooms. Thus, the discussion of a new solution with the management team was needed. After the discussion, the reduction of process time for some activities was considered. The new lead time was set and put in Microsoft Excel Solver to find the optimal number of doctors and resident doctors again. Besides, the batch size reduction was applied to this scenario too. Finally, the solution was verified in simulation again.

Table 5.1: Total Lead Time for As-Is and To-Be

Scenario	Total Cycle Time/ Entity (mins)
As-Is	41.28
To-Be	29.92

Table 5.1 shows the results of total lead time after improvement in which total cycle time reduced for 27%.

5.3 Recommendation

Queue management is one of the methods for process improvement. If the queue is managed effectively, it will help for better improvement. For example, for now, there is no specific time for non-appointment patients, so they can come any time when the hospital opens. Sometimes the queue is not followed. The example, queue improvement is to set time separately between appointment and non-appointment patients. Because the portion of appointment patients is more than non-appointment patients, the rule is to set the appointment patients' consultation time from 9.00-11.00, and the open time for non-appointment patients is from 11.00-12.00. This will help for queue arrangement.

5.4 Further Research

5.4.1 This research is mainly focuses on the process improvement by reducing total cycle time and waiting time. New studies can focus on increasing patient capacity can be studied. For example, the objective can be set as increasing patients by 10 % or 15%.

5.4.2 This research simulated a doctor's attribute by group because of the limitation. The next research can simulate a doctor's attribute individually.

5.4.3 This research studied only section of Process of OPD-ENT, but does cover the payment and pharmacy sections. Thus, further research can study the section of billing and pharmacy section.

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APPENDICES

APPENDIX A

NUMBER OF PATIENTS

Historical Data: Number of Patient

The numbers of patients in November 2008 to January 2009 are shown in Table 1 to Table 3. The patients are separated to an appointment, a non-appointment and a reject patients group.

Table 1: Number of patients in November 2008

Date	Appointment	Non-appointment	Total	Reject
4-Nov-08	118	82	200	
5-Nov-08	115	91	206	
6-Nov-08	141	76	217	
7-Nov-08	140	77	217	12
10-Nov-08	136	98	234	2
11-Nov-08	135	61	196	7
12-Nov-08	109	59	168	
13-Nov-08	114	83	197	
14-Nov-08	175	82	257	7
17-Nov-08	128	77	205	
18-Nov-08	198	71	269	
19-Nov-08	130	72	202	
20-Nov-08	129	81	210	
21-Nov-08	115	64	179	5
24-Nov-08	79.	58	137	18
25-Nov-08	152	72	224	5
26-Nov-08	144	77	221	14
27-Nov-08	139	76	215	21
28-Nov-08	158	74	232	

Table 2: Number of patients in December 2008

Date	Appointment	Non-appointment	Total	Reject
1-Dec-08	139	79	218	
2-Dec-08	145	78	223	
3-Dec-08	184	78	262	
4-Dec-08	124	82	206	12
8-Dec-08	115	91	206	2
9-Dec-08	155	80	235	7
11-Dec-08	195	89	284	
12-Dec-08	144	66	210	
15-Dec-08	154	84	238	7
16-Dec-08	138	78	216	
17-Dec-08	157	78	235	
18-Dec-08	185	93	278	
19-Dec-08	146	76	222	
22-Dec-08	142	79	221	5
23-Dec-08	146	84	230	18
24-Dec-08	118	68	186	5
25-Dec-08	200	88	288	14
26-Dec-08	124	59	183	21
29-Dec-08	162	104	266	
30-Dec-08	151	72	223	91

Table 3: Number of patients in January 2009

Date	Appointment	Non-appointment	Total	Reject
5-Jan-09	145	103	248	
6-Jan-09	142	87	229	4
7-Jan-09	70	71	141	
8-Jan-09	223	91	225	
9-Jan-09	134	91	225	
12-Jan-09	171	71	242	
13-Jan-09	154	76	230	
14-Jan-09	201	83	284	
15-Jan-09	127	65	192	
16-Jan-09	138	83	221	
19-Jan-09	187	84	271	
20-Jan-09	144	86	230	
21-Jan-09	90	77	167	
22-Jan-09	169	78	247	8
23-Jan-09	123	72	195	
26-Jan-09	164	105	269	
27-Jan-09	147	81	228	
28-Jan-09	185	80	265	
29-Jan-09	192	77	269	
30-Jan-09	109	72	181	

APPENDIX B

DATA COLLECTED

Data Collection Results

The data record sheet form is shown in figure 1.The sheet contains the information of activities (value added and non-value added) that occur in OPD-ENT, the number of room and doctor's name. However, the focus is to record the time of each activity including activity and waiting time. Then the Table 2 to Table 7 are shown the actual raw data that collected for eleven days.

Table 1: Data record sheet form

Date:		Patient:			Appoint	Non-appoint
Time:		Officer:				
Doctor name:		Room:				
		Time				
Step	**Activity**	From	To	Total	**Resource factor**	**Remark**
1	Getting medical record and going to wait fora doctor					
2	Waiting for a doctor in front of diagnosis room					
3	Consultation					
4	Waiting for a doctor in front of treatment room					
5	Treatment room					
6	Waiting for a doctor in front of ear test room					
7	Ear test					
8	Waiting for a doctor in front of endoscopy room					
9	Endoscopy					
10	Go back to the old consultation room					
11	Waiting for counter 16					
12	Going to counter 16 to get the next appointment					

Table 2: Data collected of process and waiting time of patients number 1 to number 11.

Activity	T'm mins	n	mın	Tim in	n m	in	m in	Ti m	ns		me n
Get medical record	0 1	0.5	05	0.2	0.5	0 3	0.0	0 0	0.0	0.2	0.6
Waiting for consultation	1	7 8	5.8	10.3	5.0	5.0	10.0	12.0	0	0	15.8
Consultation	1 6	7.3	3.7	7	9 3	9.0	6.0	0	4.0	8.	Z5
Resident in the first and second year waiting for consult with doctor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3	0.0	0.0
Resident in the first and second year consult with doctor	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1 0	0.0	0.0
Waiting for treatment	0.0	0.0	0.0	0.0	0.0	0.0	5 .9	0.0	130.4	0.0	0.0
eat e	0	0.0	0.0	0.0	0.0	0.0	22.0	0.0	7.0	0.0	0.0
Waiting for Audio test	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Audio test	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waiting forendoscopy	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Endoscopy	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Back to the diagnosis room	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
waiting for next appointment	Z3	0.0	0.0	Z	0.8	0.0	0.0	0.0	0.0	2.4	0
Get the next appointment	0.0	0.0	0.0	2.0	1 6	2.0	2.0	7.0	Z0	0.3	0.3

Table 3: Data collected of process and waiting time of patients number 12 to number 23.

Activity	Ti m in	m min	m	T s n	Tim min	me ins	T m n	T n	Time m ns	Ti e mi s	[illegible]	Time mins
Get medical record	0.5	0 4	0.3	0.3	0 2	0 7	0	0.3	0.4	0.	0.6	0.3
Waiting for consultation	7.9	8.0	11 3	1 .0	9.0	[illegible]	12.1	19.0	8.4	4.	[illegible] 4	29.3
Consultation	24.9	6.[illegible]	3.0	1 .0	8.6	8.0	8.1	7.8	5.4	0 2	6.9	9.2
Resident in the first and second year waiting for consult with doctor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Resident in the first and second year consult with doctor	0.0	O0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waiting for treatment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Treatment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waiting for Audio test	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Audio test	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waiting forendoscopy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Endoscopy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	O0	0.0	0.0
Back to the diagnosis room	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
waiting for next appointment	2.6	2.2	2.9	[illegible] 3	11.0	[illegible] 7	2.5	1 7	2.7	[illegible] 8	2.3	0.0
Get the next appointment	0.3	1.3	0.2	0.3	0.6	0.5	0.5	0.1	0.2	0.5	0.2	1 8

Table 4: Data collected of process and waiting time of patients number 24 to number 35.

Activity	me n	min	m E ns	T E n	Ti mins	m 'n	me mins	m in	im min	e s	E s	e n
Get medical record	0.5	0.3	0.3	[illegible]	0.5	[illegible]	0.5	0.3	0.2	0.4	0.8	[illegible]
Waiting for consultation	[illegible]	6.3	17.0	[illegible]	12.6	14.6	[illegible]	0.4	13.5	[illegible]	0.0	[illegible]
Consultation	4.1	7.7	[illegible]	3.9	[illegible]	[illegible]	[illegible]	10.4	5.6	5.6	3.2	4.0
Resident in the first and second year waiting for consult with doctor	0.0	68.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Resident in the first and second year consult with doctor	0.0	8.7	0.0	0.0	[illegible]	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waiting for treatment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Treatment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0
Waiting for Audio test	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Audio test	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waiting forenaoscopy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Endoscopy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Back to the diagnosis room	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
waiting for next appointment	5.4	0.8	1.3	0.1	0.5	4.8	4.0	5.4	1.2	2.6	0.8	4.0
Get the next appointment	0.4	3.	0.2	1.7	0.4	9	[illegible]	0.2	0.4	[illegible]	0.3	0.1

Table 5: Data collected of process and waiting time of patients number 36 to number 47.

Activity	ı s	me	m	i e mıı	Tin min	m min	• e m s	ı e mıcs	T n	• e ı	in min	i e mins
Get medical record	0.	0.5	0.3	0.3	0.5	0 5	0.8	0.4	0.5	0.3	0.2	0 3
Waiting for consultation	3.	25.9	20.5	5.0	4.0	13.7	9 6	4.0	6.0	20.0	7.4	7
Consultation	1.7	4.9	7.6	5.0	5.0	5.0	14.0	5.0	9.0	7.0	2.7	o 2
Resident in the first and second year waiting for consult with doctor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Resident in the first and second year consult with doctor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waiting for treatment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trea m	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waiting for Audio test	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Audio test	0.0	0.0	0.0	0.0	0.O	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waiting forenaoscopy	0.0	0.0	0.0	0.0	0.O	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Endoscopy	0.0	0.0	0.0	0.0	0.O	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Back to the diagnosis room	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
waiting for next appointment	5	3.4	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Get the next appointment	0.1	O	0.1	5.0	2.0	1.0	4.0	1.0	3.0	3.0	1.8	3.[illegible]

Table 6: Data collected of process and waiting time of patients number 48 to number 59.

Activity	Time (mins)	m min	E m	m nin	m.e m n	Time (mins)	E n	E min		m min	m m ns	m ns
Get medical record	0.7	0.3	0.7	0 0	0 5	0.0	0	0.0	.	0 0	0.0	0 :
Waitingfor consultation	11.8	7 4	8.0	4 0	3 0	15.0	5 8	11.		1 0	12.0	3 0
Consultation	8	2.7		3.0	6.0	11 0	0	3 0	4.0	5 0	9.0	5.0
Resident in the first and second year waiting for consult with doctor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Resident in the first and second year consult with doctor	00	00	0	00	0	00	0 0	00	0.0	0	0.0	0.0
Waiting for treatment	00	0.0	0.0	00	0.0	0.0	0 0	0.0	0.0	0.0	0.0	70.0
r m	0.0	0.0	0 0	0.0	0 0	8.0	0.0	0.0	0	0.0	00	13.0
Waiting for Audio test	00	0.0	0 0	0.0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Audio test	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waiting forendoscopy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E osc p	0.0	0.0	0.0	0.0	0.0	0.0	0 0	0 0	0.0	0 0	0.0	0.0
Back to the diagnosis room	0.0		0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
waiting for next appointment	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0 0	0.0	0 0
Get the next appointment	1 7	1.3	3 0		1.0	7.0	4.0	2.0		2 0		0

Table 7: Data collected of process and waiting time of patients number 60 to number 64.

ᴬcti	Time (mins)	Time (mins)	Time (mins)	Time (mins)	
Get medical record	0.4	0.4	0.0	0.3	0.0
Waiting for consultation	7 6	5.Z	0.0	6.Z	6.0
Consultation	3 5	2	0.0	.0	6.0
Resident in the first and second year waiting for consult with doctor	0.0	0.0	0.0	0.0	0.0
Resident in the first and second year consult with doctor	0.0	0 0	0.0	0.0	0.0
Waiting for treatment	0.0	0.0	0.0	0.0	0.0
Treatment	0.0	0.0	0.0	0.0	0.0
Waiting for Audio test	5.3	0.0	0.0	2 0	0.0
Audio test	4.7	0.0	0.0	9.8	0.0
Waiting forendoscopy	0.0	47.5	33.0	60	20.4
Endoscopy	0.0	5.6	.1	0.0	23.0
Back to the diagnosis room	1 9	0.0	2 0	0.0	1.0
waiting for next appointment	5.4	2.4	Z	0.0	0.0
Get the next appointment	0.1	0.3	0.	1.0	Z 0