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DEPARTMENT OF MECHANICAL ENGINEERING

LEAN PRINCIPLE IMPLEMENTATION IN SERVICE ORGANIZATION

WITH FOCUS ON ETHIOPIAN HEALTH CARE FACILITIES

A CASE STUDY ON HAWASSA UNIVERSITY REFERRAL HOSPITAL

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BY

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***LEAN PRINCIPLE IMPLEMENTATION IN SERVICE ORGANIZATION WITH FOCUS
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A Case Study on Hawassa University Referral Hospital

By Ibrahim Bedane

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Declaration

I, the undersigned, declare that this project report entitled “Lean Service Principles in the Service Organization with Focus on Ethiopian Health Care Facilities: A Case Study on Hawassa University Referral Hospital” is the result of my own research carried out under the supervision of Dr. Tafesse G/senbet. It has not been presented as a thesis in any other university and all source of material used for this thesis are duly acknowledged.

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Date

This is to certify that the above declaration made by the candidate is correct to the best of my knowledge.

Dr. Tafesse G/Senbet
Advisor

Date

In the memory of my mother Ayantu Furo

Dedicated to my parents and wife for their unending love and support

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ABSTRACT

Lean Service is a standardized operations service system, constituted only by client adding value tasks, focusing on explicit intangibles and looking for accomplishing expectations of quality and price. The overriding purpose of a lean system is to configure assets, material resources, and workers in a way that improves the process flow to the customer's benefit while minimizing losses caused by waste, variability, and inflexibility. In this thesis, lean service principles implementation in Ethiopian Health care facility is studied by taking a case study in vital few department and case teams of Hawassa University Referral Hospital.

The thesis aimed at assessing the existing service condition in the hospital; identify wastes and problem areas causing wastes by direct observation of the service area and by referring to the existing work towards improvement and proposing solutions which are helpful in minimizing the core problems and wastes. As a result of the study, Lean implementation model is developed. The study recommended the right use of Lean tools and techniques with a revised Hospital layout and patient flow system for each vital few case teams in the service provision process of the hospital.

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LIST OF ABBREVIATIONS

BPR: Business process Reengineering

BSC: Balanced Score Card

CT: Central triage

ED: Emergency Department

HSDP: Health Sector Development Plan

HURH: Hawassa University Referral Hospital

IPD: Inpatient Department

MOH: Ministry of Health

MOPD: Medical Out Patient Department

OPD: Out Patient Department

SOPD: Surgical Out Patient Department

VSM: Value Stream Map

WS: Work Station

CHAPTER I: PROBLEMS AND ITS APPROACHES

On top of providing some background information on the features of Health care Facilities, this chapter presents description of the objectives, significance, scope and limitation of the study. The structure of the study and the methodologies utilized are also dealt with briefly.

1.1. Background of the Thesis

This research addresses the application of lean service principle on service giving organization with focus on health sector within Ethiopia. After world war II, Japanese manufacturers, particularly in automotive companies, were faced with the dilemma of shortages of material, financial, and human resources. Eiji Toyoda and Taiichi Ohno at Toyota motor company in Japan pioneered the concept of the Toyota production system, or what is known today as lean manufacturing. The basic idea behind the system is eliminating waste. Waste is defined as anything that does not add value to the end product from the customer's perspective.

The overriding purpose of a lean system is to configure assets, material resources, and workers in a way that improves the process flow to the customer's benefit while minimizing losses caused by waste, variability, and inflexibility. These forms of loss are apparent in the public sector, where the consumer must often wait in lines, whether to receive health care, obtain a visa, or pass through security checks to board an airplane.

Toyota identified seven types of waste that inhibit a system's flows: overproduction, waiting, transportation, over processing, inventory, motion, and rework. Nearly all are relevant in the public/service sector. Take transportation. Is any movement of materials or people unnecessary? Does the movement of files needlessly lengthen an application process? In a prison system, is poor case management causing unnecessary and duplicative trips between prisons and courts? Similarly, consider waiting times. Do any idle periods result from poor coordination between activities? Are expensive CT (computerized tomography) scanners, say, idle because of the booking system, and do hospital operating rooms start work late because of staff shortages? Likewise, is work or inventory being stockpiled? In a back-office process, for example, employees may be either overworked or idle because work often accumulates before moving to the next stage.

According to Kotler (2000), the present economy of developed countries consists of a mix of seventy percent of Services and thirty percent of Products. In Ethiopia the contribution of the service sector to GDP is higher. In 2006/07 it was just **40.3%**, in comparison to 46.3% from the agricultural sector and 5.1% from the manufacturing sector. Hospitals are one of basic service giving organization by take caring of health of each individual and community around and facilitate economic growth of our country. Hawassa University School of Health Science Referral Hospital is one of the major referral hospitals in the country, comprising of teaching and medication service for inpatients, outpatients and emergency cases. The hospital is giving service to a highest number of patients; though they are complained by customers. The main complaints are related with service quality which was caused by seven types of wastes.

1.2. Problem Statement

In Ethiopia, regardless of the stern global competition in modern business, most companies are still very inefficient and are competing under suboptimal conditions. Reports from different production and service organizations in the country reflects most companies are characterized by low profit, waste of resources, poor and unsafe working environment, high employee dissatisfaction, high labor turnover, long delivery time, customer dissatisfaction, etc. These problems were solved with the help of one or more of the different tools and technique of lean manufacturing. However, one key issue has to be overlooked. That is for anything to implemented, there need to have a standard reference or bench mark based on which proper implementation can be made to see if the tools and techniques implemented is beneficiary for our country organizations.

There was Business Process Re-engineering (BPR) study conducted on referral hospital by consultants and hospital itself which focus on how to facilitate and improve the quality of work. Though the proper implementation of BPR is arguable, the question of waste like underproduction, long waiting time, rework, unnecessary motion, and transportation and so on is an everlasting issue. Thus, the current study “**lean health care facilities on Hawassa University Referral Hospital** will focus on identification and reduction of seven types of waste for overall quality servicing.

The study shows that “there is high customer complain in the wastes cause less quality of service given in this referral hospital like high waiting time, delay, under production of professionals, unnecessary motion of the customers to get service or lack of properly designed, arrangement and assignment of rooms, transportation of patient and document over long distance and poor service quality. Above all service delivery and waste reduction process/system of the hospital is the central problem that drives other problems, mostly delay and waiting time. Much of the delay accepted by the public is both unnecessary and costly. Patients are harmed in the process of delay, not only through wasted time, but through unnecessary suffering, and through adverse medical outcomes. Health care providers are harmed through the added cost and reduced efficiency resulting from the complications of handling delayed patients.

Crowding in waiting rooms and treatment areas, loss in privacy, delays in accessing needed equipment, and delays in providing medication are all add to patient suffering. Hospitals in particular, HURH, demand for service can be so large that the system rarely empties of waiting patients, either because the ED itself has insufficient capacity, or because the hospital’s wards are not absorbing the inflow of patients, thus causing spillback into the ED. At times when waits become particularly long, more patients will opt to leave without being seen, either immediately at time of arrival, or subsequently after becoming frustrated with the wait, bringing waits back into balance. And continual queuing de-motivates employees, as no matter how hard they work patients will still be queued. And service will be unproductive, as patients must be shuttled in and out of treatment rooms as they wait for test results or resources. Crowding can also lead to diversion of ambulances to more distant hospitals, slowing the time until patients can be treated (ACEP, 1999; Litvak et al, 2001). For these reasons, it is imperative for all providers to seek out and implement solutions that reduce wastes.

1.3. Objective of the Study

I. General Objective

This study locates the basic and core concept in lean service principle implementation on service organization and design the optimum model to address the problems in Ethiopian health care facilities.

II. Specific objectives

Specifically, this thesis achieves the following:

1. Develop a clear understanding of the philosophy, relevance and components of Lean related to the health care sector.
2. Show how customer satisfaction achieved by specifying Value and putting the patient at the center means measures such as medical quality, waiting times and patient satisfaction.
3. Indicate the level of improved productivity and quality that can be expected through the introduction of Lean
4. Give recommendations and suggestions about how to establish and implement Lean across Ethiopian health care facility and Services.

1.4. Limitations of the Study

In this study office and store workplaces have not been studied since productivity is more directly measured in serving shop and profitability of the whole organization depends primarily on the productivity of operations carried out on the shop floor.

1.5. Organization of the Thesis

The thesis has been divided into six chapters. Brief descriptions of the contents of each chapter are:

Chapter 1 introduces objectives, methods, limitation and organization of this paper. In Chapter 2, an extensive review of the literature on the subject has been carried out. It includes various tools and techniques of lean, lean Principles and Application in Service Firms, Approaches adopted for service firms and health care, and finally health care in Ethiopia is studied and presented.

Chapter 3 covers the design of study, with overall methodology, detailed analysis carried out and tools and techniques employed for this analysis. It also contains the description of services and processes of Hospital unit where work has been carried out. Flow charts of various processes and other process details are covered.

Chapter 4 presents the main body of the work. It covers the complete step by step analysis carried out including data collection, calculation of various types of wastes, root cause analysis and

comparison with the requirements of lean. And Chapter 5 discusses detail lean servicing implementation model developed with expected implementation barriers.

Chapter 6 concludes the work by presenting the whole work results, conclusions, recommendation and the scope for further research work.

CHAPTER 2: LITERATURE REVIEW

It covers a detailed review of literature on various aspects of lean . The literature review includes the Lean Principles and its application in Service Firms. Approaches adopted for lean in health care have also been studied and presented in the Chapter. Finally, health care in Ethiopia is reviewed.

2.1. The History of Lean

After World War II Japanese, manufactures were faced with the dilemma of vast shortages of material, financial, and human resources. The problems that Japanese manufacturers were faced with differed from those of their Western counterparts. These conditions resulted in the birth of the “lean” manufacturing concept. Toyota Motor Company, led by its president Toyoda recognized that American automakers of that era were out-producing their Japanese counterparts; in the mid-1940’s American companies were outperforming their Japanese counterparts by a factor of ten. In order to make a move toward improvement early Japanese leaders such as Toyoda Kiichiro, Shigeo Shingo, and Taiichi Ohno devised a new, disciplined, process-oriented system, which is known today as the “Toyota Production System,” or “Lean Manufacturing.” Taiichi Ohno, who was given the task of developing a system that would enhance productivity at Toyota, is generally considered to be the primary force behind this system. Ohno drew upon some ideas from the West and particularly from Henry Ford’s book “Today and Tomorrow.” Ford’s moving assembly line of continuously flowing material formed the basis for the Toyota Production System. After some experimentation, the Toyota Production System was developed and refined between 1945 and 1970, and is still growing today all over the world. The basic underlying idea of this system is to minimize the consumption of resources that add no value to a product.

In order to compete in today’s fiercely competitive market, US manufacturers have come to realize that the traditional mass production concept has to be adapted to the new ideas of lean manufacturing. A study that was done at the Massachusetts Institute of Technology of the movement from mass production toward lean manufacturing, as explained in the book “The Machine That Changed the World” (Womack, Jones and Ross, 1990), awoke the US

manufacturers from their sleep. The study underscored the great success of Toyota at NUMMI (New United Motor Manufacturing Inc.) and brought out the huge gap that existed between the Japanese and Western automotive industry. The ideas came to be adopted in the US because the Japanese companies developed, produced and distributed products with half or less human effort capital investment, floor space, tools, materials, time, and overall expense (Womack et al., 1990).

2.2. What Is Lean

Lean is a methodology developed from JIT production in Toyota. The term “lean” as Womack and his colleagues define it denotes a system that utilizes less, in term of all inputs, to create the same outputs as those created by a traditional mass production system, while contributing increased varieties for the end customer. It focuses on abolishing or reducing wastes (or “muda”, the Japanese word for waste) and on maximizing or fully utilizing activities that add value from the customer’s perspective. From the customer’s perspective, value is equivalent to anything that the customer is willing to pay for in a product or the service that follows. It helps organizations become competitive through waste elimination and product (or service) quality improvement in a flow environment which is pulled by customer demands. So the resounding principle of lean is to elimination waste through continuous improvement that will eventually reduce the cost of services and products, thus growing more profits.

All lean is about is creating more value with less of everything,” says Jim Womack, the president of the Lean Enterprise Institute [20]. The definition is simple, but it describes the essence of lean, and it is pursued by all for-profit organizations. “More value” means higher output and better quality, while “less of everything” means lower cost and less throughput time. Output, quality, cost, and throughput time are four performance measurements used by profit organizations. Better performances on all of these metrics can be achieved through applying lean principles.

Today, lean principles are not only for manufacturing, but also can be applied to service. The term Lean Production is used to identify methods and waste reduction on productive systems. When transferred to the Service sector, these methods can be described as Lean Service. According to Nascimento and Francischini (2004), “Lean Service can be defined as a

standardized operations service system, constituted only by client adding value tasks, focusing on explicit intangibles and looking for accomplishing expectations of quality and price". Fortes (2010), states that the Lean Service implementation is based on Lean principles, with some changes for Service organizations.

The Lean Service philosophy is still considered to be an emergent area either in applications and consequently in literature. The initial publications about the implementations have been done on the health sector. There are also some cases based on financial and government agencies, (Wei 2009). More recently the Lean concept has been applied in the transportation sector, whereas the applications in the education sector have emerged only in the last decade, in particular the implementation of Lean in Higher Education Institutions (HEIs), (Hines and Lethbridge 2008).

The overriding purpose of a lean system is to configure assets, material resources, and workers in a way that improves the process flow to the customer's benefit while minimizing losses caused by *waste, variability, and inflexibility*. These forms of loss are apparent in the service sector, where the consumer must often wait in lines, whether to receive health care, obtain a visa, or pass through security checks to board an airplane.

Waste: Toyota identified seven types of waste that inhibit a system's flows: overproduction, waiting, transportation, over-processing, inventory, motion, and rework. Nearly all are relevant in the service sector. Take transportation. Is any movement of materials or people unnecessary? Does the movement of files needlessly lengthen an application process? In a prison system, is poor case management causing unnecessary and duplicative trips between prisons and courts? Similarly, consider waiting times. Do any idle periods result from poor coordination between activities? Are expensive CT (computerized tomography) scanners, say, idle because of the booking system, and do hospital operating rooms start work late because of staff shortages? Likewise, is work or inventory being stockpiled? In a back-office process, for example, employees may be either overworked or idle because work often accumulates before moving to the next stage.

Variability: In the context of a lean system, variability is any deviation, in a service or product that creates unnecessary costs. In manufacturing, production variability might lead to the

extensive reworking or scrapping of parts. In the service sector, variations in the way investigators gather evidence for a trial can lead to unnecessary acquittals. Often, managers use the inherent complexity of a process to justify a refusal to standardize any aspect of it. However, defining and sharing best practices can bring considerable benefits in quality and productivity.

Inflexibility: Finally, inflexibility refers to any systemic rigidity that prevents a supplier from meeting the customer's requirements at reasonable cost. In manufacturing, inflexibility could mean forcing customers to purchase a package of extras when they actually want only one. In the public sector, staffing levels are often inflexible: the same number of police might work a shift on Monday night as one on a busy Saturday night. Too often, governments design public services on the one-size-fits-all model in the mistaken belief that a standard service necessarily offers economies of scale. In reality, different customer segments require different levels and types of service.

These sources of loss are strongly linked to the overall objectives of a lean organization: reduced costs, higher quality, and better customer service. In the lean approach, managers and staff tackle all three simultaneously to create a consistent flow.

2.3. Lean Principles and Application

Lean is a methodology developed from JIT production in Toyota [3]. Lean helps organizations become competitive through waste elimination and product (or service) quality improvement in a flow environment which is pulled by customer demands. Fortes (2010), states that the Lean Service implementation is based on Lean principles, with some changes for Service organizations. The key principles behind Lean explained in this part will be applied in this research to health care facilities.

a) **Recognition of waste** - The first step is to recognize what does and does not create value from the customer's perspective. Any material, process or feature, which is not required for creating value from the customer's perspective, is waste and should be eliminated. For example, transporting materials between workstations is waste because it can potentially be eliminated.

b) **Standard processes** - Lean requires the implementation of very detailed production guidelines, called Standard Work, which clearly states the content, sequence, timing and outcome of all actions by workers. This eliminates variation in the way that workers perform their tasks.

c) **Continuous flow** - Lean usually aims for the implementation of a continuous production flow free of bottlenecks, interruption, detours, backflows or waiting. If the products or customers continue to flow, the number of their stops is reduced. Since they do not stay somewhere waiting for a machine or worker, the wasted time due to waiting can be eliminated. In order to achieve a continuous flow, the utilization of scarce resources must be maximized, and the workload among all processes should be evenly balanced. When this is successfully implemented, the cycle time can be reduced.

d) ***Calls for a pull system***, where customers demand direct production flow and quantity. Pull-production aims to produce only what is needed, when it is needed. Based on the required production/service quantity, plans can be made for the manufacturing/service process. Therefore, no waste from over and under-production will happen.

e) **Quality at the Source** - Lean aims for defects to be eliminated at the source and for quality inspection to be done by the workers as part of the in-line production process.

f) **Continuous improvement** - Lean requires striving for perfection by continually removing layers of waste, as they are uncovered. This in turn requires a high level of worker involvement in the continuous improvement process.

Besides the lean principles discussed above, there are lean tools and techniques, such as workplace organization (5S), Kaizen (continuous improvement), VSM, Lean layout, work standardization, preventive maintenance and etc discussed below.

Many lean techniques have been successfully applied by service firms. Just as in manufacturing, the suitability of each technique and the corresponding work steps depend on the characteristics of the firm's markets, production and equipment technology, skill sets, and corporate culture. Service firms are not different in this respect. Here are 10 of the more successful applications. [5]

1. **Organize problem solving group:** Honeywell is extending its quality circles from manufacturing into its service operations. Other corporations as diverse as first bank/Dallas, standard meat company, and miller brewing company are using similar approaches to improve service. British airways used quality circle as a fundamental part of its strategy to implement new service practices.
2. **Upgrade housekeeping:** good housekeeping means more than winning the clean broom award. It means that only the necessary items are kept in a work area, that there is a place for everything, and that everything is clean and in constant state of readiness. The employees clear their own areas. Service organizations like McDonald have recognized the critical nature of housekeeping. Their dedication to housekeeping has meant that service process work better, the attitude of continuous improvement is easier to develop, and customers perceive that they are receiving better service.
3. **Upgrade quality:** the only cost effective way to improve quality is to develop reliable process capability. Process quality is quality at the source- it guarantees first-time production of consistent and uniform product and service. Quality doesn't mean producing the best; it means consistently producing and service that give the customers their money's worth.
4. **Clarify process flows:** clarify process flow based on JIT themes, can dramatically improve the process performance. For examples, federal express corporation government used JIT approach to cut the time to record a deed transfer by 50% and Super maids send in a team of house clearances, each with a specific responsibility, to clean each house quickly with parallel process.
5. **Revise equipment and process technologies:** revising technology involves evaluation of equipment and processes for their ability to meet the process requirements, to process consistently within tolerance, and to fit the scale and capacity of the group. A hospital reduced operating room setup time so that it had the flexibility to perform a wider range of operations without reducing the operating room availability.
6. **Level the facility load:** service firm synchronize production with demand. They have developed unique approaches to leveling demand so they can avoid making customers wait for service. For example the post office charges more for next-day delivery and McDonald

offers a special breakfast menu in the morning. These examples are the service approach for creating uniform facility loads.

7. **Eliminate unnecessary activities:** a step that does not add value is a candidate for elimination. A step that does add value may be a candidate for reengineering to improve the process consistency or to reduce the time to perform the tasks. A hospital discovered that significant time was spent during an operation waiting for an instrument that was not available when the operation began. It developed the check list of equipment required for each categories of operation.
8. **Reorganize physical configuration:** work area configurations frequently require recognition during a lean implementation. Often manufacturers accomplish this by setting up manufacturing cells to produce items in small lots, synchronous to demand. These cells amount to micro factories inside the plant.

Most service firms are far behind manufacturers in this area. However, a few interesting examples do come out of the service sector. Some hospitals_ instead of routing patients all over the building for test, exam, x-rays, and injections_ are reorganizing their services into work group based on the type of problems. Teams that treat only trauma are common, but other work groups have been formed to treat less immediate conditions like hernias; these amount to micro clinics within the hospital facility.

9. **Introduce demand pull scheduling:** due to the nature of service production and consumption, demand-pull (customer-driven) scheduling is necessary for operating service business. Moreover, many service firm are separating their operations into “back room” and “customer contact” facilities. This approach creates new problems in coordinating schedules between the facilities. The original Wendy’s restaurants were setup so cooks could see cars enter the parking lot. They put a pre-established number of hamburger patties onto the grill for each car. This pull system was designed to have a fresh patty on the grill before the customer even placed an order.
10. **Develop supplier networks:** the term supplier network in the lean context refers to the cooperative association of suppliers and customers working over the long term for mutual benefit. Service firm have not emphasized supplier networks for materials because the service costs are often predominantly labor. Notable exception must include service

organization like McDonald's, one of the biggest food products purchasers in the world, which has been developing lean practices.

2.4. Lean Tools And Techniques

To identify sources of waste tools such as Value stream mapping, root causes analysis and others will be used. Once companies identify the major sources of waste, tools such as continuous improvement, just-in-time production, production smoothing, and others will guide companies through corrective actions so as to eliminate waste. In the following sections a brief description of such tools is given.

A. Value Stream Mapping

A value stream is a collection of all actions value added as well as non-value added that are required to bring a product or a group of products that use the same resources through the main flows, from raw material to the arms of customers (Rother and Shook, 1999). These actions are those in the overall supply chain including both information and operation flow, which are the core of any successful lean operation. Value stream mapping is an enterprise improvement tool to assist in visualizing the entire production process, representing both material and information flow.

The goal is to identify all types of waste in the value stream and to take steps to try and eliminate them (Rother and Shook, 1999). Taking the value stream viewpoint means working on the big picture and not individual processes, and improving the whole flow and not just optimizing the pieces. It creates a common language for production process, thus facilitating more thoughtful decisions to improve the value stream (McDonald, Van Aken, and Rentes, 2002). While researchers and practitioners have developed a number of tools to investigate individual firms and supply chains, most of these tools fall short in linking and visualizing the nature of the material and information flow in an individual company.

At the level of the individual firm many organizations have moved toward becoming lean by adapting different lean tools such as JIT, setup reduction, 5S, TPM, etc. In many of these cases

firms have reported some benefits; however, it was apparent that there was a need to understand the entire system in order to gain maximum benefits.

Stream mapping can serve as a good starting point for any enterprise that wants to lean. Rother and Shook (1999) summarize other benefits of value stream mapping as follows:

- It helps you visualize more than just the single process level in production. You can see the entire flow.
- Mapping helps you not only see your waste but also its source in the value stream.
- It provides a common language for talking about manufacturing/service processes.
- It ties together lean concepts and techniques, which help you, avoid “cherry picking.”
- It forms the basis for an implementation plan. By helping you design how the whole door-to-door flow should operate a missing piece in so many lean efforts.
- Value stream maps become a blueprint for lean implementation.

B. Cellular Manufacturing

Cellular manufacturing is one of the cornerstones when one wants to become lean. Cellular manufacturing is a concept that increases the mix of products with the minimum waste possible. A cell consists of equipment and workstations that are arranged in an order that maintains a smooth flow of materials and components through the process. It also has assigned operators who are qualified and trained to work at that cell.

Arranging people and equipment into cells has great advantage in terms of achieving lean goals. One of the advantages of cells is the one-piece flow concept, which states that each product moves through the process one unit at a time without sudden interruption, at a pace determined by the customer’s need. Extending the product mix is another advantage of cellular manufacturing. When customers demand a high variety of products as well as faster delivery rates, it is important to have flexibility in the process to accommodate their needs. This flexibility can be achieved through grouping similar products into families that can be processed on the same equipment in the same sequence. This will also shorten the time required for changeover between products, which will encourage production in smaller lots. Other benefits associated with cellular manufacturing include:

- Inventory (especially WIP) reduction
- Reduced transport and material handling
- Better space utilization
- Lead time reduction
- Identification of causes of defects and machine problems
- Improved productivity
- Enhanced teamwork and communication
- Enhanced flexibility and visibility

C. Continuous Improvement

Continuous improvement is another fundamental principle of lean manufacturing. Kaizen, which is the Japanese word for a continuous endeavor for perfection, has become popular in the west as a paramount concept behind good management. Kaizen is a systematic approach to gradual, orderly, continuous improvement. In manufacturing settings improvements can take place in many forms such as reduction of inventory, and reduction of defective parts. One of the most effective tools of continuous improvement is 5S, which is the basis for an effective lean company. 5S is a first, modular step toward serious waste reduction. 5S consists of the Japanese words Seiri (Sort), Seiton (Straighten), Seiso (Sweep and Clean), Seiketsu (Systemize), and Shitsuke (Standardize). The underlying concept behind 5S is to look for waste and then to try to eliminate it. Waste could be in the form of scrap, defects, excess raw material, unneeded items, old broken tools, and obsolete jigs and fixtures (Monden, 1998).

The first S, Seiri, deals with moving those items that are not currently being used on a continuous basis (e.g., items that will not be used for the next month or so) away from those that are. Moving those items and tossing away needless items will make material flow smoothly, and workers move and work easily (Feld, 2000).

Seiton has to do with having the right items in the right area. Items that do not belong to a given area must not be in that area. For a given workplace area tools must be marked and arranged as belonging in that area. This will make it easier to move those items that are not labeled from that area. Arranging items in the right place will make tools, jigs, fixtures, and resources noticeable, detectable, and easy to use (Feld, 2000).

Seiso deals with cleaning and sweeping the work place methodically. The workplace should look neat and clean and ready to use for the next shift. The work place should be maintained on a regular basis (e.g., daily). All tools and items should be in the right place and nothing should be missing. A well-maintained workplace creates a healthy environment to work with (Feld, 2000).

Seiketsu is maintaining a high standard of housekeeping and workplace arrangement. A regular audit should be run and scores should be assigned for areas of responsibilities. If every area has people assigned to it then everyone has responsibility to maintain a high standard of housekeeping and cleaning (Feld, 2000).

Shitsuke is management's accountability to train people to follow housekeeping rules. Management should implement the housekeeping rules in a practiced fashion so that their people can buy into it. Management should walk the shop floor, explain what they want from people, reward those who follow and instruct those who do not (Feld, 2000).

Taken together, 5S means good housekeeping and better workplace organization. Kaizen tools such as 5S are not only a means to increase profitability of a firm but also allow companies to reveal potential strengths and capabilities that were hidden before (Hirai, 2001). Sweeny (2003) and Cox (2002) have reported good results implementing 5S. Further, benefits of implementing 5S will be described later.

D. Just-In-Time

Closely associated with lean manufacturing is the principle of just-in-time, since it is a management idea that attempts to eliminate sources of waste by producing the right part in the right place at the right time. This addresses waste such as work-in-process material, defects, and poor scheduling of parts delivered (Nahmias, 1997). Inventory and material flow systems are typically classified as either push (traditional) or pull (just-in-time) systems. Customer demand is the driving force behind both systems. However, the major difference is in how each system handles customer demand. Just-in-time is a tool that enables the internal process of a company to adapt to sudden changes in the demand pattern by producing the right product at the right time, and in the right quantities (Monden, 1998). Moreover, just-in-time is a critical tool to manage the

external activities of a company such as purchasing and distribution. It can be thought of as consisting of three elements: JIT production, JIT distribution, and JIT purchasing.

Some of the benefits of JIT

- Eliminating unnecessary work-in-process, this results in reduction of inventory costs.
- Since units are produced only when they are needed, quality problem can be detected early.
- Since inventory is reduced, the waste of storage space will be reduced.
- Preventing excess production can uncover hidden problems.

E. Standardization of Work

A very important principle of waste elimination is the standardization of worker actions. Standardized work basically ensures that each job is organized and is carried out in the most effective manner. No matter who is doing the job the same level of quality should be achieved. At Toyota every worker follows the same processing steps all the time. This includes the time needed to finish a job, the order of steps to follow for each job, and the parts on hand. By doing this one ensures that line balancing is achieved, unwarranted work-in-process inventory is minimized and non-value added activities are reduced. A tool that is used to standardize work is what called “takt” time is. Takt (German for rhythm or beat) time refers to how often a part should be produced in a product family based on the actual customer demand. The target is to produce at a pace not higher than the takt time.

Takt time is calculated based on the following formula.

$$\text{Takt time (TT)} = \frac{\text{available work time per day}}{\text{customer demand per day}}$$

F. Total Productive Maintenance

Machine breakdown is one of the most important issues that concern the people on the shop floor. The reliability of the equipment on the shop floor is very important since if one machine breaks down the entire production line could go down. An important tool that is necessary to account for sudden machine breakdowns is total productive maintenance. In almost any lean environment setting a total productive maintenance program is very important. There are three

main components of a total productive maintenance program: preventive maintenance, corrective maintenance, and maintenance prevention. Preventive maintenance has to do with regular planned maintenance on all equipment rather than random check ups. Workers have to carry out regular equipment maintenance to detect any anomalies as they occur. By doing so sudden machines breakdown can be prevented, which leads to improvement in the throughput of each machine.

Corrective maintenance deals with decisions such as whether to fix or buy new equipment. If a machine is always down and its components are always breaking down then it is better to replace those parts with newer ones. As a result the machine will last longer and its uptime will be higher. Maintenance prevention has to do with buying the right machine. If a machine is hard to maintain (e.g., hard to lubricate or bolts are hard to tighten) then workers will be reluctant to maintain the machine on a regular basis, which will result in a huge amount of lost money invested in that machine.

G. Other Waste Reduction Techniques

Some of the other waste reductions tools include zero defects, setup reduction, and line balancing. The goal of zero defects is to ensure that products are fault-free all the way, through continuous improvement of the manufacturing process. Human beings almost invariably will make errors. When errors are made and are not caught then defective parts will appear at the end of the process. However, if the errors can be prevented before they happen then defective parts can be avoided. One of the tools that the zero-defect principle uses is poka-yoke. Poka-yoke, which was developed by Shingo, is an autonomous defect control system that is put on a machine that inspects all parts to make sure that there are zero defects. The goal of poka-yoke is to observe the defective parts at the source, detect the cause of the defect, and to avoid moving the defective part to the next workstation.

2.5. Application of Lean Principles in Health Care

The success of Lean in industry has prompted many people to ask "Why not in Health care?" A few people have begun to answer that challenge and today we have enough experience to say that lean works well in health care facilities since lean principles have been adopted in various hospital services, although the way that they have been implemented differs depending on the organization. This includes for example, the use of Lean production, flow, kaizen, process and value stream mapping, standardizing systems and root cause analysis in hospitals to improve emergency care services, intensive care units and operating units and to reduce waiting times (8). However there are still few empirical studies on the implementation of Lean in the Health sector within both academic and practitioner literature.

A study assessing the suitability of Lean Thinking in the UK health service looked at how a performance measurement system called the "flow model" was designed to identify key performance indicators that measure changes towards Lean Thinking (19). The study concluded that Lean Thinking is applicable in health care settings, and that the flow model is a suitable tool for following up these initiatives. This has practical implications for health care practitioners, who may use the findings to develop measurements of the outcome of Lean Thinking initiatives on existing care processes. However, it is argued that the flow model needs to be balanced with other measurements in order to receive a complete picture of Lean Thinking performance (19). The same study also reported similar findings in a study of the Swedish health care system (19).

In an evaluation of Lean Thinking in health care, some writers (19) have used the five elements of the Womack and Jones Lean model to discuss how applicable Lean is to health care and, in particular, how measurement can be used to reflect this application: these principles are discussed in table below.

Lean Principle	Applied to Health Care
Determine value from the customer's perspective	The customer, or the patient, values an efficient and effective health care experience in which all of their needs are met
Identify the value stream for each product or service	Every step of the patient's health care experience produces value

Make value flow smoothly from beginning to end	The patient moves continuously through the health care system with no delays, interruptions, or gaps in care
Let the customer pull value from the process	The patient “pulls” products and services (e.g., appointments, prescriptions, tests, information) easily when needed
Pursue perfection and continuous improvement	Care processes are continuously re-evaluated and redesigned to optimize the patient experience

Note. Adapted from Womack & Jones (2003)

Table 1: Lean Principles Applied to Health Care

They examines how well the “flow model” used in the health care system provides measures which support all five Lean principles and found that additional measures e.g. policy deployment, patient satisfaction and continuous improvement are needed in order to fully capture the changes towards Lean thinking. Also suggests that designing a performance measurement system that reflects Lean initiatives is one important phase in implementing Lean Thinking in the entire organization (19).

2.6. Health care in Ethiopia

Modern medicine was introduced into Ethiopia in the 16th century and remained as a privilege to the members of the royal courts until the establishment of 1st hospital in Addis Ababa in 1900 GC. The foundation of formalized health service in Ethiopia goes back to 1908 GC (when office dealing with health was created in ministry of interior).

Ministry of Health (MoH) did not formulate National policy and strategy for define health services till 1955 E.C (1963 G.C) when the second five development plan was launched. Currently different reform plan was established for improvement of health condition in the country including for Twenty Year Health Sector Development plan (1996 – 2015).

2.6.1. Health Sector Strategic Assessment

One of Strategic Objectives of Ethiopian Health Sector that was settled on HSDP IV by Ethiopian MOH to achieve health sector mission and vision is **Improve quality of health services**. This strategic objective includes provision of health services as per the standard by

health facilities at all levels. *This standard includes: speed of delivery, harmonization at service delivery point through the integration of vertical programs in order to ensure that there will be holistic approach to service delivery and also avoid missed opportunities in the delivery of service, effectiveness of the services and patient safety, ethical and professionalism in service delivery, and availability of the required inputs (HR, finance, pharmaceuticals ...)*

The expected outcome is the creation of a health system that satisfies the community's health care needs through the fulfillment of the required inputs, delivering safe and optimum quality of health services in an integrated and user-friendly manner.

The Other strategic objective is about evidence-based decision making through enhanced partnership, harmonization and alignment: and integrations of projects and programs at the point of health service delivery. *It includes identification of health system bottlenecks; research; HMIS; performance monitoring; quality improvement; surveillance; use of information for policy formulation, planning, and resource allocation.* The expected outcome of the strategic objective is proper generation and use of evidence to address the critical health problems of the community at all levels of the health system and the realization of one-plan, one-budget and one-report and effective integration and alignment of health programs and projects.

Other stated objectives of Ethiopian MOH are as follows:

1. Improve Health Infrastructure
2. Improve Human Capital and Leadership
3. Improve regulatory system
4. Improve Pharmaceutical Supply and Services
5. Improve Public Health Emergency Preparedness and Responses
6. Maximize resource mobilization and utilization
7. Improve community ownership
8. Improve Access to Health Services

2.6.2. Concept of Quality in Ethiopia Health Care system

Quality of Health Care is the degree to which health services for individuals and populations increase the likelihood of the desired health outcomes consistent with current professional

knowledge. The delivery of quality health services is central to improving the health status of the population. In addition, satisfying patients and clients is the primary goal of the Government's reform program including BPR.

Current strategy focuses on a comprehensive and continuous quality monitoring mechanism that will enable all levels of the health system (both management and service delivery) to look at all aspects of performance and quality of services. Inputs, processes and outcomes of the health care system will be monitored for quality, and the mechanism will also seek to involve all managers and every health care worker in the ongoing processes of quality improvement at all levels of the health system.

Improving the quality of services will be realized through scrupulous implementation of tools, manuals and standards that have been developed as part of BPR. BPR already defined quality structures, quality planning, quality performance measurement, quality improvement activities, and mechanisms for involving actors, evaluation of quality on programs, service delivery and health management at all levels of the health system. Although almost all of the core and support processes have a quality component in them; rigorous implementation of the Performance Monitoring and Quality Improvement Standard Operating Procedure, and the Health Regulatory Core Processes becomes indispensable to ensure adherence to standards by all actors in the sector. Health and Health Related Regulatory Core Process is designed to effectively monitor the adherence by all health service providers focusing on professional practice, quality of products and premises of service delivery. Regulation of health services will be enhanced by putting in place an independent inspection. This will imply the implementation of the Health Service Regulatory Core Process in order to properly regulate health services and take the necessary corrective measure. This will include regular monitoring of premises, personnel, practices and products to ensure adherence to agreed standards.

The Quality of Health service applies a three-pronged approach to improving quality of health services. These are supply side interventions, demand side interventions and regulatory aspect (stated above). The supply side interventions include availing adequate number of skilled and motivated professionals; strengthening the supply chain management system in order to ensure adequate and uninterrupted supply of pharmaceuticals at the point of service delivery. It also

include improving the fiscal space of health institutions through the implementation of HCF reforms to ensure the allocation of adequate resources for the procurement of commodities, maintenance of infrastructure, creating conducive environment for patients and clients as well as motivation of health human resources. An inbuilt quality assurance mechanism will be put in place through effective implementation of the Performance Monitoring and Quality Improvement Standards and Tools at all levels of the health system.

Demand side interventions include active participation of the community. Community participation is an important aspect of improving quality of services as it guarantees that patients' and clients' opinions are heard and their satisfaction with services is optimized. Community members will therefore be included in health facility governance boards, a patients' rights charter will be developed and regular surveys on client satisfaction will be conducted. Involving the community in the planning, implementation, monitoring and evaluation of health interventions will be enhanced. The quality of care in the curative and rehabilitative services will be addressed at each level of service delivery point and *all facilities will be organizing their service delivery into inpatient services, outpatient services and emergency medical care*. All patients will pass through screening/triage for prioritization. In the case of emergency case, a patient will be referred directly to the emergency medical care and will be able to receive an immediate attention and treatment.

CHAPTER 3: DESIGN OF STUDY

This chapter covers the overall methodology of the research work including the steps of analysis and tools and techniques employed. A brief description of the hospital unit where the study has been carried out is also given.

3.1. Brief Description of the Hospital (HURH)

This organization (HURH) was established as a referral hospital in 1994 E.C. having the objectives of providing medical service to the society and practical training to health science students. The hospital was estimated to serve a population of about 12,000,000 people currently having 280 beds when it works with its full potential It will have a capacity of 350 Beds.

3.1.1. Vision, Mission, Values and Objectives of HURH

A. Vision:

With the full fledged implementation of the radically transformed health care service process Hawassa University Referral Hospital aspires to be one of the leading specialized hospitals.

B. Mission:

The mission of the referral hospital is to promote good health care service of the community by providing the highest quality and cost effective services to health care seekers and being a center of excellence in teaching and conducting research.

C. Values:

- **Patient First** - We strive to deliver the best to every patient every day. The patient is the first priority in everything we do;
- **Service** - We strive to meet customer satisfaction in health care service, education and research;
- **Integrity** - Upholding firm principles and high standards, and demonstrating a high level of trust, honesty and Medical ethics;
- **Respect** - We treat each individual with the highest professionalism and dignity;
- **Innovation** - We embrace change and work to improve all in fiscally responsible manner;

- **Teamwork** - System effectiveness is built on the collective strength and cultural diversity of everyone, working with open communication and mutual respect;
- **Openness** - Being upfront and truthful in actions and words.

D. Objective

The General Objective of Hospital Service Process would be redesigned as customer focused that could produce the greatest satisfaction, and the employees would also be able to take responsibility for the performance of an entire process.

Specifically the specific Objectives of the hospital are:

- Perform customer focused process;
- Maximize its service to its level best;
- Avoid defames against its relegated performances in service, and renew its public favor;
- Maintain lovely support and cooperation from its stakeholders, and;
- Be competent canter of practical training

3.1.2. Major Services Given In HURH

Hawassa University Referral Hospital (HURH) represents the highest tertiary level and is “Specialized Referral Hospital”. The hospital major services are:

- It serves as referral hospital for patients throughout the south western Ethiopia.
- It provides training for undergraduate medical students.
- It provides outpatient and inpatient care in the fields of Medicine (with sub-specialty in neurology), surgery (sub-specialties with urology), orthopedics, Gynecology and obstetrics, Pediatrics (with sub-specialties). Services are provided for paying and for non-paying patients. The care covers various forms of examination, diagnostics, treatment and therapy.
- It provides emergency services and care for medical, surgical and trauma patients. The forms of diagnostics include radio-diagnostics (X-ray), etc, ultrasound etc; pathology (FNA, PAP, etc.) and laboratory tests (biochemistry, bacteriology, hematology, etc).
- It provides general services such as food, laundry, pharmacy, sterile supplies, consumables, technical operation and maintenance etc.

3.1.3. Major Department In HURH

In HURH there are; emergency service department, OPD (outpatient diagnostic) department, IPD (inpatient diagnostics) department services and additional supportive services as represented below.

A. Central Triage

Here patients will be welcomed (received), registered, pay registration fee, receive approval of free of charge (credit), screened receive personal cards and will be sent to the outpatient case team. Any emergency cases found here are directly sent to emergency case team without delay

B. Emergency Department (ED)

This department plays a vital role in providing care to patients and they are recognized for their contribution that they make to the society. The available statistics make it clear about the indispensability of this healthcare service operation that the country relies upon to provide emergency care services to the patients on a 24Hr 7 days basis. Emergency care service of HURH classified as Emergency other than labouring mother which is treated by ED and Labouring mother those directly taken to the delivery service room at arrival without reporting to the central triage for registration

This department has one laboratory, and single pharmacy working on 24 hour basis, and two observation room with 6 beds each and other 10 beds in side corridors. There is also one procedure room, two wound care section, two dorms to do small or medium surgery services. Under this department there are three basic units which are listed in table below.

C. Out Patient Diagnosis Department (OPD)

This department is the largest department of all which has one laboratory and pharmacy for medical, surgical and orthopedic case teams and pediatrics and Gynecology case teams have their own laboratory and pharmacy each. There is also guidance and counseling section with VCT service. This department has the following case teams with care units listed in table below.

Note: Case teams accommodate the following Services:

- Cold case management At the 4 OPDs
- MCH (Pediatric and obstetric) case management
- Medical
- ENT and/or Ophthalmology case management

- Surgical
- Pediatrics
- Gynecology and obstetrics
- Other special clinics as deemed necessary:
 - Dental case management
 - Psychiatric case management
 - Physiotherapy service
 - Dermatology case management

D. Inpatient Diagnosis Department (IPD)

This department has two pharmacies, two laboratories and more than 400 beds. It is a place where the patient is intensively examined and observed daily with high care of patients. These department deals with care units listed in table below. Some of Inpatient Care Services are:

- Medical
- Surgical
- Pediatrics
- Gynecology and obstetrics
- Ophthalmology and others

E. Other departments

There are other departments and case teams which are listed in table blow and are basic for serving patient wisely. Some their services are: Centralized services, public health services and other.

Centralized services

- laboratories,
- diagnostic imaging,
- drug store,
- infection prevention and control service
- operation services

Public Health Services Carry out:

- Responding to epidemic diseases like HIV/AIDs, TB and Malaria
- Disease surveillane on nationally and internationally notify able diseases
- Patient health education, continuing education for health workers
- Sanitation and waste management
- Occupational health services
- Incinerator services
- Food inspection

OPD case teams and units				
Medical OPD	Surgical OPD	Pediatric	Obstetrics and Gynecology	Other
<ul style="list-style-type: none"> ✓ Medical regular OPD ✓ Medical Referral Clinics like <ul style="list-style-type: none"> • Cardiology Unit • Endocrinology and Diabetic Unit • Gastro-Intestinal Unit • Neurology Unit and others 	<ul style="list-style-type: none"> ✓ Surgical regular OPD ✓ Operating theaters/minor OR ✓ Surgical Referral Clinics like <ul style="list-style-type: none"> • General • Urology (Genito-urinary Surgery) Unit and others 	<ul style="list-style-type: none"> ✓ Pediatrics Emergency ✓ Pediatrics Regular ✓ Pediatrics Referral ✓ Pediatrics ART clinic 	<ul style="list-style-type: none"> ✓ Obstetrics Unit ✓ MCH Unit ✓ Delivery Unit ✓ Gynecology Unit ✓ Family Planning and Mini Lap-anatomy Unit 	<ul style="list-style-type: none"> ✓ Pathology ✓ Dermatology ✓ ENT ✓ ART clinic and ✓ Others
ED	IPD	Diagnostic Services	Other	Pharmacy
<ul style="list-style-type: none"> ✓ Emergency Surgery ✓ Medical emergency ✓ Wound section 	<ul style="list-style-type: none"> ✓ Delivery care unit ✓ Surgical care unit/ward ✓ Medical care unit/ward ✓ Pediatrics and child care unit/ward ✓ Optimality ward 	<ul style="list-style-type: none"> ✓ Diagnostic imaging like Radiography and Ultrasound ✓ Laboratory service ✓ Physiotherapy 	<ul style="list-style-type: none"> ✓ Central triage case team ✓ Administrative department 	<ul style="list-style-type: none"> ✓ Central pharmacy ✓ ED pharmacy ✓ OPD case teams pharmacies ✓ IPD pharmacies ✓ And other

Table 2: summary of HURH department Services

3.2. Methodology

3.2.1. Data Collection

Data has been collected using the following methods:

- Observation of current performance and activities.
- Previous records: - Data from records include patient arrived, appointment, etc.
- Personal interaction: - It includes interviews of personnel directly related to the process.

3.2.2. Identification of Wastes in Healthcare and Their Quantum

To analysis waste, office and store workplaces have not been studied since productivity is more directly measured in production shop floor and profitability of the whole organization depends primarily on the productivity of operations carried out on the shop floor.

Originally seven main types of waste were identified as part of the Toyota Production System [Sullivan et al, (2002)]. For HURH the main types of waste identified are:

- A. Unnecessary inventory (number of patient waiting) - Excessive storage and delay of information and patients, resulting in excess number of patient waiting and cost, leading to poor customer service.
- B. Delay - Long periods of inactivity for people, information or goods, resulting in poor flow and long lead times.
- C. under servicing - Producing too soon, resulting in poor flow of information or goods and excess inventory.
- D. Excessive transportation -. Excessive movement of people, information or goods, resulting in wasted time and cost. In HURH, transportation waste can show up when moving patients, tests, materials or information around
- E. Unnecessary motion - Poor workplace organization, resulting in poor ergonomics, e.g., excessive bending or stretching and frequently lost items.
- F. Inappropriate operation - This is doing more/less than is required, especially from the customer's point of view. A simple example of over processing results in patients (customers) trying to figure out multiple claim forms, including the ones that state, "This

is not a bill.” Going about work processes using the wrong set of tools, procedures or systems, often when a simpler approach may be more effective.

- G. Defects. Defects, corrections, adjustments or inaccurate or incomplete information cause many problems. For example, a label on a blood tube that is misapplied, illegible or improperly aligned can cause errors or delays in processing.

No.	Type of waste	Data collection	Waste identification method
1	Delay	<ul style="list-style-type: none"> ➤ duration of patient and workers Arrival ➤ Service time of each station ➤ Other Avoidable and Unavoidable delays. 	<ul style="list-style-type: none"> ➤ From time study records. ➤ Standard working hours. ➤ Delay of workers
2.	Patient waiting	<ul style="list-style-type: none"> ➤ Cycle time, Setup time, service time, arrival rate. ➤ WIP-patient waiting in process for other units. 	Data from records and observation
3.	Transportation waste	Assignment of patient to inappropriate case team	. From observation
4.	under service	<ul style="list-style-type: none"> ➤ Total number of patient served. ➤ Total requirement 	Difference in total number of patient served and requirement.
5.	Inappropriate operation	Using wrong set of tools, procedures or systems and appointments	From records.
6	Unnecessary motion	Distance between work stations and/or physician examination rooms	Direct measurement on shop floor
7	Defects		

Table 3: wastes in health

3.2.3. Analysis Strategy

The steps employed in the studying and modeling have been as under:

- a. Analysis and Identification of problems and causes of wastes
- b. Identification of vital few case teams using Pareto principle, analyze their current conditions and tools and techniques suitable to reduce and/or avoid these wastes
- c. Identification of factors influencing implementation of identified tools and techniques by brainstorming, idea generation and implemented reform tools
- d. Using experience from other health care and companies implementing lean tools and techniques, formulate a phase implementation approach.

CHAPTER 4: DATA COLLECTION, ANALYSIS AND RESULT

This chapter presents the main body of the work. It covers the complete step by step analysis carried out including data collection, calculation of various types of wastes, root cause analysis and comparison with the requirements of lean. Finally, lean implementation strategic approach is developed to lean hospitals.

4.1. Service Description

Current service delivery system of each units of HURH case teams and departments are analyzed starting from patient entrance (central triage case team) including servicing system and condition of ED, OPD and IPD up to exit of patients from the hospital.

4.1.1. Service system

Central triage (CT) receive all patients arriving with all case like referral, personally, emergency or scheduled appointments by OPD by registering and opening their document/card and direct/assign them to the right physicians and keeping their documents in appropriate way and place. Also, serves to identify priorities for patient care in emergency departments and most surge situations in which resources are rarely limited.

ED is *continuous process* healthcare service delivery system where patients treated continuously until they leave the room. It represents one of the most visible service sectors with 13.5% of patient arrival where the effects are very stark. Poor service delivery can often make the difference between life and death. The serious issue concerning healthcare in hospitals' ED is that they are very crowded and the waiting times are so long that it is rarely a smooth and satisfying experience..

Outpatient is a very common way for patients to access health care. It is *discrete service* process where patients move and transported from work station to other work station based on their medical condition and type These groups of patients include non-urgent patients coming from various clinics or hospitals outside HURH with or without a referral certificate. The department typically schedule appointments for patients in advance, and patients arrive to the clinic

expecting service to begin at their scheduled time. It shares 86.5% of patients visiting hospital by working five day a week in 8hr basis and include more than seven case teams all with total share shown on the table and chart below.

Case teams	No. of servers	No. of patient/month	Patient/server	% OPD patient
Surgical	2 & 1 SRC	1686	562	27.76
Medical	3 & 1 MRC	1636	409	26.94
GYN	1	555	555	9.14
Eye	1	466	466	7.67
Pediatrics	1	431	431	7.10
ENT	1	385	385	6.34
Dermatology	1	310	310	5.10
Psychiatrics	1	230	230	3.79
dental	1	224	224	3.69
OBS and other	1	150	150	2.47
Total OPD		6073		100.00

Table 4: Number of patient per month for each case team and server in OPD

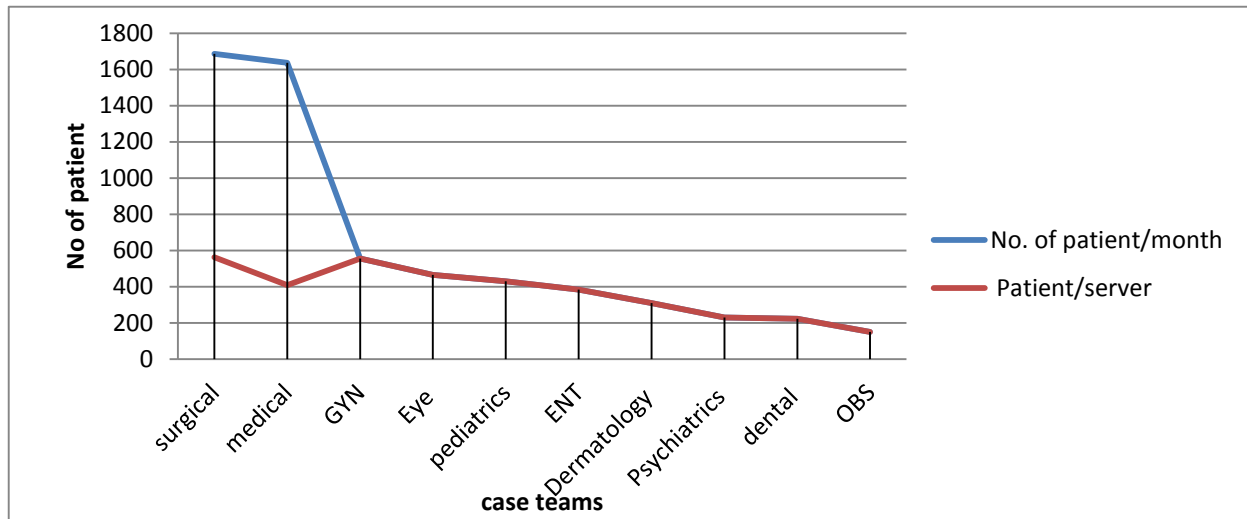


Figure 1: Number of patient per month for each case team and server in OPD

The in-patient diagnosis (IPD) department patients arrived through Emergency Department (ED) and OPD departments of the hospital. Patients coming through ED are treated in different units of ED and after treatment they are either discharged and left ED or admitted to IPD units of the hospital. Other patients coming main hospital entrance through referral and appointment to OPD are admitted in IPD and after treatment they are discharged.

In this research, it is assumed that an analysis done on vital few departments will work for all departments and case teams in hospital.

According to Ethiopia HSDP IV Strategic Objective, quality Improvement of health services targets to Increase customer satisfaction index from 50% to 100%, Decrease Average Length of Stay from 6.7 days to 5 days, Increase the proportion of referred patients completing referral process successfully (from the beginning to the feedback) to 80%, Increase the proportion of emergency patient receiving emergency care in less than 5 minutes from 50% to 100% and other.

It is difficult to analysis all departments and case teams of HURH in this thesis due to time and cost needed to cover all. However, to satisfy strategic objectives target listed above, I need to identify vital few departments using Pareto chart like shown below and work on them by assuming that it will work for all other departments and case teams in hospital.

Case teams	Room No.	Patient /Month	Patient/Ws	% Of Patient	Note
Emergency	23, 24, 25	948		13.50	
Outpatient diagnosis (OPD) department				86.5	
Surgical	39, 40, 42	1686	562	24.01	
Medical	50,51, 52,53	1636	409	23.30	
GYN	85	555	555	7.90	
Eye	13	466	466	6.64	
Pediatrics	90	431	431	6.14	
ENT		385	385	5.48	
Dermatology		310	310	4.42	
Psychiatrics	114	230	230	3.28	
Dental		224	224	3.19	

OBS and other		150	150	2.14	
Total		7021		100.00	
IPD				From ED	
				From OPD	

Table 5: number of patient per case team

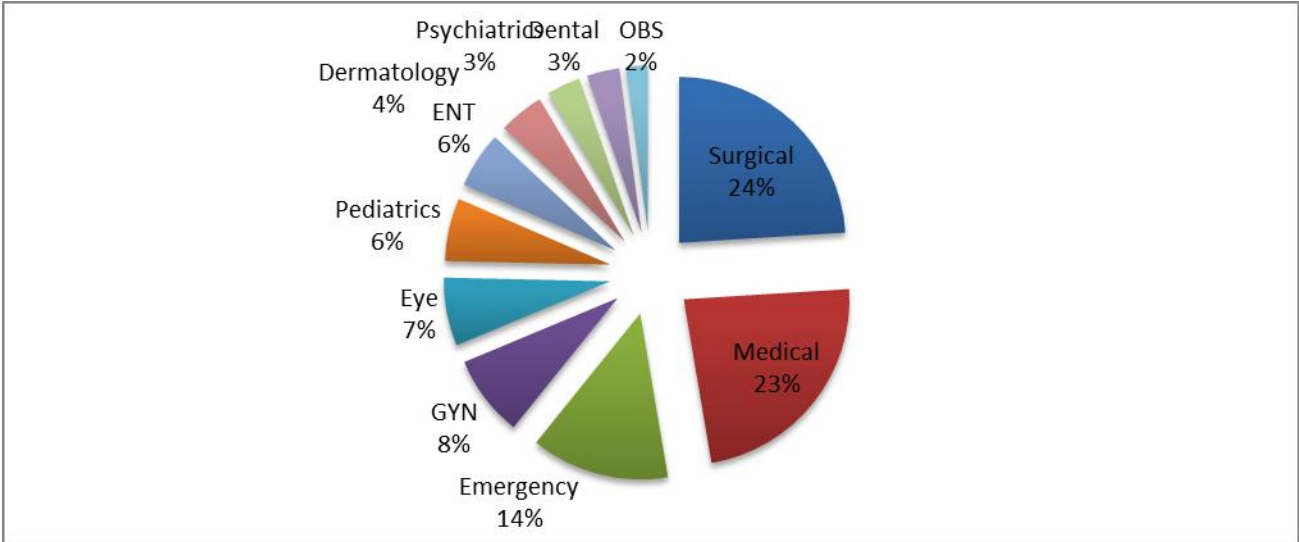


Figure 2: Pie chart of number of patients per case team

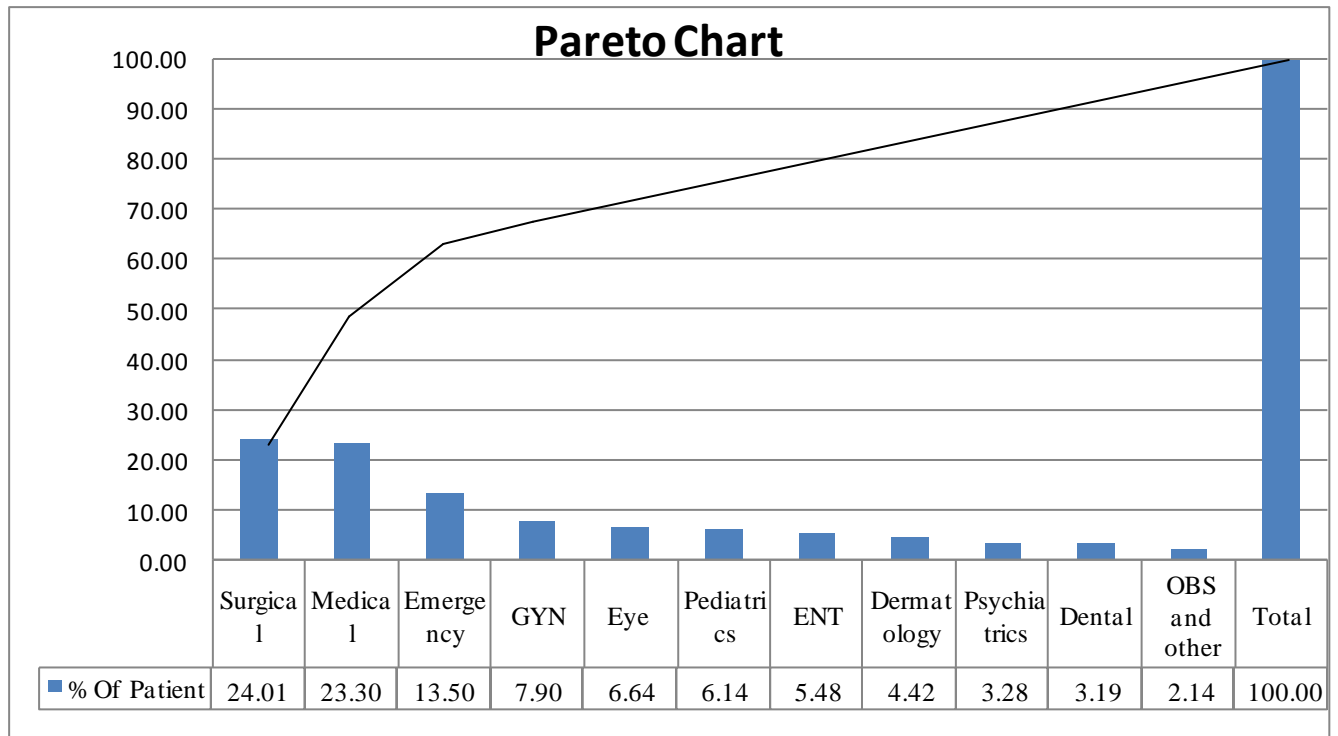


Figure 3: Pareto chart

From the above Pareto chart, 11 unit (departments and case team) are found all with equal need to be analyzed, 27.3 % of the units (3 out of 11; surgical OPD, medical OPD and emergency) are the vital few or the magnificent area which serves about 61% of arriving patients. Therefore, this thesis is brought in by focusing on the *central triage, emergency department, medical and surgical OPD case teams*.

4.1.2. Service Conditions

The process of patient care often involves services from several departments and multiple steps for a single episode of care. If not accurately managed and scheduled, the experience can be negative for all involved. Patients are overwhelmed and confused while staffs are frustrated and delayed. The organizational impact is reduced patient flow resulting in higher cost and reduced revenue.

Patient Flow in the HURH is very intense, as a result, problems causing higher customers complains occurred. The major real-time problems that have been reducing service quality and increasing customers complains encountered in HURH service system are as follows:

- Long patient waiting time occur at the front desk
- Poor communication across stages of the patient visit and Patient conveyed to wrong service
- Large number of patients waiting to be served at the case teams result in uncomfortable conditions such as congestion, noise, and poor ventilation.
- A sound scheduling is not performed due to incorrect examination time
- Patient appointment overlap
- Inefficient use of time and rework in collecting patient information
- Arbitrary Patient Arrival proves difficult to manage
- Patients not arriving at scheduled appointments (“no-show”)
- Staff waste time searching for necessary supplies in disorganized areas
- Inconvenient location of patient charts
- Inaccurate and incomplete patient information and visit process
- Staff time wasted searching for patients transiting between various departments and looking for ‘lost patients’ waiting in the wrong room.

To solve these problems the root causes of these problems are analyzed

4.1.3. Root Cause Analysis

For the purpose of analysis, the most common wastes and sources of wastes that have been reducing service quality and increasing customers complains are categorized into six different types as discussed below.

A. Waiting of patients

Waiting in queues waiting lines is one of the most common occurrences in everyone's life. Anyone, who has gone to a hospital, has experienced the inconvenience of waiting in line to get serviced. If you observe the serving room in HURH, you can see lots of patients and their family makes queuing line to get served. Patient waiting occurs in each and every patient flow stage and in all patient types (i.e. ED and OPD patients) arriving to get served.

The most common causes of Excess patient waiting are.

- a) Arbitrary patient arrival
- b) Randomly Patient Scheduling

- c) Poor record keeping and retrieval
- d) unbalanced service lines
- e) Bottlenecks in the processes
- f) Less workers and top management commitment and attention on waiting levels

B. Delay of work stations

From direct observation of work stations, there are inactive stations without service even though customers are waiting to get service, information and/or goods which results in poor flow and long lead times.

The basic causes of Delay are:

- a) Workers present but not working deliberately because of negative attitude, unionism, lack of motivation, low morale, no concern and lack of a accountability.
- b) Un-avoidable delays due to:
 - Absence of proper equipment, tools etc.
 - Time consuming inspection checks.
- c) Higher number of Patients due to:
 - Poor planning.
 - Ineffective patient scheduling.
- d) Break downs of machines and equipment due to: Poor maintenance strategy adopted.
- e) Excessive time spent on setting
- f) Absenteeism
 - Without authorization.
 - Alienation from the place of work and go to their private clinic.

So we can conclude that delay in HURH can be classified into two categories:

- I. Avoidable Delays: Avoidable delays are due to excessive breakdowns, willful absenteeism, large setup/cycle times, and operators missing from workstations.
- II. Unavoidable Delays: Unavoidable delays are allowances given due to fatigue or rest on prescribed by the International Labor Organization.

C. Under Service

Under service is not that common in the hospital, since all patients arrived are served as much as possible. A bigger problem is that some patients are not served with in the desired service time. The under servicing are often caused by:

- a) Long service Time: Patients served for longer service time due to their health condition and service delivery problem causes under servicing by increasing service time which reduces number of patient served.
- b) Rework: are inappropriate operations that caused by some activities that are carried on in examination room which increase service time and causes under service. These are activities like blood pressure test; heart beat and etc which can be taken before patient enter the room even they can as soon as patient enters the hospital for registration.
- c) Workers assignment: Sometimes serves cannot be delivered until physician visit admitted patient or patients in wards which reduces total working hour of the station and causes under servicing.

In some way these all causes underserved, because physicians net service time was reduced by unscheduled and unnecessary activities.

D. Inappropriate Operation

In HURH, there is inappropriate operation. There are activities in processes that can either add value to the customer, be necessary for the function of the process or non-value adding. Some inappropriate operations are:

- a) Rework: The rework during medication is one of inappropriate operation. In examination room, after nurse take blood pressure, pulses and body temperature of patient physician do it again.
- b) Wastage due to excessive operation at examination room:

E. Defect

In hospital there is no as such defect waste occurs. But, corrections, adjustments or inaccurate or incomplete information cause many problems. For example, a label on a blood tube that is misapplied, illegible or improperly aligned can cause errors or defects in processing. The most common causes of defect are:

- | | |
|---|---|
| <ul style="list-style-type: none"> a) Improper machine and equipment due to: <ul style="list-style-type: none"> ➤ Poor upkeep and maintenance. | <ul style="list-style-type: none"> b) Human error due to: <ul style="list-style-type: none"> ➤ Lack of planning. |
|---|---|

- Non-suitability of lab and other equipment.
 - Non-adherence of process parameters.
 - Too many bottlenecks.
 - Faulty information and control system.
 - Insufficient descriptions of previous history on patient card.
- c) Poor inputs like patient, materials, tools etc due to:
- Poor selection.
 - Inefficient patient assignment.
- d) Human error by workers due to:
- Deliberately not being careful in working and maintaining the laid down parameters.
 - Not being suitable for the job.
 - Chance variations.

F. Waste Due To Transportation And Motion

The study has been carried out in the HURH to identify wastes Due to Transportation and Unnecessary Motion. The unnecessary transportation of patient is a common cause of waste in the hospital. In this case, the patient does not follow a specific line flow due to their moves depends on their health situation and types, they move from one station to another in a haphazard manner.

The easiest way to think about motion waste is walking (or body movements). A lot of walking waste can arise from poor design of an area or lack of optimal working conditions that result in staff having to make multiple trips for things. For instance; there are unscheduled frequencies of motion of workers those transfer patient cards from CT to each case teams and units in side hospital. Suppose all individual transport an average of 10 cards at once.

Person	ALTAYECH	SENAYIT	SELAM	SOLOMON	ASELEFECH	MESELECH	
Departm.	Dental, Eye	pediatrics	Medical OPD		Surgical OPD	ED and Dermatology	Total
	ENT and OBS	Gyn	51, 52	50, 53			
Patient	989	1455	859	777	1686	1255	7021
Distance	48	36	85	85	28	30	338
frequency	99	146	86	78	169	125	703
distance	4752	5256	7310	6630	4732	3750	32430
T. distance	9504	10512	14620	13260	9464	7500	64860
Difference	-1306	-298	3810	2450	-1346	-3310	0

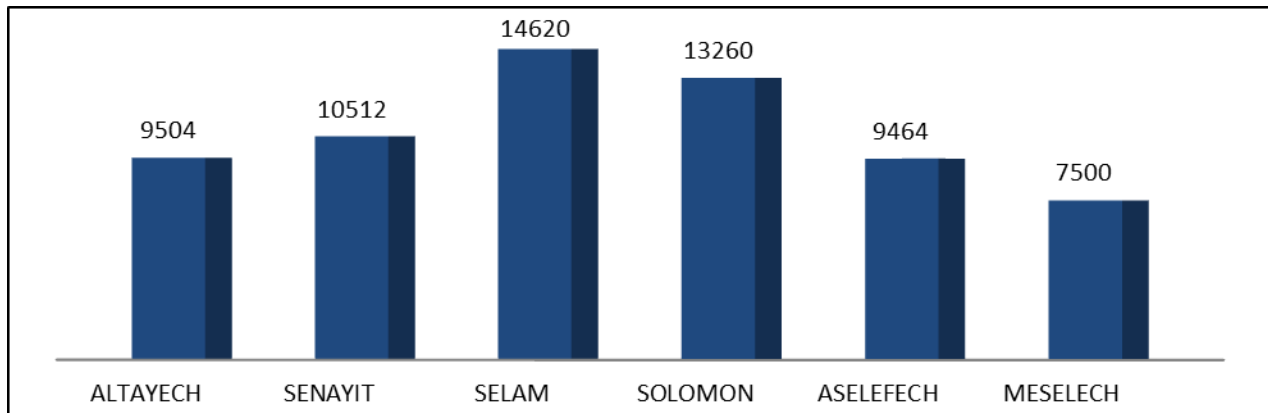


Figure 4: Distance traveled in meter/workers

In short, the major causes of Excessive Patient and Workers movement are

- a. Improper layout.
- b. Inability of top management to plan modernization.
- c. Poor understanding of patient flow.

In order to reduce these wastes, the layout of the case teams is proposed to be amended to facilitate single flow, schedule faire assignment of staff and also reduce unnecessary patient transportation.

A Cause and Effect was developed to examine the factors that are contributing to the problem. Wastes caused by specific problem are causes for some other wastes. Patient waiting is caused by all other wastes like in appropriate operation, under servicing, workers delay, defects and unnecessary motion of workers according to their level of impact. Table below illustrate cause and effect relationship of wastes based on their causing ranks.

Rank	Effect					
	Patient Waiting	Worker Delay	Unnecessary Motion & transportation	Under servicing	Inappropriate Operation	Defect
Causes	1	In. Operation		Delay		
	2	Under serv.	In. Operation	In. Operation	In. Operation	In. Operat.
	3	W. Delay	Motion	W. Delay	Defect	W. Delay
	4	Defect		Defect		p. Waiting
	5	Un. Motion			Motion	

Table 6: cause and effect relationship of wastes

Patient waiting is the vital waste that is caused by HURH working problems and all other wastes. No one can reduce patient waiting without considering and improving all other wastes that causes it. We reduce patient waiting by improving all other wastes. So, in this paper I decide to focus on patient waiting analysis and reduction.

The Cause -and-Effect Diagram was developed for patient waiting through four steps, namely:

1. Identify the problem's characteristics.
2. Brain storm the reasons why the problem is occurring using a causal table (also known as the Why –because technique)
3. Group the causes by relationship
4. Create a Cause- and-Effect Diagram

The causes are grouped under the following headings: (1) workers, (2) Machine, (3) Patient and (4) Method. The diagram makes it easy to see many possible root causes of the issues that may lead to patient waiting.

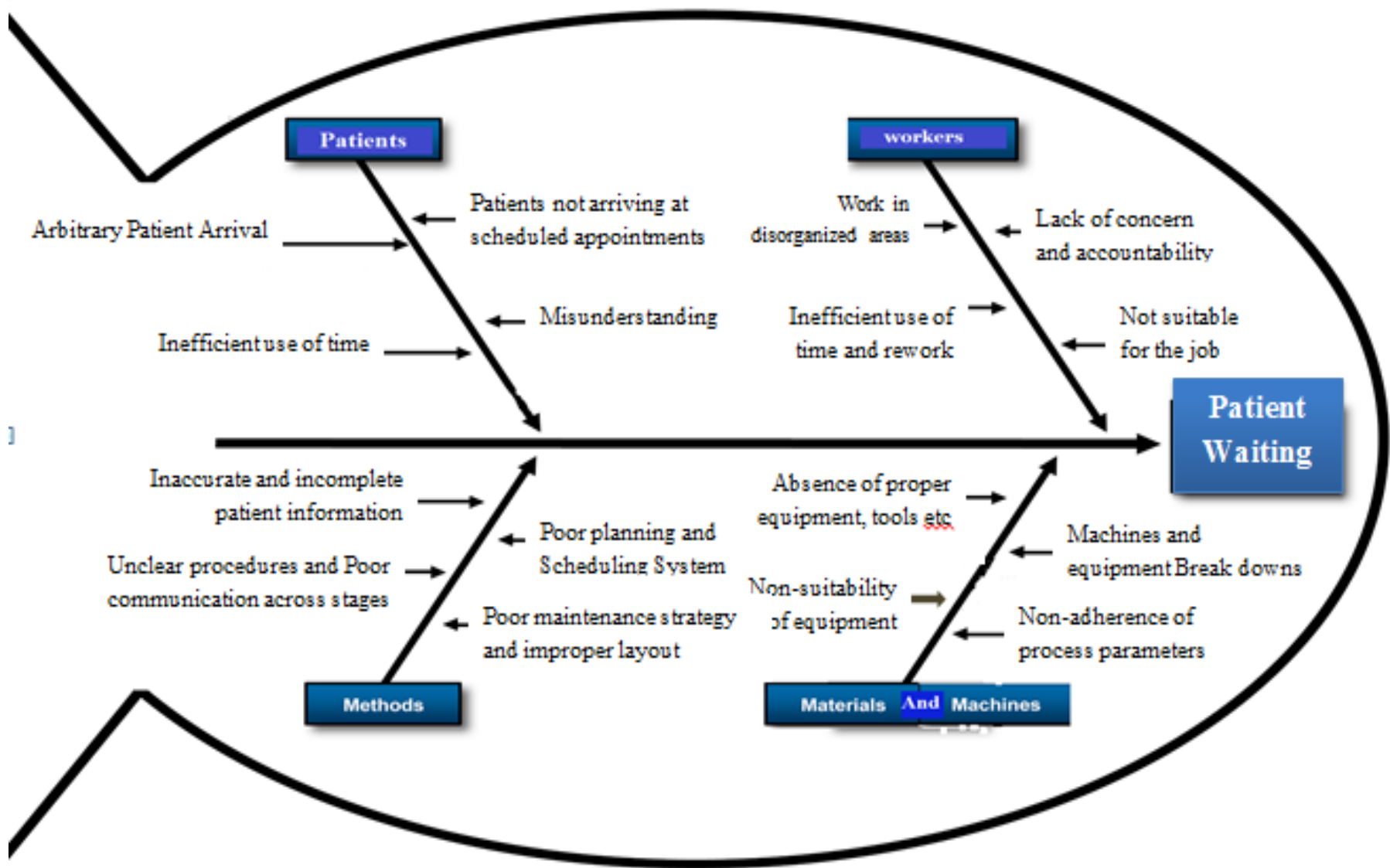


Figure 5: cause and effect diagram

4.2. Central Triage

The central triage consists of four major areas: Front desk, two Registration desks each with the patient Screening nurse (attendant) in most cases or rarely a general practitioner in this room, Waiting area (triage), and two finance offices.

4.2.1. Current CT Service Delivery Process

When patient enters the CT asked by front-desk clerk to provide name and reason for visit. The clerk also clarifies if patient was pre-registered for this service or not. If the answer is yes, the clerk gets patient's documentation ready for the registration representative. Then the patient receives an assigned number and is asked to wait in waiting or triage area for registration representative to call the name and number. Registration representative determines if the patient ever receives the service at the hospital and if so, pull up patient's data and verifies patient's personal information. If the patient is visiting the hospital for the first time, CT clerk creates patient's profile in the Hospital Database card. An attendant nurses in this room identifies and determines patient's type (outpatient (OPD), Clinical (CLI), Referred (REF), Recurring (RCR), emergency, Surgical Day Care (SDC)) and creates new account and then orders the carter to transport the card once a patient has paid a registration fee. CT serves most outpatient and emergency types, with REF, some RCR and INP.

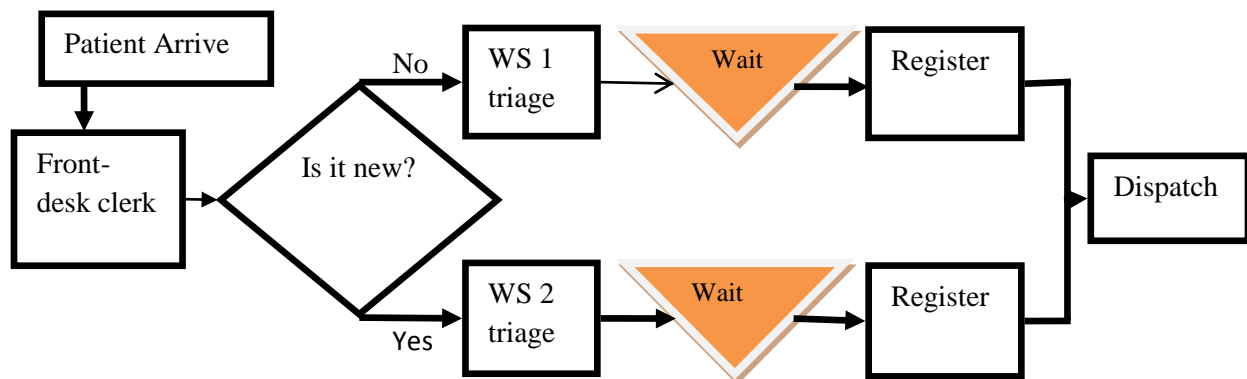


Figure 6: CT process flow

In short Regular and referred patient arrive early in the morning at 7:30 am making a long queue. The front desk clerk screens each patient to identify where patients should go. Next, patients will be sent to Screening or Registration Room where they have to get a patient card upon paying a registration fee. The Registrar then distributes the cards as per Screen Room's instructions. Patients can be assigned to go to Regular Surgical OPD, Medical OPD, Gyn OPD, pediatrics and other OPDs according to their cases.

4.2.2. Working condition

Patient Flow in the CT is very intense, as a result, overcrowding and longer waiting time of patient which causes higher customers complains are the major problems in the case team, except for that of referral and emergency case which have a priority of registration as soon as they came.

In the CT, two main events cause an instantaneous change in the state of the system:

1. The entry of a patient into the system (patient arrival)
2. The release of a patient upon completion of registration (patient dispatching)

Based on information obtained from experts, observation, and historical data, the following logic governs the flow and conditions of arriving patients:

- The order of registration priority is emergent, referral, and regular cases, respectively.
- Arriving patients are classified as follows:
 - *Emergency case*: a probability of 13.5% which includes 4.5% of referral case.
 - *Referral case*: a probability of 34.5% which includes referred emergency case.
 - *Regular case*: a probability of 56.5% on which nearly 28.9% of regular patients are appointed patients comes in their scheduled day to meet their physicians.
- When a risky emergency case arrives, it does not pass through the triage or data-entry stages; the person is treated directly by a physician.
- When a referral and regular case arrives, the person must pass through both triage and registration stages.

4.2.3. Analysis of Waiting in Central Triage

To analysis the waiting time of the case team, I should know and identify the property and conditions of queuing system elements i.e. arrival rate, service rate, queuing discipline and other.

a) Arrival Rate

In observing arrivals at a hospital, we can look at them from two viewpoints: first, we can analyze the time between successive arrivals to see if the time follow some statistical distribution. Usually the time between arrivals is exponentially distributed. Second, we can set some time length (T) try to determine how many arrivals may enter the system within T. typically assumes that the number of arrivals per time unit is Poisson distributed.

Using stopwatch, I try to collect data of inter arrival time of patients to hospital and central triage case team, by using number of patient arrived through time interval specified. From collected data the number of patients arrived is higher in the morning and decreasing from time to time and increasing after lunch time. Let us look it on the table and chart below.

Shift		Morning				Lunch	After noon			Total
Time	From	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	8:00 Am
	To	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	4:00 Pm
1		96	53	28	15	1	56	35	9	302
2		85	52	35	12	7	61	31	4	287
3		92	49	33	9	5	57	32	10	287
4		83	50	38	11	2	60	28	8	280
5		89	51	31	13	0	56	34	9	283
Total		445	255	165	60	15	290	160	40	1439
Av. no.		89	51	33	12	3	58	32	8	286
Arrival Rate		1.48	0.85	0.55	0.2	0.05	0.97	0.53	0.13	0.6

Table 7: number of patient visiting hospital daily

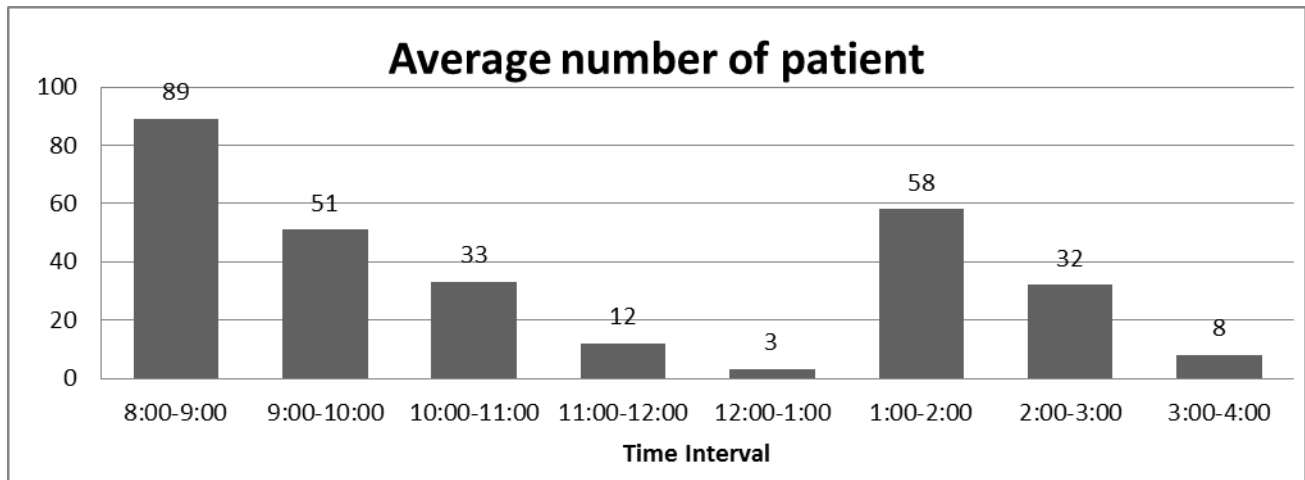


Figure 7: Average number of patient arriving verses time graph

Arrival rate= $\frac{\text{No.of patient arrived}}{\text{time interval}}$ for example, AR = 89/60 minute =1.48

From this table we understand that, the arrival rate change with time based on the number of patient arrived. So, we can analysis arrival system of patient by assuming the arrival rate of patient as Poisson distribution.

In healthcare, the Poisson process has been identified as an optimal representation of unscheduled arrivals to various systems (Kim et al 1999, Green et al 2005). Since in our case the majority of out-patient visits were not scheduled and the trend of patient arrived in morning and afternoon shifts resembles Poisson distribution, we can use the Poisson distribution for arrival process in the models as first alternative. This distribution is obtained by finding the probability of exactly n arrivals during T. If the arrival process is random, the distribution is the Poisson, and the formula is $P_T(n) = \frac{(\lambda T)^n e^{-\lambda T}}{n!}$

This shows the probability of exactly n arrivals in time T. In our case, the mean arrival rate of patients into the system is 36 patient per Hr ($\lambda=36$) and if we want to find the probability that exactly 4 patient will arrive within a one minute period ($n=4$, $T=0.016\text{Hr}$), we have

$P_T(n) = \frac{(36+0.016)^4 e^{-36+0.016}}{4!} = 0.002$ That is, there is 0.2 percent chance that there will be 4 arrivals in any one minute.

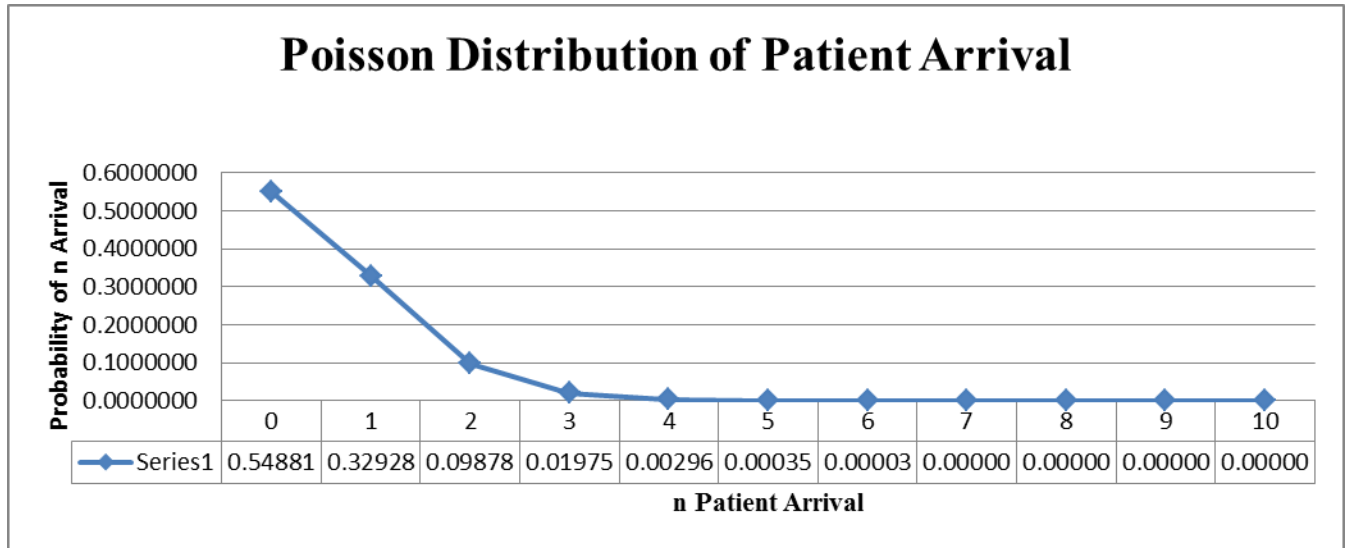


Figure 8: Poisson distribution of patient arrival

b) Service Rate

Since the service time of CT is random as shown in the following table, we can analyze using Exponential Distribution Method using data in table below.

Date	Service Time Per Patient In Second For New Card														
1	148	108	131	97	111	168	116	90	98	139	133	93	173	102	112
2	137	127	163	139	175	110	144	134	113	127	139	172	152	120	93
3	116	142	98	113	116	172	132	135	128	177	98	104	166	179	119
4	102	169	95	168	108	158	180	139	155	146	90	148	105	142	140
5	174	178	126	117	179	147	109	100	152	108	148	133	120	110	144
6	130	120	171	160	144	150	180	138	158	135	143	166	174	118	133
7	173	131	118	112	164	120	99	115	110	167	175	161	171	170	152
8	169	90	164	176	119	170	147	131	91	179	123	140	99	100	118
9	145	164	110	178	117	99	149	99	125	95	134	180	174	129	173

10	175	167	121	146	112	116	179	162	165	175	111	130	151	167	118
1	144	150	182	166	147	190	183	159	150	184	186	150	164	196	143
2	146	169	194	161	197	144	186	148	162	155	174	182	164	185	186
3	194	144	144	194	196	136	176	182	168	190	167	143	186	166	191
4	177	194	149	143	162	198	190	185	158	190	198	137	147	139	181
5	188	154	172	168	154	145	142	196	145	140	143	165	154	197	191
6	179	189	158	185	180	195	139	191	185	198	196	170	163	175	187
7	139	151	153	187	191	172	187	160	156	187	190	148	159	144	159
8	141	186	193	146	169	186	169	177	194	188	145	171	169	200	186
9	193	141	151	182	154	136	172	157	147	195	185	188	179	149	162
10	178	188	196	144	137	166	178	146	156	189	158	168	145	198	147
Summary of old card	mean	169.36		Standard deviation	19.52602	Min									
	max	200				136sec									
Summary of new card	Mean	137.26		Standard Deviation	27.24619	Min									
	Max	180				90sec									

Table 8: Service Time per Patient

Using exponential distribution as an approximation of the service times, we will refer to μ as the average number of patient that can be served per time period. For the case of simplicity let us take the two serving station as stations giving similar service.

Average service time = total service time for both card types /total number of observation = $(20589 \text{ sec} + 25404)/300 = 153.31\text{sec}$ (2.55minute/person). $\mu = 1/\text{average service time} = 0.39$ patient/minute = 23.4 (23) patients/Hr

c) Queue Discipline: The order of treatment priority is FIFO first come first served

d) Waiting Time Analysis

In general to analyze the waiting time of patient in central triage, we can use two alternatives.

These are:

Methods	Service Phase	Source	Arrival Pattern	Service Pattern	Q. Discipline	Lay Out
---------	---------------	--------	-----------------	-----------------	---------------	---------

1	Single	Infinite	Poisson	Exponential	FCFS	Multi-channel
2	Single	Infinite	Timed Poisson	Exponential	FCFS	Multi-channel

Figure 9: Waiting Time Analysis options of CT

I. Poisson Arrival and Exponential Service (M/M/2 model)

Since we have two counters, each with mean service rate and with an arrival rate and following Poisson distribution and exponential distribution respectively, we should use the following formula in analyzing the waiting time using inputs from previous discussions.

- Arrival rate $=\lambda = 0.6$ person per minute $= 36$ patients/Hr $c =$ number of WS $= 2$
- Service rate $=\mu = 0.39$ person per minute $= 23$ patients/Hr
- mean effective service rate $C\mu = 0.78$
- Utilization of servers $= \lambda/C\mu = 76.92\%$
- The probability of an empty or idle system, $P_0 = \frac{1}{\left[\sum_{n=0}^{c-1} \frac{(\lambda/\mu)^n}{n!} \right] + \frac{(\lambda/\mu)^c}{c!} \frac{c\mu}{c\mu-\lambda}} = 13.04\%$
- The expected number of patients in the system $L_s = L_q + \lambda/\mu = 3.77$
- The expected number patients in the queue is $L_q = \frac{\lambda\mu \left(\frac{\lambda}{\mu}\right)^c P_0}{(c-1)!(c\mu-\lambda)^2} = 2.23$
- The expected time in the queue is $W_q = L_q/\lambda = 3.72$ minute
- The expected time in the system, is $W_s = L_s/\lambda = 6.28$ minute

II. Timed Poisson Arrival and Exponential Service

Since the M/M/s model assumes that the arrival rate does not change over the day, to model our system (that had a fluctuating arrival rate) I use the M/M/2 model as a part of a SIPP (stationary independent period-by-period) approach to determine how to vary staff to meet changing demand. The SIPP approach starts with dividing the day into staffing periods, then a series of M/M/s models are constructed. After that, each of these periods is separately analyzed and solved for optimal number of servers to meet the target service requirements (Green 2006). In my study, the day was divided into 8 periods: from 2:00am in the morning to 10:00 o'clock with one hour interval.

Queuing analysis revealed a critical congestion in the CT system from 8:00 am to 9:00 am (with 89 patient) when the CT functions in the emergency mode because of unscheduled arrivals (see Table and Figure below). During this time period, the arrival rate exceeds the capacity of the system and the queue starts building up.

current model	From	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	Average
	To	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	
INPUTS										
Av. no. Of Patients		89	51	33	12	3	58	32	8	36
Number of Servers		2	2	2	2	2	2	2	2	2
Arrival Rate (units/min)		1.48	0.85	0.55	0.20	0.05	0.97	0.53	0.13	0.60
Av. Service time (mi /pati)		2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56
mean effective service rate		0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
OUTPUTS:										
Traffic Density										
server Utilization Factor %		189	108.8	70.4	25.6	6.4	124.1	67.8	16.67	76.8
% Idle Time for Server				29.6	74.4	93.6		32.2	83.33	39.14
Av. Time in System min				5.07	2.74	2.57		4.74	2.63	6.24
Aver. Time in Queue min				2.5	0.18	0.01		2.18	0.07	3.68
Aver. Numb. in System				2.8	0.55	0.13		2.51	0.34	3.74
Aver. Numb. in Queue				1.38	0.04	0.001		1.15	0.01	2.21
Probab. of idle system %				17.37	59.24	87.97		19.16	71.47	13.12

Table 9: Timed Poisson Arrival and Exponential Service analysis

From table, It was determined that the values of service and waiting time tend to reach their maximum during the “busy” hours, when the arrival rate is the highest and revealed that the maximum number of patient waiting in waiting area occurs during the time period when the arrival rate reaches its maximum level.

4.2.3.1.1. Summary of Waiting Time Analysis in CT

The objective of queuing analysis is to offer a reasonably satisfactory service to waiting customers (reduce waste occurs due to waiting time of customer) and reduce idleness of servers. It determines the measures of performance of waiting lines, such as the average waiting time in queue and the productivity of the service facility, which can then be used to design the service installation. This study quantifying the phenomenon of waiting in lines using representative measures of performance, such as average queue length, average waiting time in queue, and average facility utilization. A waiting customer is selected from the queue to start service with the first available server. The arrival rate at the system is patient per unit time and both parallel servers are identical, meaning that the service rate for any server is number of patient per unit time. The number of customers in the system is defined to include those in service and those waiting in queue.

To sum up queuing analysis of central triage, a convenient notation for summarizing the characteristics and appropriateness of the queuing analyzing methods is given in the following section. Let us compare both methods to select best alternative which suit well to analyze the waiting time in hospitals triage area.

1. **Poisson arrival and exponential servicing:** under this section I try to develops a general queuing model with M/M/s model that combines both arrivals and departures based on the Poisson arrival assumptions and the inter arrival and the service times follow the exponential distribution. Under this analysis I take single average arrival rate which do not consider the real difference between inter arrival time of patients which bring unrealistic results of representative measures of performance like shown in table below. This model should be used based on the long-run or steady-state behavior of the queuing situation, which is achieved after the system has been in operation for a sufficiently long time and fully random and the arrival should be not like health care which is time dependent or it should be fully random with unknown variation of customer arrival.
2. **Fluctuating Poisson Arrival and Exponential Service:** In reality, number of patient arrive different based on time of a day as discussed early, so managers should consider modified or timed Poisson arrival to get most appropriate representative measures of performance.

Let us see the comparison and summary of all models I use to analysis waiting time of central triage case team on table below.

Elements		Poisson and Exponential	Modified Poisson				
			10-11	11-12	12-01	02-03	03-04
Inputs	Av. no. Of Patients	286	33	12	3	32	8
	Number of Servers		2	2	2	2	2
	Arrival Rate (units/min)	0.6	0.55	0.20	0.05	0.53	0.13
	Av. Service time (mi /pati)	2.564	2.56	2.56	2.56	2.56	2.56
	mean effective service rate		0.78	0.78	0.78	0.78	0.78
Outputs:	Traffic Density						
	Server Utilization	76.92%	70.4	25.6	6.4	67.8	16.67
	Server Idle Time (%)	23.08	29.6	74.4	93.6	32.2	83.33
	Av. Time In System in minute	6.28	5.07	2.74	2.57	4.74	2.63
	Aver. Time In Queue in minute	3.72	2.5	0.18	0.01	2.18	0.07
	Aver. No. In System	3.77	2.8	0.55	0.13	2.51	0.34
	Aver. No. In Queue	2.23	1.38	0.04	0.001	1.15	0.01
	Probability of idle system %	13.04%	17.37	59.24	87.97	19.16	71.47

Table 10: summary of models used to analysis waiting time of central triage case team

From over all analysis, I select Timed Poisson Arrival and Exponential Service model. So we can summaries patient waiting time in CT as follows. Out of total time the patient spends in CT, about 60% of time was spend in waiting for service only 40% of time is spend on getting services. Based on the direct observation done to analysis idleness of work stations, the servers are nearly idle from 10:30am to 12:00am and from 3:00pm to 5:00pm. The reasons why CT servers are idle can be classified into two categories:

- 1.Patient arrival pattern: high arrival rate in the morning and less as time goes on, so patient already registered before these time intervals which cause idle CT servers.
- 2.HURH working system: If you see the working systems of hospital, there are a lot of areas with long lead time where average time a patient spends in the system is relatively 3 hour. If

CT registers patients within these time intervals, patient treatment may go out of time and will postpone to next shift or day. So, patients do not have the willingness to be registered during these intervals and make work station idle.

4.2.4. CT Service Improvement

The improvement of service with respect to waiting time has become more important in recent years because of the increased emphasis on quality, especially in service-related operations. When customers go into a hospital to get service they increasingly equate quality service with rapid service. By awakening this, more and more hospitals are focusing on reducing waiting time as an important component of quality improvement.

The service level in a queuing facility is a function of the service rate, and the number of parallel servers, c . This section presents two decision models for reducing waiting time and determining "suitable" service levels for queuing systems: (1) a cost model, and (2) an aspiration-level model. Both models recognize that higher service levels reduce the waiting time in the system. Both models aim at striking a balance between the conflicting factors of service level and waiting.

a) **Cost models** attempt to balance two conflicting costs:

1. Cost of offering the service.
2. Cost of delay in offering the service (customer waiting time).

The two types of costs are in conflict because an increase in one automatically causes reduction in the other. The service rate and/or number of parallel server represent the service level in the cost model. The service level increased as number of server increase and/or optimizing service rate. The number of servers can be increased by hiring more admitting clerks. This is the most obvious by not necessarily the best decision because it provides immediate results and increases cost of offering the service.

The main obstacle in implementing cost models is the difficulty of obtaining reliable estimates of the cost of waiting, particularly when human behavior is an integral part of the operation like healthcare. The viability of the cost model depends on how well we can estimate the cost parameters. Generally, these parameters are difficult to estimate, particularly the one associated with the waiting time of customers.

b) Aspiration Level Model

The aspiration level model seeks to alleviate this difficulty by working directly with the measures of performance of the queuing situation. The idea is to determine an acceptable range for the service level (μ or c) by specifying reasonable limits on conflicting measures of performance. Such limits are the aspiration levels the decision maker wishes to reach.

We illustrate the procedure by applying it to the multiple-server model, where it is desired to determine an "acceptable" number of servers, c^* . We do so by considering the following two (conflicting) measures of performance:

- a) The average time in the system, W_s
- b) The idleness percentage of the servers, X .

The idleness percentage can be computed as follows: $X = \frac{c - \rho}{c} * 100 = \frac{c - (L_s - L_q)}{c} * 100 = \left(1 - \frac{\lambda}{c\mu}\right) * 100$

The problem reduces to determining the number of servers c^* such that $W_s \leq \alpha$ and $X \leq \beta$ where α and β are the levels of aspiration specified by the decision maker.

According to HSDP-IV strategic objective stated before, quality Improvement of health services targets an increase customer satisfaction index from 50% to 100%. Based on this strategic objective target, we may stipulate that we should reduce an average time in the system by 85%, $\alpha = 6.6$ minutes and reduce idle percentage of server to average idle percentage, $\beta = 23.2\%$.

Time interval		C	Number Of Servers				
From	To		1	2	3	4	5
8:00	9:00	W_s				14	3.6
		λ	1.48	1.48	1.48	1.48	1.48
		μ	0.39	0.39	0.39	0.39	0.39
		X	-289.5	-89.5	-26.3	5.25	24.2
9:00	10:00	W_s			4.35	2.9	2.67
		λ	0.85	0.85	0.85	0.85	0.85

		μ	0.39	0.39	0.39	0.39	0.39
		X	-120	-10	26.6	45	56
10:00	11:00	Ws		5	2.86	2.6	2.55
		λ	0.55	0.55	0.55	0.55	0.55
		μ	0.39	0.39	0.39	0.39	0.39
		X	-40	30	53.3	65	72
11:00	12:00	Ws	5.15	2.7	2.6		
		λ	0.20	0.20	0.20	0.20	0.20
		μ	0.39	0.39	0.39	0.39	0.39
		X	48.7	74.4	82.9	87.2	89.76
12:00	1:00	Ws	3.1	2.61			
		λ	0.05	0.05	0.05	0.05	0.05
		μ	0.39	0.39	0.39	0.39	0.39
		X	87.2	93.5	95.6	96.75	97.4
1:00	2:00	Ws			6.19	3.13	2.7
		λ	0.97	0.97	0.97	0.97	0.97
		μ	0.39	0.39	0.39	0.39	0.39
		X	-148.7	-25	16.6	37.5	50
2:00	3:00	Ws		5.1	2.9	2.62	2.57
		λ	0.53	0.53	0.53	0.53	0.53
		μ	0.39	0.39	0.39	0.39	0.39
		X	-35.9	32	54.6	66	72.8
3:00	4:00	Ws	3.75	2.62			
		λ	0.13	0.13	0.13	0.13	0.13
		μ	0.39	0.39	0.39	0.39	0.39
		X	66.7	83.3	89	91.75	93.4
Average		Ws		7.2	3.07	2.66	2.5
		λ	0.6	0.6	0.6	0.6	0.6
		μ	0.39	0.39	0.39	0.39	0.39
		X	-54	23.5	48.6	61.5	69.2

The solution of the problem may be determined by plotting W_s and X as a function of c , as shown in Figure below. By locating α and β on the graph, we can immediately determine an acceptable range for c^* .

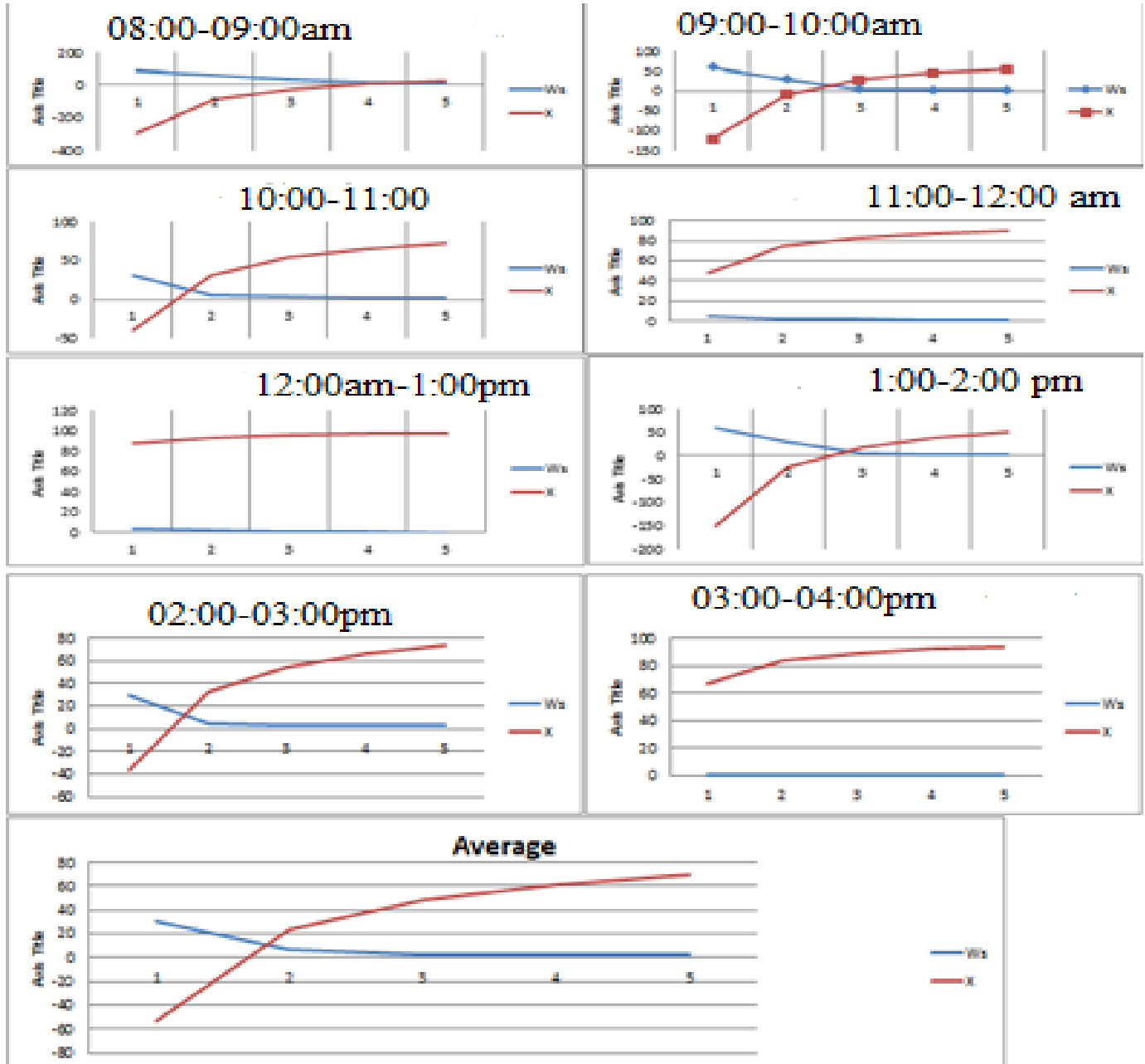


Figure 10: Idleness and service time for varying number of servers graphs

Since the two conditions cannot be satisfied simultaneously, then one or both must be relaxed before a feasible range can be determined. To do so, we should analysis it further by optimizing

number of server, managing arrival rate and optimizing service rate of the servers consecutively until we get relatively appropriate average time in the system and percentage of idleness of server with reference to target value specified early.

1. Optimize number of server

The number of servers can be increased by hiring more admitting clerks. This is the most obvious but not necessarily the best decision. Increasing the number of servers provides immediate results of improvement as shown in Table below.

		Morning				Lunch	Afternoon			Remark
Modified model 1	From	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	
	To	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	
INPUTS:										
Number of Servers		4	3	2	1	1	3	2	1	2
Available servers		2	2	2	2	2	2	2	2	48 patient/Hr capacity
Mean Service Time (min./server)		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	
Arrival Rate (units/min)		1.48	0.85	0.55	0.20	0.05	0.97	0.53	0.13	36 patient/Hr on average
mean effective service rate		1.6	1.2	0.8	0.4	0.4	1.2	0.8	0.4	
OUTPUTS:										
Traffic Density										
server Utilization Factor		94.75	73.4	70	51.3	12.8	83.4	68	33.3	76.5
% Server Idle Time		5.25	26.6	30	48.7	87.2	16.6	32	66.7	$\beta = 23.2\%$
Deviation from target β		18.25	-3.1	-6.5	-25.2	-63.7	-6.9	-8.5	-43.2	
Average Time in System		14	4.35	5	5.15	3.1	6.19	5.1	3.75	$\alpha = 6.6$
Deviation from target α		-7	2.65	2	1.85	3.9	0.81	1.9	3.25	
Aver. Time in Queue		11.5	1.76	2.45	2.6	0.5	3.6	2.53	1.22	4.66
Aver. Numb. in System		20.8	3.7	2.75	1.03	0.155	6.01	2.7	0.5	4.34
Aver. Numb. in Queue		17	1.5	1.35	0.52	0.025	3.51	1.34	0.158	2.8

Table 11: Increase Number of Server

Based on these results, we can understand that different number of servers required for each time interval and higher variation of percentage of idleness with higher deviations from our target values, so the most effective approach to improvement should involve optimization of all three variables, i.e. Number of servers, arrival rate and service time

From previous analysis, we should use two servers as an optimum number of servers because they have more than enough capacity to serve average arriving patients. So, we should optimize and manage what we can control our self like the service time and arrival pattern of patients to improve CT further.

2. Managing Arrival pattern

To manage arrival pattern, the arrival rate should be decreased during busy times and increased during “slow” periods. To do it, we should investigate reason why such high arrival rate in the morning and less as time goes on.

The reasons for varying arrival rates are due to patient attitude and hospital working system. Let us see one by one.

Patient cases:

- Patient attitude of getting better medication in the morning from free minded physicians than afternoon or tired mined
- Most of them need care rapidly and some Healthy conditions and problems require laboratory at early in the morning before patient eat, drink, urine and etc.
- Most patients arrive from distant areas and need to be served quickly to return to their Arrival place timely.

Hospital cases:

- Longest lead time working system. If you see the working systems of hospital, there are a lot of areas with longer waiting line which leads to long lead time with relatively average time a patient spends in the system 3 hour. Patients need to get treatment within an hour if possible or at least within a day on which they arrival. If they came in afternoon, their treatment may goes out of time and will postpone to next day.

- Scheduling system of appointed patients: physician in outpatient department schedule appointment of patients' base on their healthy condition. Mostly these appointments are scheduled without knowing arrival and servicing time of patients on random bases which causes higher arrival rate in the morning.
- Nature of the diseases: some diseases laboratory needs a patient without breakfast, with full urine and other which creates needs of early arrival of patient.

To manage arrival rate, we should schedule appointed regular patients appropriately. Scheduling arrivals would modify the arrival rate to the necessary degree. If the hospital starts using appropriate scheduling system to its full extent, the arrival rate in the CT is expected to be stabilized significantly.

From a total of 286 average patients registered in CT per day, about **56.5%** are regular patients on which nearly 28.9% of them are appointed patients comes in their scheduled day to meet their physicians for checkup. So, we can manage their arrival pattern easily since we are the only decision maker on time and dates of their arrival. But now, both scheduled and unscheduled regular patients wait in CT together to get service without considering reasons of their arrival.

We can manage arrival pattern of the patient using scheduled regular patients by transferring cards of appointed patient to appropriate case teams without direct contact of patient. Since their appointed reason and date was stated clearly, CT worker can identify and sent file to physicians who appoint them before starting registration process. Since the card is already sent, scheduled patient move to examination room directly without waiting in CT waiting line. Due to these nearly 46 patients can be reduced from CT waiting line.

The current arrival rates are depicted in table below, along with the impact of this change on the overall arrival pattern for the CT. The impact of combining these modifications in staffing and arrival rate on the average time in the system and the queue are shown in Table.

		Morning				Lunch	Afternoon			Remark
Developed model 2	From	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	
	To	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	
INPUTS										

Number of Servers	2	2	2	2	2	2	2	2		
Patient Arrival	89	51	33	12	3	58	32	8	36 patient/Hr on average	
Arrival Rate (units/min)	1.48	0.85	0.55	0.20	0.05	0.97	0.53	0.13		
Mean Service Time (min./ server)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	45 patient/ hr capacity	
Deviation from capacity	41	3				10				
Modified arrival	62	43	33	12	3	47	32	8	Without scheduled patients (46)	
Deviation from capacity	14	-	-	-	-	-	-	-		
Modified Arrival rate	1.03	0.71	0.55	0.20	0.05	0.78	0.53	0.13		
Effective service rate	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8		
OUTPUTS										
server Utilization Factor		88.75	68.75	25	6.25	97.5	66.25	16.25		
Server Idle Time %		11.25	31.25	75	93.75	2.5	33.75	83.75	$\beta = 23.2\%$	
Deviation from target β			8.05	51.8	70.55		10.55	60.55		
Aver. Time in System		7.9	3.2	2.52	2.50	42.5	2.94	2.5	$\alpha = 6.6$	
Deviation from target α		1.3								
Aver. Time in Queue		5.4	0.66	0.02	0	40	0.44	0.005		
Aver. Numb. In System		5.6	1.7	0.5	0.12	33.2	1.56	0.32		
Aver. Numb. In Queue		3.8	0.36	0.0	0	31.2	0.23	0		

Table 12: managed arrival pattern

3. Optimizing The Service Rate

The third key variable that can affect system patient flow is service rate. It can be decreased by various means: pre-registering larger number of patients, introducing automated queuing management system, optimizing clerk work place layout by providing personal office equipment will eliminate the need of visiting the work room while serving the patient and etc.

		Morning				Lunch	Afternoon			Remark
Developed model 3	From	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	
		To	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00

INPUTS:									
Number of Servers	2	2	2	2	2	2	2	2	
Arrival Rate (units/min)	1.48	0.85	0.55	0.20	0.05	0.97	0.53	0.13	30 pat./Hr on aver.
Modified arrival	62	43	33	12	3	47	32	8	
Modified arrival rate	1.03	0.71	0.55	0.20	0.05	0.78	0.53	0.13	240
Mean Service Time (min./ server)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	Modified to 60 pat/Hr
Modified service time	1.9	1.9	2.0	2.0	2.0	1.9	2.0	2.0	
Deviation from capacity	2	-	-	-	-	-	-	-	
Effective service rate	1.05	1.05	1	1	1	1.05	1	1	
OUTPUTS:									
server Utilization Factor	97.9	67.5	68.75	25	6.25	74.14	66.25	16.25	
% Server Idle Time	2.1	32.5	31.25	75	93.75	25.86	33.75	83.75	27.96%
Deviation from target β	Deviation from target is $(27.96-\beta= 23.2)$ %.								4.76%
Average Time in System	38.6	2.23	2.96	2.51	2.50	2.41	2.82	2.5	11.85
Deviation from target α	11.85- ($\alpha =6.6$)								5.25 min
Aver. Time in Queue	36.67	0.33	0.46	0.012	0	0.51	0.32	0.003	
Aver. Numb. in System	39.7	1.58	1.63	0.5	0.12	1.88	1.5	0.32	
Aver. Numb. in Queue	37.8	0.23	0.25	0	0	0.4	0.17	0	
	25.8	17.9	13.75	5	1.25	19.58	13.4	3.34	

Table 13: Optimized Service Rate

Changes in the total time-in-system and percentage of idle time of servers were observed, as shown in figures below.

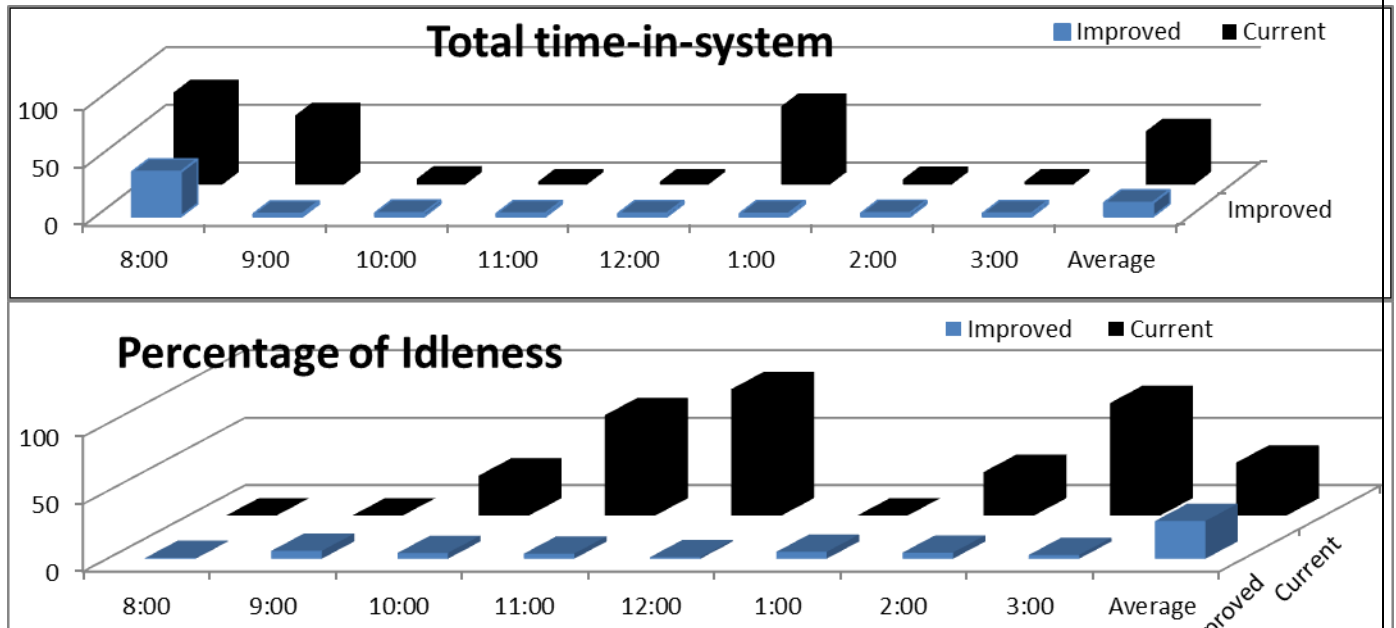


Figure 11: Changes in the total time-in-system and percentage of idle time of servers

The new average time-in-system is 11.85 minute. Compared to an average time-in-system of more than 46 minutes in the initial model, improvement actions resulted in about a 75% reduction in average patient time-in-system. Changes in percentage of idle time of servers is from more than 48.14% in the initial model to 27.96%, improvement actions resulted in about a 41.92% reduction in average percentage of idle time of servers.

4.3. Emergency Department

In the emergency service area, there is an arranged place for the emergency patient and their families to stay until they get their turn. These groups of patients include urgent cases that come to the hospital with a referral certificate from other health care institutions or simply coming without referral. The ED provides medical service to the patients on a 24hr 7 days basis of three shifts. They have medical emergency and surgical emergency examination offices with two room of observation each with 6 beds and other 10 beds inside corridors. Each shift includes one main physician at each examination room. There is an Emergency laboratory and pharmacy facility. The ED service delivery process can be represented by the following set of core activities as shown in general process chart.

4.3.1. Current ED Service Delivery condition

In the ED, two main events cause an instantaneous change in the state of the system:

1. The entry of a patient into the system (patient arrival)
2. The release of a patient upon completion of treatment (patient departure)

Based on information obtained from experts, observation, and historical data, the following logic governs the flow and conditions of patients in the ED:

- The order of treatment priority is high risk, medium risk, and normal cases, respectively.
- ED patients are classified as follows:
 - *Risky case*: a probability of 40%
 - *Medium-risk case*: a probability of 30%
 - *Normal case*: a probability of 30%
- When a risky case arrives at the ED, it does not pass through the triage or data-entry stages; the person is treated directly by a physician.
- When a medium-risk case arrives, the person passes through triage but does not pass through the data-entry area.
- When a normal case arrives, the person must pass through all three stages: triage, registration, and treatment.
- One physician can treat up to two patients in the emergency room.
- Patients leaving the emergency room are routed as follows:
 - Those who will leave the hospital: a percentage of 60%
 - *Those who will continue the treatment in other specialist units in the hospital*: a percentage of 40%

4.3.2. Current ED Service Delivery Process

Since a patient's treatment varies based on his/her exact condition, it is impossible to classify precisely the flow of all ED patients through the system. Therefore, the patient flow process that is described in this paper is the general flow process for a typical ED patient treatment. If emergency patients arrive at the hospital, the Screening Room will be the first to see the patients.

An attendant, in most cases a nurse in this room to identifies the medical and surgical patients and then orders patients to issue a patient card from the Registrar unit. The Registrar unit prepares the card once a patient has paid a registration fee if he/she is new. This unit will then distribute the cards to the medical emergency or surgical emergency room depending upon the decision made in the Screening Room. Inside the emergency department, there is a card receiving room, and then temporary checking is done to group the patient as most emergent, emergency and least emergent.

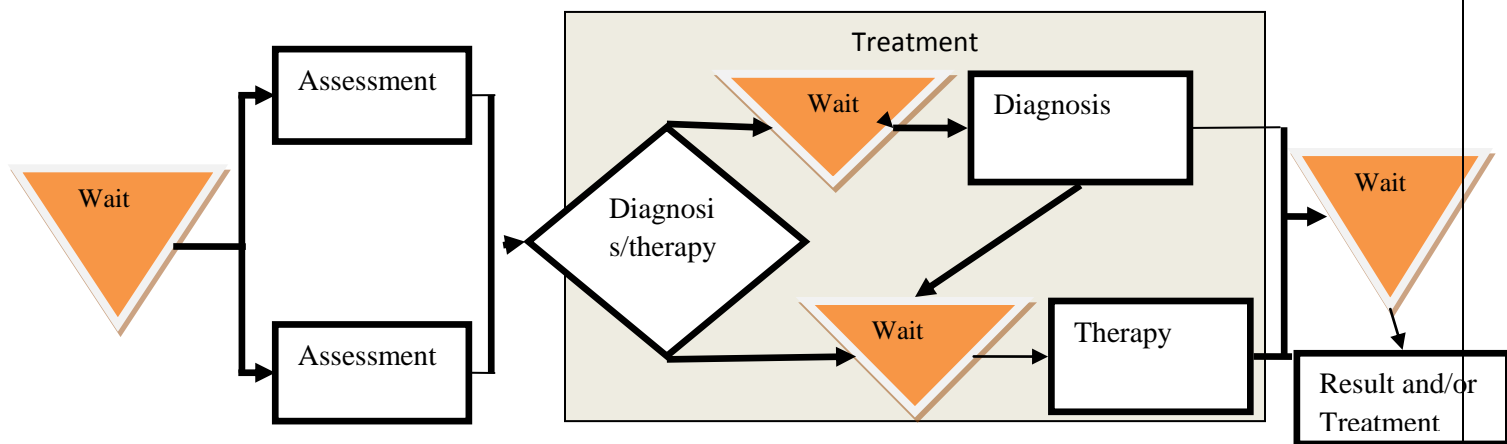


Figure 12: ED flow Diagram

Typically, a patient enters ED through one of two modes: walk-in or vehicle (ambulance). Walk-in patients are categorized as being the least emergent. Most emergent patients that require immediate care from a physician are served first, while other patients are expected to see a physician upon a number of visits to the ED, however, they have been witnessed to be waiting over an hour in the waiting room. Assuming that the patient is conscious, the patient is sent to the waiting room until a triage nurse is available for registration; patients who are unconscious skip the registration process by the triage nurse and are immediately taken to a treatment room.

Treatment Unit gives patients the best quality of service. In HURH, ED department have two treatment units these are surgical emergency and Medical emergency. The typical treatment process within these care units begins with an initial assessment from a nurse. Then, the primary caregiver continues treatment of the patient and makes decisions as to whether or not the patient requires additional testing, such as x-rays, ultrasound, etc. If diagnostic testing is required, the patient is transported to the appropriate testing area and then returned to his or her bed in the

treatment unit to wait for the primary caregiver to order any further medical procedures based on initial test results.

Diagnostic testing provides additional testing alternatives required by a primary caregiver for a patient. This unit is divided into two areas: imaging (such as X-ray and ultrasound) and lab testing that performs tests on a variety of patient specimens, including blood and urine.

Following any necessary diagnostic tests, the patient returns to his or her bed within the treatment area to await further treatment. Upon receiving the test results, the primary caregiver then provides necessary medical orders to the staff, and the patient receives the ordered treatment. Finally, the patient is either discharged from the ED or admitted to the hospital or referred to other hospital, depending upon the primary caregiver's orders.

4.3.3. Analysis of ED Patients Waiting

ED wait time is an important patient flow measure since this is where many patients enter the hospital and delays can affect the results. The number of patients waiting in ED is more difficult to evaluate since most of the waiting is in a bed and varies over the 24x7 operation. Also, it is impossible to determine which of the waiting people are patients and their family members.

Waiting in the ED area is not simply at the entrance like CT but occurs in several locations during the ED visit. These are shown in admissions, Medical seen, and discharge over the course of a day.

An ED system can be viewed as a queuing system with a single channel (i.e., admission, treatment, release). The patient flow within the ED is sequential and can be combined into a one-stop service in order to apply the formulas of the single-server queuing model. In practice, however, different ED resources provide service at different locations.

The ED is not a typical first-in-first-served system; the ED operates using specific rules to route patients. The priority for a patient to enter the ED depends on his or her medical case and the risk involved in making the patient wait. The system can still be described by the rate of patient arrivals and the service mechanism, which includes the following three broad stages:

1. Passing by triage
2. Registration which deals with Entering a patient's related data in records
3. Physical treatment which includes assessment by the physician, diagnostic testing and/or therapy, and evaluation of the diagnostic reports and/or medical assessment, a decision to admit or discharge the patient is made.

I face with a lack of historical data (records of patient arrivals and service durations) essential to estimating the service and inter arrival times. Thus, I decided to collect data using a stopwatch. After getting permission from the hospital administration, I started my work by observing the situation in the ED and collecting pertinent data, including measuring the service time at various process stages and the inter-arrival time of patients, tracking patient flow, and so on. Relevant data of 40 discharged emergent patients were collected in Wednesday 18/04 and Friday 20/04/2012. Table below summarizes the data collected in terms of patient arrival times and the time for end of service at each main ED stations. Using the data collected, values are estimated for each patient's inter arrival and service times at the ED stations.

Patient	Arrive At	Depart At	Inter Arrival Time	Waiting time (min) in		Service Time (min) in		Total time (min) in		
				Triage	Treatment	Register	Treatment	Service	Waiting	System
1	2:30	4:12	0	10	0	2	30	32	10	42
2	3:00	4:00	30	25	25	5	5	10	50	60
3	3:20	4:25	20	10	35	5	15	20	45	65
4	3:50	4:23	30	9	11	3	10	13	20	33
5	4:15	4:10	25	14	25	4	12	16	39	55
6	4:20	5:34	5	14	17	3	40	43	31	74
7	4:22	5:44	2	11	9	2	60	62	20	82
8	4:35	5:50	13	10	39	4	22	26	49	75
9	4:40	6:47	5	8	27	4	88	92	35	127
10	4:45	6:08	5	8	14	2	58	60	22	82
11	4:45	6:50	0	7	38	3	77	80	45	125
12	5:00	8:00	15	9	39	5	127	132	48	180

13	6:10	7:13	70	7	40	3	13	16	47	63
14	7:20	8:24	70	7	25	3	28	31	32	63
15	7:30	8:36	10	10	26	5	25	30	36	66
16	7:35	9:17	5	30	40	2	30	32	70	102
17	8:00	8:47	25	15	18	4	10	14	33	47
18	8:00	8:57	0	14	22	5	16	21	36	57
19	8:45	10:00	45	11	19	3	42	45	30	75
20	9:30	10:19	35	10	14	2	23	25	24	49
21	2:29	3:15	0	15	27	4	10	14	42	56
22	2:57	3:44	28	16	24	2	5	7	40	47
23	3:05	4:08	8	35	18	4	6	10	53	63
24	3:07	4:02	2	13	26	11	5	16	39	55
25	3:40	5:04	33	24	39	4	17	21	63	84
26	3:50	5:17	10	32	22	3	30	33	54	87
27	3:55	5:37	5	39	22	4	37	41	61	102
28	4:10	6:04	15	11	39	10	54	64	50	114
29	4:35	5:58	25	17	13	3	50	53	30	83
30	4:35	5:29	0	14	24	4	12	16	38	54
31	4:55	6:30	20	7	13	3	72	75	20	95
32	5:00	7:00	5	10	24	5	80	85	34	119
33	5:40	7:19	40	11	14	4	70	74	25	99
34	5:45	6:50	5	13	15	5	32	37	28	65
35	6:10	7:53	25	13	33	2	55	57	46	103
36	7:30	8:44	80	9	39	4	22	26	48	74
37	7:40	9:04	10	24	27	8	25	33	51	84
38	8:00	9:28	20	26	40	4	18	22	66	88
39	8:05	9:50	5	9	40	6	50	56	49	105
40	10:20	11:25	135	12	10	3	40	43	22	65
Total			881	589	992	162	1421	1583	1581	3164
Average			22.025	14.72	24.8	4.05	35.525	39.575	39.525	79.1

Table 14: collected data from each main ED stations

The observation was on major service areas as shown above and average time for each was taken by considering the average duration measured in each activity. Using the collected data and summarizes in terms of patient arrival times and the time for end of service, values are estimated for each patient's inter-arrival and service times.

	Formula	Results	Remark
Average patient waiting time	$(\text{total waiting time in ED})/(\text{number of patients})$	39.5	
Average service time	$(\text{total service time})/(\text{number of patients})$	39.58	
Average inter arrival time	$(\text{sum of inter arrival times})/(\text{number of patients} - 2)$	23.18	we have two reference patient
Average waiting time for waiting patients	$(\text{total waiting time})/(\text{number of patients who wait})$	41.6	Only 2 patient served without waiting
Average time-in-system	$(\text{total time in system})/(\text{number of patients})$	79.1	can also be calculated by summing the average waiting and service time
The probability a patient has to wait	$(\text{number of patients who wait})/(\text{number of patients})$	95%	
The utilization of the station	total service time/total run time	55%	

Table 15: collected data result summary

Using waiting lines analysis result, I try to summaries time by sorting non value adding times from serving time or value adding time by talking direct time patient get service in ED process. From observation in ED working area major value adding activates is treatment and we can say registration is necessary non value adding activity.

No	activities	Value adding	Non-value adding necessary.	Non-value adding unnecessary	Total time
1	Time At triage			15	15
2	Time of Registration		4.07		4.07
3	Waiting time for treatment			25	25
4	Treatments	35.9			35.9
	Total	35.9	4.07	40	79.97

Table 16: Activates observations of ED Values

From analysis, only about 45.0% of time was spend in adding value to patient, about 5% on necessary non-value adding activity and the rest 50% was spent in unnecessary non-value adding activities.

4.3.4. ED Improvement

Based on observations and statistics, the following measures were taken to improve ED operations. Improvement efforts are focused on reducing patient waiting time before registration time, and waiting for treatment time. This will significantly reduce the overall time spent in the system. Other measures are aimed at increasing the effectiveness of ED operations by optimizing the number of physicians and increasing the utilization of reception and triage resources. Other micro measures can also take place to improve work procedures, especially for preparing patient files and entering patient information.

Following is a summary of ED improvement actions:

1. The long time spent in the reception stage was reduced first since a long waiting time may affect patient health negatively (i.e., may convert it from normal or medium to serious). The reception and registration time is improved by developing a more effective work procedure for preparing patient files and entering patient information. A time and motion study was recommended for this purpose. An integrated hospital database often provides a substantial time saving in this regard.
2. Time spent while patients wait for physicians at the treatment station was reduced by changing the rule of “one doctor to two and more patients” and allowing the immediate assignment of another available doctor to the second patient.

3. The triage and registration resources were combined, due to urgency of the case and serving patient without waiting triage resource.

Changes in the total time-in-system were observed through a confirmation. The new average time-in-system is 59.3 minutes. Compared to an average time-in-system of 79.1 minute in the initial ED model, improvement actions resulted in about a 25% reduction in average time-in-system.

4.4. Medical and Surgical OPD Case Team

These groups of patients include appointed patient comes on their date of schedule and regular patients coming from various clinics or hospitals with a referral certificate or without referral.

4.4.1. Current Service Delivery conditions

Based on information obtained from experts, observation, and historical data, the following logic governs the flow of patients in OPD:

- Their operation pattern is 8 hours per day from 8:00 am to 04:00pm with a 1-hour lunch, which is set initially 12:00am to 1:00pm.
- Eighty two percent of OPD patients are required to take a lab blood and other biochemical test which takes 23 minutes on average. Patients who take their lab test must return to the physician who requested the test. Patients returning from the lab test have different processing times by physicians.
- Twenty-nine percent of patients are required to reschedule appointments for further treatment.
- Ninety eight percent of patients are sent to the pharmacy to get prescription drugs.
- Fifteen percent of patients are treated and released from the clinic in their first visit.
- The medical assistant performs three functions: taking blood pressure, checking temperature, and asking patients questions about their health.

4.4.2. Current Service Delivery Process

The service commences with registration by taking patient information. Following the registration, the patient is ready to assess by the physician. Following the assessment by the physician the patient undergoes the diagnostic testing, and after evaluation of the diagnostic reports and/or medical assessment, a decision to admit or discharge the patient is made.

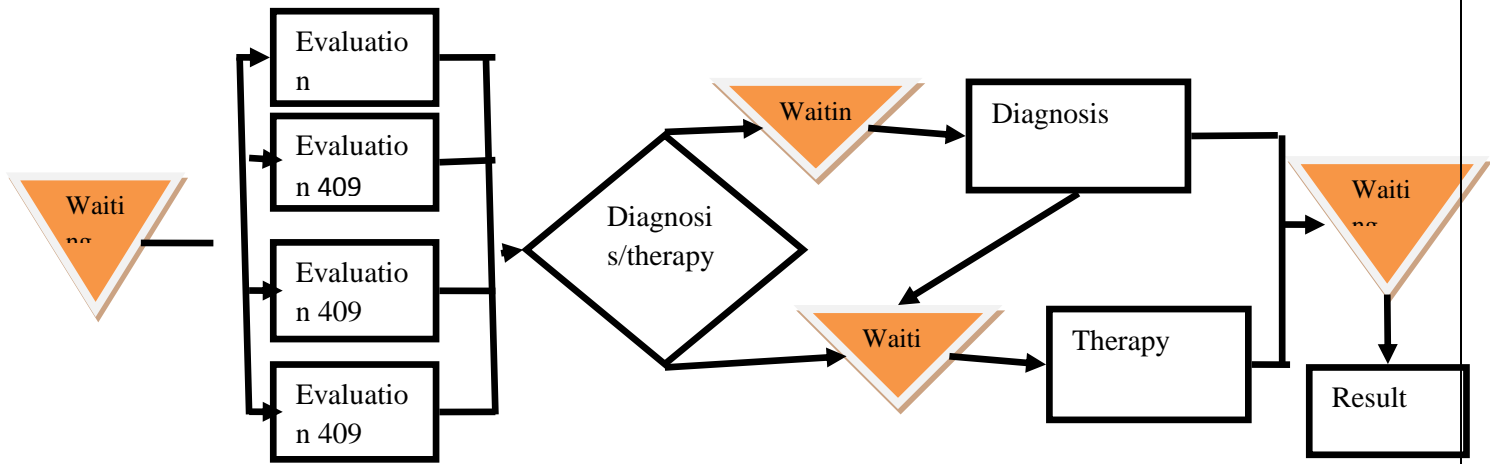


Figure 13: Medical OPD flow diagram

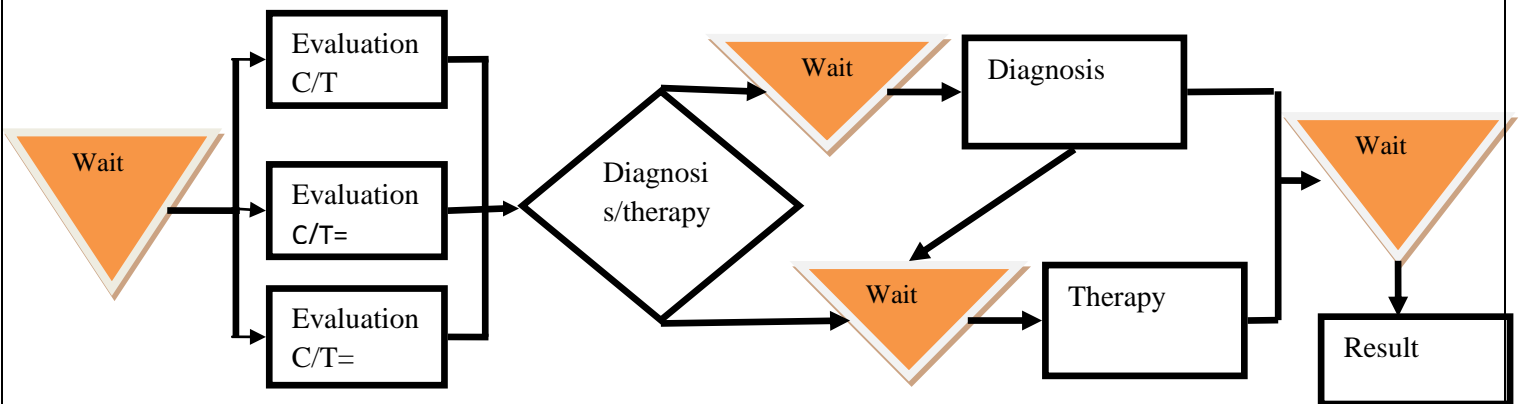


Figure 14: Surgical OPD flow Diagram

Takt time is the important tool needed for the assessment of current system. It is a tool used to eliminate over servicing. The OPD works in single shifts with 8 hours in shift. The lunch breaks

as well as other necessary breaks for the working staff are included in it. So the total available time is 8 hours a day which equal to 480 minutes. As mentioned in before, in average, the annual visits (flow) are 20232, and 19632 which is equivalent to 56 and 54 visits per day to surgical and medical OPD respectively and 254 and 204 patient visits registration and diagnosis respectively. So the Takt Time for each process of the service is calculated below with the reference to formula mentioned in [9].

- Patient Registration takt time = $\frac{480}{286} = 1.68$ minute per patient
- Medical Patient Evaluation takt time = $\frac{480}{54} = 8.9$ minute per patient
- Surgical Patient Evaluation takt time = $\frac{480}{56} = 8.6$ minute per patient
- Diagnostic Tests takt time = $\frac{480}{180} = 2.67$ minute per patient
- Medical Results Evaluation takt time = $\frac{480}{54} = 8.9$ minute per patient
- Surgical Results Evaluation takt time = $\frac{480}{56} = 8.6$ minute per patient

4.4.3. Analysis of Patients Waiting

Waiting in Medical and Surgical OPD case teams are not simply at the entrance like CT but occurs in several locations of patient flow. These are shown in admissions, seen, diagnosis and discharge over the course of a day.

Medical and Surgical OPD system can be viewed as a queuing system with a multiple channel (i.e., parallel servers in registration, examination, diagnosis and evaluation results). The patient flow within case teams is sequential and can be combined into a one-stop service in order to apply the formulas of the single-server queuing model. In practice, however, different OPD resources provide service at different locations.

Unlike ED, OPD is typical first-in-first-served system. The OPD patient appointment is depends on his or her medical case and the risk involved in making the patient wait. Although more complex queuing models (e.g., a network of queues) can be used to approximate the system, the system can still be described by the rate of patient arrivals and the service mechanism.

To use queuing theory in such case for better quality and efficiency, we must understand the process flow of case teams and identify the sources of Variability, Determine the arrival pattern of patients and Patient arrival rates, the service rate, Number of servers and Assumptions to use in the queuing model

A. The process flow of case teams and the sources of Variability

We can analysis the process in depth by visualizing current VSM of each case teams activities. The MOPD and SOPD services commences with registration by taking patient information. Following the registration, the patient is ready to assess by the physician. Following the assessment by the physician the patient undergoes the diagnostic testing, and after evaluation of the diagnostic reports and/or medical assessment, a decision to admit or discharge the patient is made. Entries in the data box underneath the process icon include entries for cycle time, change over time and waste time. Cycle time is the time it takes to service a patient. Cycle time includes issues like face to face contact with the patient and physical examination. The change over time included in the data box accounts for cleaning and preparation for the next patient. Waste time is the time the patient takes until they start serving him/her in each process. Utilizing all these concepts the current VSM of the process is shown on figure below.

No	Operation Description	Cycle time	Staff	CT/ staff	Available time 8hr*60min/hr	Capacity/ day	required/ day	Utilized time	Idle time
1	Patient Registration	2.5	2	1.25	960	384	286	715	245
2	M. OPD Evaluation	15	4	6	1920	80	54	1296	625
	Results Evaluation	9							
3	S. OPD Evaluation	12	3	6	1440	81	56	1008	432
	Results Evaluation	6							
4	Diagnostic Tests	18	8	2.25	3840	213	180	3240	600

Hospital Director

One shifts/day; 5 day/week; 8 hr/days

Weekly

Discharge free or with Appointed

Admission or refer to other Hospital/unit

Central Triage Case Team

Medical OPD Case Team

Patient arrival with care needs

10 patient

2 patients

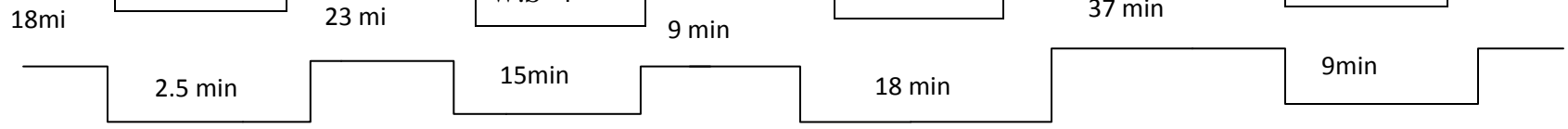
Registration
C/T= 2.5
C/O=1 min
Waiting=18
W.S=2

Evaluation
C/T=15
C/O=2min
Waiting=23
W.S=4

Diagnostic
C/T=18
C/O=5
Waiting=9
W.S=8

Result
C/T=9 min
C/O=2min
Waiting=37
W.S=

- Lead time =131.5 min
- Cycle time=44.5 min



Hospital Director

5 days/week; 8hrs/day

Weekly

Patient arrival
with care
needs

Discharge

Central Triage
Case Team

Surgical OPD Case
team supper visors

Admission



9 patients

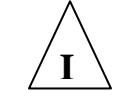
7 patients

Registration
C/T= 2.5
C/O=2 min
Waiting=18
W.S=2

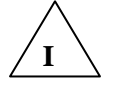
Evaluation
C/T=12
C/O=2min
Waiting=26
W.S=3

Diagnostic
C/T=18
C/O=5min
Waiting=9
W.S=8

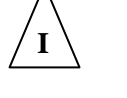
Result
C/T=6 min
C/O=2min
Waiting=43
W.S=



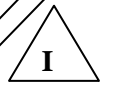
5 patients



5 patients



5 patients



5 patients

- Lead Time =134.5 Min
- Cycle Time=38.5 Min

20mi

18min

26 min

9 min

43 min

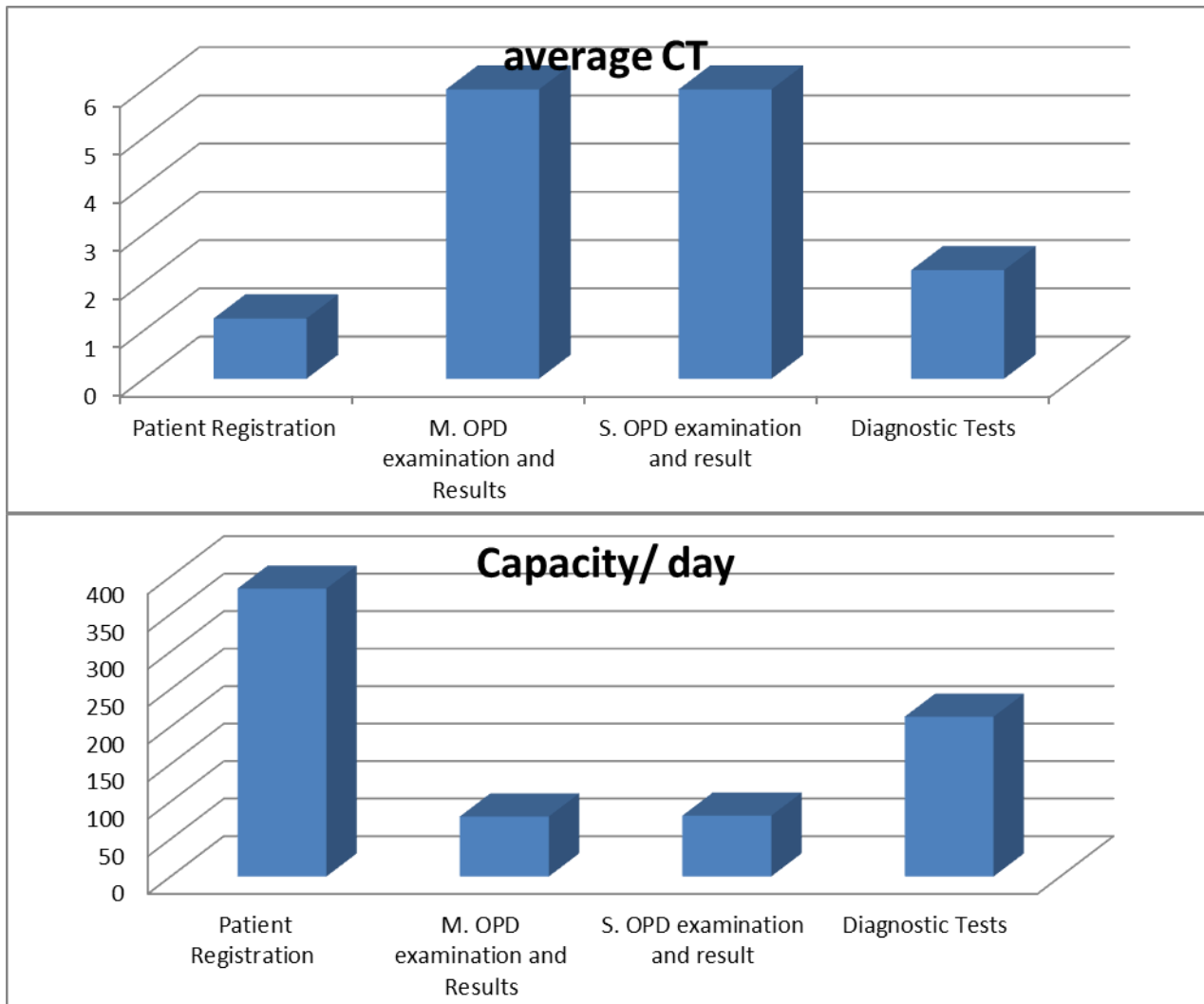
2.5 min

12 mi

18 mi

6 min

The main objectives of applying lean principles are to reduce wastages, waiting time of patients, idle time of operators and to increase the production/service capability by combining some of the operations or adding new ones. So it is decided to improve the service capability by applying lean philosophy. These analyses will be discussed by analyzing bottleneck process and calculating accurate Lead and Cycle Time of reduced wastes process. So, first we should determine bottleneck processes using current value stream map diagram and then use analysis and improvement of patient waiting time result to construct future value stream map as follows.



These figures show the relationship between capacity per day and their respective operations. It can be clearly seen that the bottleneck and variability problems is in the evaluation physician operations, where their capacity per day is clearly low compared to other operations.

B. Determine the arrival pattern of patients and Patient arrival rates

From process analysis we can understand that patient arrive to these case teams from two stations. These are:

1. From central triage station
2. From lab for result

So we can say that total number of patient arriving to station is the sum of patient arriving based on CT assignment and patient arriving from lab to know their lab result.

Central triage case team and OPD are opened to patient from 8:00AM to 4:00PM, a total of 9hrs. Staff is responsible to work for 8Hrs per day. For simplification we will assume that patients can arrive over the 8 hrs. Patient average arrival rate to the hospital is 35.75 pat/hr ((286pat/day)/8 hrs/day). But the arrival rate of patient arriving to HURH is fluctuating with time interval and the rate is at peak from 8:00-9:00 AM on morning. So, the arrival rate of patient arriving from triage with in time interval can be analyzed assuming time factor and share of case teams from total arriving patients. So:

$$N_T = N_{Aver} * FT \text{ therefore } \lambda_T = \lambda_{Aver} * (FT)$$

Where:

- λ_T – arrival rate at time interval T
- λ_{Aver} – average arrival rate
- N_T – number of patient arrival at time interval T
- N_{Aver} – number of average patient arrival
- (F_T) – time factors at time interval T

Based on previous analysis, arrival share and rate of patient are assumed as follows:

- 23.3% of the patients are triaged to the MOPD queue
- Arrival rate to the SOPD queue is 24.01% of total arrivals
- Average patient arrival rate to HURH is 35.75pat/hr so,
- Average MOPD patient arrival rate= 35.75 pat/hr* 0.233= 8.33 pat/hr
- Average SOPD patient arrival rate= 35.75 pat/hr*0.24=8.58 pat/hr

Laboratories are opened to patient from 8:00AM to 4:00PM, a total of 9hrs. Staff is responsible to work for 8Hrs per day. Based on information obtained from experts, observation, and historical data about eighty two percent of OPD patients are required to take a lab blood and other biochemical test which takes 23 minutes on average. Patients who take their lab test must return to the physician who requested the test. Patients returning from the lab test have different processing times by physicians. Based on collected data and VSM, we will assume that total time patients waiting in lab before service and time the result wait in Laboratory after diagnosis are estimated to be 43 minutes on average so that it can return to the work station. Therefore, Average time patient spent in the laboratory system is 66 minutes.

Service rate of single laboratory station is 2.6 patient/Hrs and number of laboratory work stations are eight, so the average laboratory service rate is 21 patients per hr. since these lab work stations serve both case teams, average service rate for each case teams depends on their share from total patients arriving OPD, Whereas MOPD share 26.94% and SOPD share 27.76%. so, service rates of MOPD and SOPD are 10.3 pat/hr and 10.7 pat/hr respectively.

- Patients from Lab= patients to lab = 83% of patient assigned to laboratory.
- $N_T(\text{to lab}) = 0.83 * N_t(\text{examined}) = N_{ave} * F_T * 0.83$
- $N_T(\text{from lab}) = \sum_0^t NT(\text{to lab}) - (\sum_0^t NT(\text{in lab system}) + \sum_4^t NT(\text{exit}))$ since result evaluation began after two hour of examination.

Since the flow of patient to and from lab depend on case teams service rate we must analysis service rate of each case teams before we decided the arrival rate. The average service time of OPD case teams include both examination and result evaluation time. That means:

- Total service time is the sum of total examination and result evaluation time.
- Total examination time = number of patient assigned to case team * average examination time
- Total result evaluation time = number of patient from lab to case team * average evaluation time
- Number of patient from lab to case team = number of patient assigned to case team * 83%

Based on collected data and VSM, average examination and result evaluation times of MOPD are 15 and 9 minutes respectively while 12 and 6 minutes are for SOPD case team. MOPD and SOPD have four and three servers respectively. So:

- Total service time of MOPD at time T = patients assigned from CT *15 minutes + patient arrive from lab * 9 minutes
- Total service time of SOPD = patients assigned from CT *12 minutes + patient arrive from lab * 6 minutes
- Average service rate of MOPD = 1patient/ (15 + 7.47) minute =2.67 pat/hr
- Average service rate of SOPD= 1patient/ (12 + 4.98) minute =3.53 pat/hr
- Average effective service rate of MOPD = 2.67 pat/hr * servers (4) = 10.64 pat/hr
- Average effective service rate of SOPD= 3.53 pat/hr* server (3) = 10.59 pat/hr but the effective service rate of the case teams varies with time interval so we must use approximation method of service rate analysis

Shift		Morning				Lunch	After noon			Average
MOPD	From	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	
	To	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	
Av. No. of pat		89	51	33	12	3	58	32	8	35.75
Time factors		2.49	1.43	0.92	0.34	0.0	1.62	0.89	0.22	
Patient Arrive from CT		20.7	11.9	7.7	2.8	0.7	13.5	7.5	1.9	8.33
Examined		16.0	16.0	7.7	2.8	0.7	13.5	7.5	1.9	
patients to lab		13.3	13.3	6.4	2.3	0.6	11.2	6.2	1.5	83%
Diagnosed		10.3	10.3	10.3	4.3	0.6	10.3	7.1	1.5	
Waiting for lab		3.0	5.9	2.0	0.0	0.0	0.9	0.0	0.0	
Effective service rate		16.0	16.0	21.5	24.8	0	17.7	21.7	25.4	
served from lab		0.0	0.0	13.9	21.4	0.6	4.1	13.3	1.5	
Waiting after lab		10.3	20.6	17.1	0.0	0.0	6.2	0.0	0.0	
Arrive from lab		10.3	10.3	10.3	4.3	0.6	10.3	7.1	1.5	
Total arr. Rate		31.1	22.2	18.0	7.1	1.3	23.8	14.5	3.4	

Shift		Morning				Lunch	After noon			Aver.
SOPD	From	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	
	To	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	
Av. No. of pat		89	51	33	12	3	58	32	8	35.75
Time factors		2.49	1.43	0.92	0.34	0.0	1.62	0.89	0.22	
Patient Arrive from CT		21.4	12.3	8.0	2.9	0.7	14.0	7.7	1.9	8.58
Examined		15.0	15.0	8.0	2.9	0.7	14.0	7.7	1.9	
patients to lab		12.5	12.5	6.6	2.4	0.6	11.6	6.4	1.6	83%
Diagnosed		10.7	10.7	10.1	2.4	0.6	10.7	7.3	1.6	
Waiting for lab		1.8	3.5	0.0	0.0	0.0	0.9	0.0	0.0	
Effective service rate		15.0	15.0	22.0	27.1	0.0	16.0	22.3	28.1	
served from lab		0.0	0.0	14.1	19.8	0.6	2.0	16.0	1.6	
Waiting after lab		10.7	21.4	17.4	0.0	0.0	8.6	0.0	0.0	
Arrive from lab		10.7	10.7	10.1	2.4	0.6	10.7	7.3	1.6	
Total arr. Rate		32.1	23.0	18.1	5.3	1.3	24.7	15.0	3.5	

Table 17: MOPD and SOPD arrival and service rate analysis

Since the arrival and service rate varies based on time and analyzing it separately needs time. We can analyze the waiting time of patients with in the specified time using approximation method of average inter arrival and service time of patients. To compute waiting time, we need standard deviation and coefficient of variation of inter arrival time and service time to reduce higher variation of inter arrival and service time of patients within fixed time intervals. All what we need is mean and standard deviation; It does not assume a particular arrival and service rate. To use this method, I use inter arrival and service time of patients listed for each fixed time interval.

To sum-up the arrival and service rate and pattern of MOPD and SOPD are summarized as follow:

		MOPD	SOPD
Patient arrival rate	λ	17.16	17.4
Standard deviation of inter arrival time	S_a	-0.10	-0.09
Coefficient of variation inter arrival time	$C_a = S_a * \lambda$	-1.72	-1.56

Patient service rate	μ	20.44	20.79
Standard deviation of service time	S_s	0.001	0.01
Coefficient of service time variation	$Cs = S_s * \mu$	0.02	0.21

C. **Queuing discipline:** it is FIFO first come first served principle.

D. Using Approximation Method

Based on previous discussion it is better if we use an approximation of arrival and approximation method of queue analysis. Using these data we can calculate the following parameter of waiting time. These are:

Symbol	Parameter	Formulas	MOPD	SOPD
S	No. of server		4	3
λ	Arrival rate		17.16	17.4
Ca	Coefficient of arrival variation		-1.72	-1.56
Cs	Coefficient of service variation		0.02	0.21
Sμ	Effective Service rate		20.44	20.79
P	Utilizations of Servers %	λ/μ	83.95	83.69
L_q	Expected Length of Waiting Line	$\frac{\rho\sqrt{2(s+1)} * Ca^2 + Cs^2}{(1-\rho) * 2}$	24.47	17.98
Ls	Expected No. of Pat. in the System	$Lq + Sp$	27.83	20.49
W_q	Expected Time Waiting in Line hr	Lq/λ	1.43	1.03
Ws	Expected Time in the System hr	Ls/λ	1.62	1.18

The results show that, the capacity utilization of both case teams is more than 83%. MOPD case team's average number of people waiting in queue is 24.47, average number of people in the system at a point in time is 27.83, average waiting time in queue is 1.43 hr or 88 minutes and average time in system is 1.62 hour and for SOPD average number of people waiting in queue is 18, average number of people in the system at a point in time is 20.5, average waiting time in queue is 1.03 hr or 62 minutes and average time in system is 1.18 hour; the arrival pattern has

Poisson distribution. This shows that the queue and waiting times are too large and would probably result in decreased satisfaction of the patient and increased employee workload.

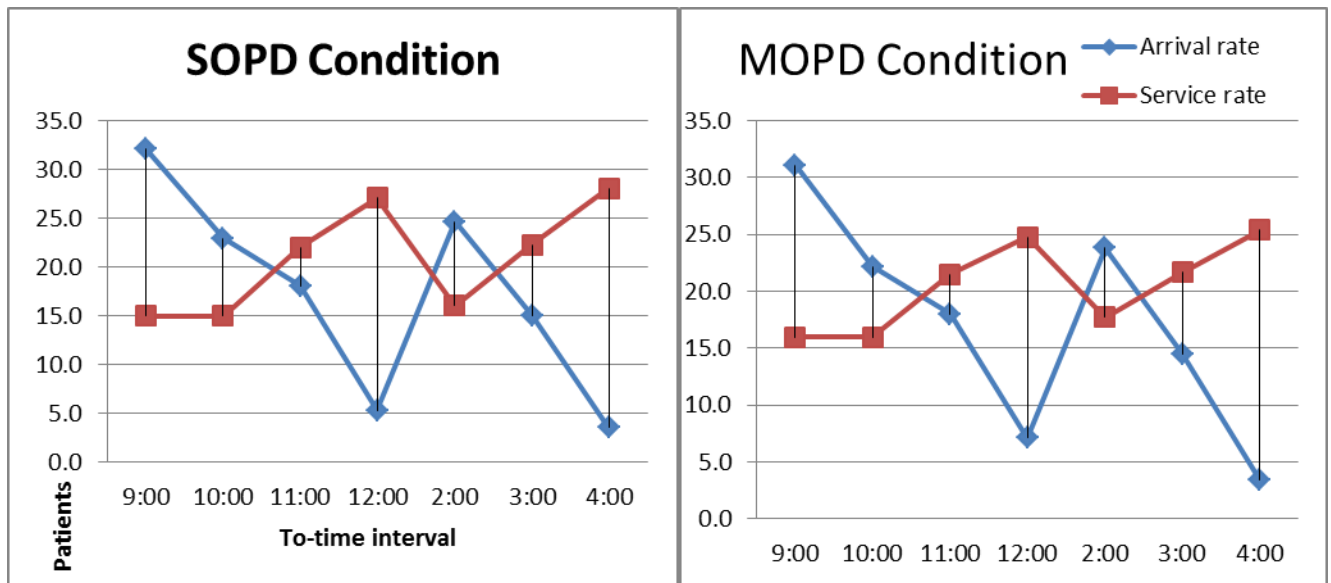


Figure 15: SOPD and MOPD arrival and service rate

In Medical OPD case team only about 12.07% of time was spend in adding value to patient and the rest 87.93% was spent in unnecessary non-value adding activities. In the same way, for Surgical OPD only nearly 12.25% of time was spend in adding value and the rest 87.75% was spent in unnecessary non-value adding activities.

4.4.4. Improvement

The waste management of healthcare facilities such as outpatient department is very complex and demanding to manage. The most common objectives of studies on the OPD have included the reduction of patient's time in the system (OPD), improvement on customer service, better resource utilization, and reduction of operating costs [34]. Improving the time and way people were flow and queued was an important contributor to patient satisfaction.

Waiting of OPD patients can be decreased by various means like: sequencing and standardizing work, introducing pull system using automated queuing management system, lean Hospital layout and optimizing clerk work place layout by providing personal office equipment to eliminate the need of visiting the work room while serving the patient and etc.

1. Work sequencing and Standardizing

It is a well-known fact that one of the best ways to ensure quality outcomes is to standardize process steps. Some professions could not be carried out by humans without standard work documents. At first glance, patient care does not appear to be a good application of standardization as it seems to make the work rigid and smother creativity. Much to the contrary, there are many processes in a HURH setting that would benefit from establishing standards for all to follow.

In HURH OPD, most operating procedures stored away from the work area, so workers rarely refer to them and follows different processing steps all the time. This includes the time needed to finish a job, the order of steps to follow for each job, and the parts on hand. In addition, there is usually no time expectation associated with the process steps.

To standardize HURH work, sequencing of OPD operation is important since the service time for different operation is different. In HURH OPD, there are two types of patients requiring different service time. These are:

- Patients with appointment: they arrive for checkup and further medication. Since doctor knows their history and conditions, he examines them with in short time. So they served with in short service time.
- New regular patient: these patient arrive the case teams without physicians request. The time doctors spent to examine them depend on their health condition. So they need longer service/process time to serve them.

Since top priority is given to the number of waiting patient, it's better if we use shortest processing time sequencing rule. We give priority to the appointed patient since the required operating time at the work center is shortest, so as the number of patient waiting in the system will be reduced and patient satisfaction will increase.

Using sequenced process they must develop and operationalize templates, check lists and a policy regarding new and appointed patients, including set hours that they will be seen and reserve slots in provider schedules for them to create a uniform release of information process to

follow. Checklist developed must detailing all necessary steps for patient check-in and checkout to ensure accuracy of patient information, including contact numbers and standard, organization-wide policy. Staff members follow a standard process for check-in and checkout, ensuring that all required information is collected. These standard forms ensure appropriate and consistent patient care, Improve patient –flow and staff and patient satisfaction by Increasing patient access to care and reducing frustration and aggravation among patients and stress on staff.

By determining which job should be started first on some work center, preparing standard forms ensure appropriate and consistent patient care and documenting detailed work procedures religiously followed by everyone doing the job such that the work is performed the same way every time, we can ensures that line balancing is achieved, unwarranted patient waiting time is minimized and non-value added activities are reduced. Using standardized work for repeatable tasks will improve quality because everyone will be trained to follow standard, enhanced communication across departments and case teams since they Access necessary information timely and Reduced cycle time which Increase patients access to care and Enhanced provider productivity

2. Lean Layout and Design Flow

Lean requires the hospital layout to be designed to ensure balanced work flow with a minimum patient waiting between work stations. Each of work station is part of a serving line, whether or not a physical line actually exists. Capacity is balanced using the same logic for line, and operations are linked through a pull system. In addition, I visualize how all aspects of patient flow in a system tie to the layout and locate patient charts onto movable carts closer to health care providers.

The basic approach in Routine Improvement is to find a sub-optimum design by asking improvements in sequential fashion. First, a given layout has to be evaluated to determine what the effect will be if case team locations are interchanged. If making pair-wise exchanges can bring improvements, the exchange producing the greatest improvement can be adopted. The process continues until no improvement is possible by pair-wise exchanges.

By using *traffic intensity Method*, I systematize case teams within the OPD department. Suppose central pharmacy, finance and laboratory occupy equal space and work for three case teams and IPD department. From my interviews to central coordinators nearly 75% of patients from Medical, surgical and dermatology case teams use these central stations.

The layout has been re-designed to reduce unnecessary movement based on number of patients visiting stations. I start analyzing by forming a table that contains patient flow for all major OPD case teams. Then, arrange patient flow based on their traffic intensity and finally I try to reorganize case teams based on their arranged order. Table below shows the current and proposed movement distance between various case teams. Refer figures in appendix, which shows existing and proposed layout

		To											From	
		CT	M	S	D	IPD	CL	CF	CP	ED	GYN	PED		other
F o r m	CT	0	1636	1686	540	0	0	0	0	948	555	431	1075	6871
	M	0	0	0	4	53	1227	0	1227	13	8	0	17	2549
	S	0	0	0	7	67	1265	0	1265	17	6	0	0	2627
	D	0	6	3	0	24	310	0	310	7	0	0	0	660
	ED	0	23	29	11	284	0	0	189	0	20	0	12	568
	GYN	0	12	7	0	27	0	0	111	7	0	0	0	164
	PED	0	0	0	0	11	27	0	86	0	0	0	31	155
	other	0	18	11	0	9	13	0	156	3				210
	IPD	0	0	0	0	0	1050	0	1050	0	0	0	0	2100
	CL	0	1227	1265	310	1050	0	3892	0	0	0	27	13	7784
	CF	0	0	0	0	0	3892	0	4394	0	0	0	0	8286
CP	0	0	0	0	0	0	4394	0	0	0	0	0	4394	
To		0	2922	3001	872	1525	7784	8286	8788	995	589	458	1148	

Table 18: patient flow

Where as

Medical OPD M Central triage CT Emergency department ED
Surgical OPD S Central finance CF Gynecology and OBS GYN

Dermatology D Central pharmacy CP Ear, nose and throat other
 Inpatient department IPD Central laboratory CL Pediatrics PED

No	From	To	No. of patient	Existing Distance	Total traveled	Proposed Distance	Total traveled	Reduction (M)
1	CL	CF	4802	10	48020	10	48020	0
2	CP	CF	4802	8	38416	8	38416	0
3	CF	CL	4802	10	48020	10	48020	0
4	CF	CP	4802	8	38416	8	38416	0
5	CT	S	1686	28	47208	28	47208	0
6	CT	M	1636	85	139060	40	65440	73620
7	S	CL	1265	97	122705	32	40480	82225
8	M	CL	1227	42	51534	10	12270	39264
9	S	CP	1265	115	145475	52	65780	79695
10	M	CP	1227	60	73620	30	36810	36810
11	CT	Other*	1075	48	51600	48	51600	0
12	CT	ED	948	6	5688	6	5688	0
13	CT	GYN	555	36	19980	36	19980	0
14	CT	PED	431	34	14654	34	14654	0
15	IPD	CP	350	35	12250	80	28000	-15750
16	D	CL	310	81	25110	62	19220	5890
17	CT	D	310	44	13640	85	26350	-12710
18	D	CP	310	100	31000	42	13020	17980
Total			31803		926396		619372	307024
Average distance traveled per patient					29.13M		19.5M	33.14%

Table 19: the current and proposed movement distance between various case teams

Thus, it is observed that in the existing layout patient movement is very high and will be reduced by reordering and changing current layout to the proposed one at least with 33.14%. In the new layout, the average distance a single patient move has been reduced to 19.5 meters compared to 29.13 meters in the existing layout as referred on figures in appendix.

4.5. Pull System In HURH

The “pull system” is a basic principle of the lean system. The pull system means the downstream processes fetch from upstream processes only the goods that are needed, only when they are needed, and only in the required amounts. Naturally, as an upstream process is depleted of its products it “pulls” more work pieces from the previous process, and this gets repeated all the way up the line. In the pull system, **Automated Queue Management** system is used, so that when patients pulled from operation by the next operation work station, the information indicated on the patient management system computer can serve as a work order for the operations. The implementation of automated queuing pull operation system is currently the solution to reduce waiting time of patient in the system and improve customer service.

Automated queuing systems were becoming more widely used throughout a wide range of client service industries and specifically in some Banks of Ethiopia like Commercial bank of Ethiopia, Dashin Bank and etc... It became evident that no one Ethiopia public health services had previously attempted to integrate the technology with a patient administration system. So, planning to integrate this system is basic to decide where and why to implement. For HURH it is better to implement this system in CT and major OPD case teams like: MOPD, SOPD, Gynecology and Pediatrics case team, because these areas are where there is higher customer waiting and complains are observed.

1. For Central Triage (CT)

A touch screen ticket kiosk will be installed in the reception area, allowing patients to register themselves in a virtual queue. This ticket master station screen will have two barcoded appointment notification letters at the top of screen to facilitate self-servicing of patient and print tickets for each type of appointment. Even though the procedures require registering patients with card and requiring new card is the same, they serve them in separate area and patient requiring spatial attention and priority like: referral and emergent patient served first in both stations, which facilitates cheating and corruption in case teams. So, we can classify service in to two by merging patient with card and needing card as a regular patient and patient with referral and emergent as urgent patient.

Old card number on patient hand can be collected by master station screen assistant when patient issue queue ticket and sent to the registration room clerks so that they can know and prepare the cards before patient called to them by attendant nurses. For new patient they approach the area when called and issues new card and file so that they give him assigned number card as soon as he pay registration fee.

When the work stations are free and ready to patient, CT clerks click a button on the computer screen which initiates both an audible and visual call up of the patient's ticket number over the speaker system and waiting room television. The call up includes information on what entry door to use to enter the room. If there is urgent patient with urgency ticket, the call up will be of the patients with urgent number since Urgent patient with urgency ticket will get priority due to system adjustment to the situations..



Figure 16: Kiosks located near the front door For HURH CT

2. For OPD Case teams

A touch screen ticket kiosk to be installed in the CT near CT clerk and attendant nurse, allowing them to register patients in a virtual queue into determined OPD case type (MOPD, SOPD, Gyn, Pediatrics and ...) waiting line. They take a number kiosk prints, directs patient to case teams they already assigned and give the card to each Patient. Each patient will have a ticket with a unique identification number and take a seat in the waiting area of their assignment case team.

This ticket master station screen located in CT will have four barcoded appointment notification letters at the top of screen for MOPD, SOPD, Gyn and pediatrics case team and print different tickets for each type of appointment.

Due to doctor's difference in speed, knowledge, and work experience, their cycle time of operations is different. Doctor in room A may serve many patient quickly then Doctor in room B and C. Even patient arriving later then other patients waiting for room B and C may get service before them, which disturb the first come first served principle of hospital's OPD working system. So, it is better if CT assign patient to case teams and case team distribute patient to each work station using automatic queuing machine rather than assigning patient directly to case team's work stations.

Selected OPD case teams must have counter with at least three nurses and one supporting staff. The first nurse acts as medical assistant and performs two functions: taking blood pressure, and checking temperature of patient already assigned to the case team. The second nurse identifies and write laboratory and pharmacy prescription based on doctors order on card, and estimate and take laboratory cost according to HURH financial system using prepared itemized cost of laboratory services list. The third nurse manage over all flow of patient in the case team using case team's computer screen and automatic queuing machines, and organize laboratory report and patient flow card based on their priority. Supporting staff help these nurses in every aspect they need her like transferring information, supporting and guiding patients and transporting materials, tools, equipment's and etc.

To call patients to the counter for medical assistant, third nurse call patients unique identification number using her mouth. After medical assistant nurse take and document blood pressure and

body temperature of the patient on patient card, the patient get ready to be seen by doctor based on his card order. When the work stations/doctors are ready to see the patient, she click a button on the computer screen which initiates both an audible and visual call up of the patient's ticket number over the speaker system and waiting room television. The call up includes information on what entry door to use to enter the room.

Patient enters the room with their card already filled with basic information. So, doctors can manage the patient without or with little support from nurses. Doctor writes prescription and every required assumption on patient's card clearly so that the second nurse read and understands his order to identify and write laboratory and pharmacy prescription ordered. Patient exit the room with card and submit it to the second nurse to know the doctors order and pay laboratory expense. The third nurse call for other patient as soon as patient exit the room since the room is free and ready to serve other.

4.5.1. Implementation

To implement the system, HURH should establish implementation committee where information technology staff of the hospital and University included in it to oversee and act as part of the implementation team of the system. Information technology staff of the hospital and university team will work on the technical integration of the queuing system and patient management system using the information technology infrastructure in place at HURH Services.

Initially, the efforts of the committee should focuses on ensuring the possibility of technical integration and then scoping the project. As part of scoping the project, develop a realistic Gantt chart of activities and flow charts outlining the expected patient flow throughout the various services and case teams in hospital. Upon acceptance of the project scope and budget by the committee, the project is ready to be implemented by the information technology team.

In order to achieve the project's objectives, select machines and healthcare Patient Flow, messaging and patient management system software suitable for HURH patient flow. The integration and implementation of the project will be achieved within the prescribed timelines and according to case team's priority order.

4.5.2. Benefits of the system

While there is no post-implementation statistical information to compare the impact of the automated queuing system of HURH, a patient survey confirms that more than nine in 10 patients need to use the system like banks in Ethiopia rather than reception services. They expect greater reduction of average wait time from the time of scanning the letter at the self-service kiosk to the time that the case teams calls up the patient from the waiting area. A survey on HURH staff also suggests that the computerized automatic queuing systems will bring a major strength in customer management and patient handling systems of HURH in providing intended care service.

The implementation of the automated queuing system will reduce the need for patients having to use reception services, freeing up the reception for general inquiries and other customer service matters. Case teams managers can monitor the number and length of wait of patients. Managers are automatically alerted of the need to problem-solve any excessive wait issues, against predefined thresholds, as they occur in real time.

After Implementation of automatic queue management system In HURH,

- The waiting area will be more peaceful place. The unsightly queue will disappear and patients can sit in comfort whilst they wait, rather than standing. The noise level will also greatly reduced, as staff no longer needs to call out for patients to approach the counters.
- Improve outpatient flow from presentation to check-out that enables managers to efficiently organize staff and resources, so that patients receive the right care at the right time.
- System can partner with other software to provide scheduling solution for outpatient, emergency and Inpatient department care practices. This flexible systems can tailor to meet the needs of an individual case teams and can be fully integrated with Patient Management solution.
- The system will manages the flow of patients and their associated information from check-in to check-out covering stages such as calling a patient in the waiting room, tracking a patient's status and provision of information including treatment and waiting times.

- In relation to the staffing, the automated queuing system will reduce the number of receptionists required from four to two, as well as reduce the number of nurses from seven in to three in SOPD, from five to three in MOPD and etc. and permit them to devote more time to patients who need extra help.
- Convenience of directly referring patients from rooms and/or case teams to departments/case teams
- The system will improve workflows and increase efficiency for a more streamlined, satisfying and informative patient experience.

In general, even though keeping up-to-date of technological advances can be challenging, since the technology is new, the outcome of implementing an pull system using automated queuing system will be positive both from the health service's and patients' point of view.

4.6. Other Lean Tools

Lean tools grew out of the need to have mechanisms in place to support the lean way of thinking and to allow flow to permeate a process. Value stream mapping, 5S, work standardization, TPM, Kaizen and Kanban are among the most popular Lean tools. We try to implement VSM, Lean layout, work standardization and other optimization tools for specific cases. Now we will see other lean tools that support the whole HURH lean way of thinking and reduces wastes.

4.6.1. 5S and Visual

The five components of 5S are defined as sort, set in order, shine, standardize, and sustain. 5S is a method that reduces waste in your work environment through better workplace organization, visual communication, and general cleanliness. This is one of the primary tools necessary to improve HURH processes by eliminating wastes such as motion, searching, waiting (queuing) and improve quality and functionality of departments.

When implementing 5S, staff should not focus on getting organized. Rather, they need to consider how they deal with all the things that come to them and what is within their environment; this will help in creating a 5S workplace.

For example, doctors do not focus on getting their operating room organized. Instead, they have a defined process for preparing for an operation: they wash their hands in a certain way; the instruments used are predefined and laid out in a specific way. Instruments are checked and counted in a standard way for each surgical case every day. The result of these processes is a 5S workplace.

Let us use the practical example of cleaning their office to understand how they would implement 5S in the workplace.

The first step that they must do when cleaning their office are open the door, back out the shelf, and pull everything out that is lying around. They then make piles of the things they will need most frequently, what they will need some times, items they need to return to their friends, what to take to their home, and what to discard. They must remove those items (unnecessary supplies, equipment, and junk) that they do not need to do the job. This will remove clutter, free up floor space, and aid in improving workspace efficiency. This first step in the process is called “Sort.”

The next step is to put away the things that they need most frequently and some times. However, this time they will put them in a specific location: “A place for everything and everything in its place.” They make labeled file cabinets for their files and arrange them based on their requisite frequency. This will allow them and others to look at the cabinet in the future and know exactly what location to return files to, and they can easily access files by the label of cabinet and arrangement order by traveling short possible distance. For their tools, they can make a shadow board which allows them and others to look at the board in the future and know exactly what location to return the tool to, and they can easily identify missing tools by the shape of the empty space on the board. More importantly, it allows them to find their tools when needed. They can install clamps for brooms and shovels. Place items in proximity (point of use) to make the caregiver’s job easier. Label and identify the exact location for equipment and supplies to make this easy to maintain. This step in the process is called “Set in order.”

With everything sorted and set in order, it is time to clean the entire office. Sorted and straightened areas are easier to keep clean. Shine, another word for “scrubbing and cleaning,” is important to everyone, not to mention making patients and their families feel they are entrusting

their lives to an organization that values cleanliness. During cleaning, they can observe things that need to be fixed, such as the cracked switch plate and the torn weather stripping on the utility door. They must repair these things so that they do not become a bigger problem, cause damage, or put a customer's safety at risk. Further, they wash down the office floor and remove oil spills with a degreasing agent. This step is called "Shine."

Now they can stand back and look at their accomplishment. The office looks great. Everything is clean and organized; they can actually find what they are looking for in the office. However, beware—they will need to repeat this exercise again in a few months because they did not "Standardize" and "Sustain" their efforts. They must standardize regular maintenance and upkeep of the 5S process. It is essential to be deliberate in their ongoing efforts and to create guidelines for sort, set in order, and shine and then to actually follow those guidelines. Sustain is the true value of the 5S process having the discipline and keeping the 5S processes going to sustain their customer/patient and Joint Commission ready approach at all times. Use simple but effective audit processes to Insight Article accomplish this. Sustaining is the most important "S," and it requires the most discipline.

By implementing all of the 5S components, they have transformed their office into a neat, orderly, and safe place. Everyone can find files/things quickly, and they can easily recognize when something is missing. This simple example reveals the power of 5S and the importance of using all of the 5S steps to move hospitals Lean efforts forward. Implementing 5S in HURH will provides some of the following benefits:

- A cleaner workplace for enhanced safety and reduced clutter
- An organized, efficient workplace for increased productivity
- An always-ready environment that fosters and promotes compliance with regulatory standards
- The reduction of patient waiting and motion by reducing tools and files searching time
- The recapture of valuable space and improve functionality
- The impact of "how they feel" about their workplace, organization, and themselves

4.6.2. Kaizen or Continuous Improvement

KAIZEN is a philosophy developed and established in Japan. The meaning of KAIZEN is change for better or freely translated quest for continuous improvement in all aspects of daily live. Therefore KAIZEN can be helpful in all activities of human beings privately or for business.

There are a lot of methodologies and tool available to make KAIZEN workable for health care facilities. But main important, all the involved people from the top down to the lowest level, must be encouraged to contribute their ideas to the never ending improvement. Kaizen can only be the right approach, if the top management takes the responsibility for following up the small daily suggestions permanently by walking around and being interested in what's on going on the work floor where the real things are happens!

Now, implementing it for HURH is by introduce the KAIZEN approach at the same time and make the Staff Performance Maintenance Tool (SPMT) an integrated tool for KAIZEN using KAIZEN continuous improvement board.

This board is the main source of information regarding KAIZEN and the actual status of improvement and activities leading to further improvements. For every working group or case team such a board has to be developed and kept up to date. Therefore a company can use BPR and BSCs small units which should be encouraged to work “as independent as possible”. A team has to focus on how they can contribute to the company's overall set of targets. As long as the team is able to transform their ideas and small problems into solution, they should do this immediately without asking for help from outside the team. This is real KAIZEN!!! Only if a problem is too big, too much money needed or other departments or experts needed for realizing a solution, the team has to transfer the idea/problem (a reason how a solution contributes to improvement should be part) to the next higher hierarchy level.

As soon as every small unit or team is with such a KAIZEN board, it's easy for the whole management to be informed at any time, just be walking around and check the information given on the KAIZEN boards. This is the 5th s – sustain!!! Make sure that the reached improvement level will stay in future.

The information on the board is divided into four corners as shown in figure below. These are:

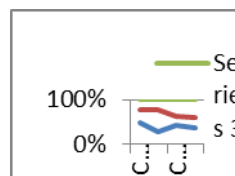
1. The “Staff performance record corner” The staff performance is visible by three different colours red = newcomer; blue = average performer with space of improvement; green = best performer able to do his process step independent without outside help) shows the actual staff performance as well as the gaps and need of training
2. The “Improvement/success corner” shows the actual status of the three to five most important improvement targets for this team. Additionally you can put samples of success (picture of best performer from this team, letter of thanks from the GM...) The improvement graphs have to be updated on a weekly basis. AS soon as the result is below the target, the team has to search for a reason why and find an idea or solution for improvement
3. The “Idea/problem corner” is the place where every team member is expected to place his ideas or small problems. Everybody from the team is invited to put his ideas on the board! After maximum one week time, the idea/problem should be transferred into a solution! So the Idea paper has to go to the solution corner!
4. The “Solution corner” covers the solution actually developing by the team. After another week, small solutions have to be put into reality! Bigger solutions/problems have to be sent to the next hierarchy level for realization.

STAFF PERFORMANCE RECORD



IMPROVEMENT/SUCCESS CORNER

Picture of well performing employee...



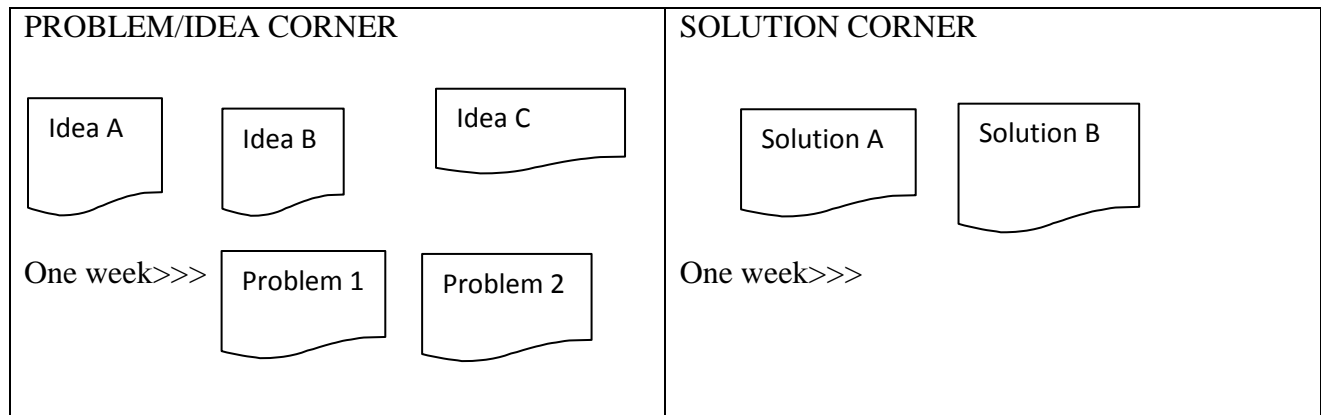


Figure 17: continuous Improvement Board

Source: Buchele Organisationsstrukturen; Austria

- The size of the stand should be 2 times a flipchart paper.
- we need space for:
 - ✓ Green; blue; red sticker
 - ✓ Idea paper
 - ✓ Marker
 - ✓ Tape

The management and case team officers in the Hospital have to stabilize a motto saying “Changes on Monday”, and they always show one improvement every Monday. This continuous improvement concept will change many things in the Hospital.

4.7. Summary

Lean tools and techniques used to improve patient flow across the three units. The changes implemented during the course of the Lean effort attached within the context of a Hospital’s daily operations. To that end, table below provides a summary of real-time HURH Lean concepts and tools applied to address problems, and expected results.

Lean concepts or tools	Result
<p style="text-align: center;"><i>Value stream mapping used</i></p> <p>Visually depict the current process and a set of action developed to achieve an improved “ideal” process</p>	<p>Improve work flows and Processes by enhancing teamwork, problem solving capacity, and employee empowerment</p>

<p style="text-align: center;"><i>Lean layout used</i></p> <p>Rearrange the case teams based on traffic intensity and locate patient charts onto movable carts closer to health care providers</p>	<ul style="list-style-type: none"> ● Save time, reduce delays, and improve patient flow ● Patient information is more accessible to health care providers and staff members
<p>5S (sort, straighten, scrub, standardize and sustain) and <i>Visual management</i> used</p> <ul style="list-style-type: none"> ● sort and label items in color-coded bins ● install colored flags outside exam rooms ● install an electronic numbering (queuing) system in the waiting room 	<ul style="list-style-type: none"> ● enable staff members to Visually identify listen (expired) and needs (missing materials) ● save staff- time and associated impact on patient -flow ● Enhance care team communication ● Reduce interruptions and staff frustration ● Improve cycle time
<p><i>Lean thinking</i> using Kaizen and PDCA led the staff and patient to identify problems and generate possible solutions to the problem</p>	<ul style="list-style-type: none"> ● Reveal and eliminate barriers to health care access ● Encourage patients to take more responsibility for their own care ● Improve access to care and reduce number of patients missing scheduled appointments
<p>Standard work used</p> <ul style="list-style-type: none"> ● develop and operationalize templates, a policy regarding patients, and create a uniform release of information process to follow ● develop a checklist detailing all necessary steps for patient check-in and checkout 	<ul style="list-style-type: none"> ● Enhanced communication across departments ● Reduced cycle time ● Increased access to care ● Improved patient -flow ● Increased staff and patient satisfaction ● Reduced frustration and aggravation among patients

Table 20: Lean concepts versus HURH Problems need improvements

As shown in the above table, the changes implemented range from the relatively simple actions, such as the development of a checklist, to more complicated interventions, such as the standardization of the role of the medical assistant.

The following results were drawn from the study;

Surgical OPD, medical OPD and emergency department are the vital few or the magnificent area which serves about 61% of arriving patients. The time patient spend on getting services is only 40%, 40.6% and 31% of total time patient spends in CT, ED and OPD respectively. From the observation done on major ED service areas without considering admitted patient, ED has a maximum capacity of 96 patients per day. The idle time for operations is 5694 minutes. Average patient waiting time is 39.5 minute and 45.0% of time was spent in value adding activities. Whereas Medical OPD case team only about 12.07% of time was spend in adding value to patient and the rest 87.93% was spent in unnecessary non-value adding activities. In the same way, for Surgical OPD only nearly 12.25% of time was spend in adding value and the rest 87.75% was spent in unnecessary non-value adding activities.

The Changes in percentage of idle time of CT servers is from more than 48.14% in the initial model to 27.96%, improvement actions resulted in about a 41.92% reduction in average percentage of idle time of servers. The average time-in- system of the CT patient reduced from more than 46 minutes to 11.85 minute with a reduction of 75%. Patient movement is very high for existing OPD layout and will be reduced by at least 33.14% by rearranging it. In the new layout, the average distance a single patient move has been reduced to 19.5 meters compared to 29.13 meters in the existing layout. The cycle time of CT, ED, MOPD and SOPD are reduced by about 56.7%, 24%, 22.9% and 24.59% respectively.

CHAPTER 5: MODEL DEVELOPMENT FOR LEAN IMPLEMENTATION IN HEALTH CARE

The outcome of this project is a recommendation roadmap for health cares to use when implementing lean principles. This roadmap consists of four parts: Ethiopian Health Sector Reform Tools, a model for lean implementation, barriers to lean implementation, and best practice checklists for the 5s and Value Stream Mapping.

5.1. Ethiopian Health Sector Reform Tools

Health sector reform in Ethiopia is an undergoing process as a comprehensive endeavor in the socio-economic reform that started with Civil Service Reform covering the entire public sector of the country. As part of this national effort, the reform in the health sector has been intensified through the application of a new concept known as *Business Process Reengineering (BPR)* followed by *Balanced Score Card (BSC)*. BPR and BSC are country led, multi-spectral undertaking implemented as a comprehensive approach to the government's civil service reform.

A. The Business Process Re-Engineering (BPR)

BPR has been used as a tool for a comprehensive analysis, redesign and revamping of the health sector in Ethiopia. As a process itself forms a fundamental rethinking and requires a purposeful and radical redesign of health business processes to achieve dramatic improvements in critical, contemporary measures of performance such as cost, quality, service and speed. *The purpose of the BPR in the context of the health sector was to establish customer focused institutions, rapid scaling up of health services and enhancing the quality of care in order to improve the health status of the Ethiopian people as indicated in the mission of the health sector.* Following a deeper and systematic analysis of the “as is” situation at all levels of the health system, including health facilities, the sector has brought in innovative approaches including , benchmarking best practices, redesign processes, revising organizational structures and a selection of 8 core process and 5 support processes listed below.

Core Processes

1. Health Care Delivery;

The support processes

1. Human Resources Development /Management;

- | | |
|--|--|
| 2. Public Health Emergency Management; | 2. Procurement, Finance and General Service; |
| 3. Research and Technology Transfer; | 3. Program-Based Audit; |
| 4. Pharmaceutical Supply; | 4. Public Relations and |
| 5. Resource Mobilization and Health Insurance; | 5. Legal Services. |
| 6. Health and Health Related Services and
Product Regulation; | |
| 7. Health Infrastructure, Expansion and
Rehabilitation; and | |
| 8. Policy, Planning, Monitoring and Evaluation. | |

Subsequent to this, series of training sessions have been given to managers and technicians at all levels, There has been changes in staff deployment and specific job assignments including recruitment of new staff leading to progressive implementations under the close oversight of the top health leadership.

The key strengths of BPR are:

- BPR has the potential to deliver significant improvement to systems;
- The key concept is to focus on 80% of the costs so that time is not wasted searching for small gains;
- The approach takes into account the historical, political and cultural context of the work;
- There is a strong emphasis on team working. Workshops are used to engage as many people as possible to get buy-in to the changes. The level of engagement of teams can be highly motivating.

B. The Balanced Scorecard (BSC)

BSC is a holistic model that has been used at various levels across the health sector, health care facilities, teams or groups. It is used to manage strategy by linking objectives to initiatives, targets and measures across a range of health sector perspectives. It has been used as a multi-dimensional framework for managing strategy by linking objectives, initiatives, targets and measures across key health sector perspectives. The scorecard sought to remedy this by providing a more balanced suite of performance measures across a number of key perspectives.

Typically these look at customers, finances, internal processes and organizational learning. However they can be adapted depending on what factors are considered important for the success of the health sector. It aims to enable health sector to manage strategy by linking corporate objectives, initiatives, measures and targets at all levels in the health sector and achieve a balanced set of performance measures and targets that allow managers to track progress in key areas.

Health sector implementing Balanced Scorecard to formulate and refine strategies; communicate strategies and priorities throughout the sector; link strategic objectives to long term targets and budgets; monitor progress and introduce initiatives to improve performance.

The key strengths of BSC are:

- Holistic overview of organizational health;
- Focuses individual objectives to the wider picture helping to create ownership, understanding and focus at all employee levels;
- Links targets and measures to operational objectives and in doing so helps rationalize performance information, identify gaps and ensure balance;
- Facilitates communication and understanding of business goals and strategies at all levels;
- Encourages a focus on key priorities, assists in allocating resources and helps organizations / groups to become more results orientated.

C. BPR, BSC and lean implementation

BPR and BSC have of a great help in the implementation of the lean servicing system based on their key strengths as follows:

- BPR implementation brings a strong emphasis on team work. Workshops are used to engage as many people as possible to get buy-in to the changes. The level of engagement of teams can be highly motivating which changes culture of workers to ward clear workers participation.
- BSC encourages a focus on key priorities, assists in allocating resources and helps organizations / groups to become more results orientated.

- BSC changes individual focuses objectives to the wider picture helping to create ownership, understanding and focus at all employee levels and facilitates communication and understanding of business goals and strategies at all levels

From these we can conclude that employees had a clear picture of the process approach in doing their day-to-day tasks, core and supportive processes were partly identified, documented and implemented, process teams were organized and process owners assigned, process bottlenecks were identified and actions being taken on them using team work approaches and management commitment and culture of work were improved from implementation of BPR and BSC which facilitates and activate lean implementation.

We can summaries BPR, BSC and Lean implementation as follows:

- BPR is concerned on organizing and construction of effective Road and Vehicles with the driver drives the vehicle in constructed road framework.
- BSC focuses on identification and setting of road and vehicles journey destination and methods of road, vehicles and drives performance measurement with reference to planed destination.
- Lean implementation gives higher emphases on improvement and/or removal of wastes occurs and follows up of every day to day activities of the journey by improving and/or reducing obstacles and problems occurs during journey like: Preventing vehicles and road breakages using TPM, work standardization and etc, improve vehicle and road conditions during journey using 5S, visual management, continuous improvement and other lean tools and improve drivers performance using continuous improvement processes.

Whereas

- ✓ Vehicles –workers and working equipment
- ✓ Roads – process and procedures
- ✓ Drivers – top managers
- ✓ Journey –customer serving activities
- ✓ Destinations – strategic objectives and goals.

5.2. Recommended Lean Implementation Model

After the investigation of Lean concepts from its conception, and the analysis of the Hospital in depth it is possible to formulate the implementation models for hospital. But, the model for lean implementation in the health care developed through this research consists of recommendations based on the generalization of themes found in conceptual models of lean from various sources found in the literature as well as through benchmarking the experiences of hospitals and the company's. Therefore, the proposed implementation model shown in figure below will be best suit for the Hospital to follow. Following is a brief discussion of each step in the implementation model.

1. **Top Management Commitment.** Top management support is especially important to the success of Lean because its operating principles are so different from traditional operations that it calls for fundamental changes in the way people do and think about their jobs. Therefore, to be successful in Lean, the commitment of time and resources required to complete the analysis will require the long-term cooperation and support of senior management. Hence, the lean principles must be briefed to the top management and full acceptance by the top management is required and should be maintained throughout the implementation phases. Ensure Health care leadership is secure, respected by the staff, understands the need for continuous improvement, and demonstrates systems-level thinking and analysis. Assess the willingness and ability to commit necessary organizational resources to Lean.
2. **Policy deployment:** A strategic Lean implementation normally starts with a policy deployment exercise. This exercise helps to define improvement priorities and generates ideas about the content, timing and sequence of specific aspects of the Lean implementation. This would include decisions such as identification of the areas that receive attention. The policy deployment brings cohesion to the implementation plan for the roll-out of Lean. This 'philosophy of lean' or the cultural change which must take place in order to base management decisions on what is best for the company in the long term instead of short term financial goals by optimizing lean barriers like reducing negative staff characteristics and increasing support or direction from top management and organization culture.

The methods of Policy Deployment are meant to get the workforce involved and Top management commitment by striving for constant improvement.

3. **Implement lean tools.** In Lean implementation an attempt is made to implement all the components and/or techniques gradually. To avoid the frustration of the Hospitals for losing their objective each traditional process of the company should be maintained at the beginning, but after Lean is started implementing these traditional approaches are gradually minimized to zero. Pilot projects on the techniques based on the type of wastes to be attacked meet these objectives.

The pilot projects are done in the following steps:

1. Choose lean tools and techniques
2. Set the goals/objectives to be attained.
3. Define the performance measure.
4. Measure the performance, and
5. Release the performance report.

Ensure goals are relevant, realistic, measurable, and may be achieved within the existing organizational capacity. Understand and appreciate the broad impact of small, incremental change.

To decide the Scope of Improvement Efforts, the level of difficulty, capital and time required to implement each tool must be considered carefully. Based on these considerations, the lean service tool implementation in HURH facilities is categorized into three phases. The three phases of suggested approach are presented in Table below.

		Key Elements for Change Programs	Tools & techniques
Phase: 1	<p>In this section we can describe the prerequisites for Lean and lean approaches used to test the validity of Lean in a new context both in terms of implementation process and the technical content of organization change. It deals with basic, less costly, easy to implement and would have positive or complementary effect on many areas in the organization results in immediate gains in productivity or other related parameters</p>	<ul style="list-style-type: none"> ➤ Need to change existing attitudes, behaviors and practices. ➤ Full and ongoing support from top management. ➤ Need for a champion to drive the change initiatives and maintain momentum by keeping house clean. ➤ Engaging employees as much as possible in the planning, implementation and evaluation of changes. ➤ Assess the developments taking place in an effort to become Lean and as a checklist for what to aim when implementing ➤ Developing an environment of openness and trust through communication and sharing information. 	<ul style="list-style-type: none"> ➤ Policy Deployment ➤ BPR and BSC ➤ Value Stream Mapping ➤ 5S

Phase: 2	<p>It deals with tools, techniques and concepts that may be implemented in advance of full Lean implementation by Developing a Process Understanding. Includes measures which are slightly more difficult to implement, which may require some kind of budgetary provisions and approvals.</p>	<ul style="list-style-type: none"> ➤ Understanding the nature of demand volumes and seasonality and Assess the actual process sequence for the systematic sample of patients and working area conditions ➤ Clustering patients in segments of similar processes ➤ Identifying the process flow of each patient and existing working area or blocks ➤ Designing and Testing the new process flow, layout and standardize working time ➤ Assessing results and implementing improved processes 	<ul style="list-style-type: none"> ➤ Visual Management ➤ TPM ➤ Lean Layout ➤ Standardize work ➤ JIT and Kanban
Phase: 3	<p>Implementation of these will require a number of iterations and trials for implementation.</p>	<ul style="list-style-type: none"> ➤ The process includes freeing participants of any other responsibilities and informing those working around them that it is about to happen. ➤ Recording the as-is process performance. ➤ Evaluating the process as it is now. ➤ Developing a new work combination (workflow). ➤ Redesigning the process flow. ➤ Implementing the new process flow. ➤ Re-measuring the new flow. ➤ Reviewing the results. 	<ul style="list-style-type: none"> ➤ Continuous Improvement

Table 21: phases of suggested Implementation approach

Figure below depicts the recommendation of model for lean implementation developed in this project.

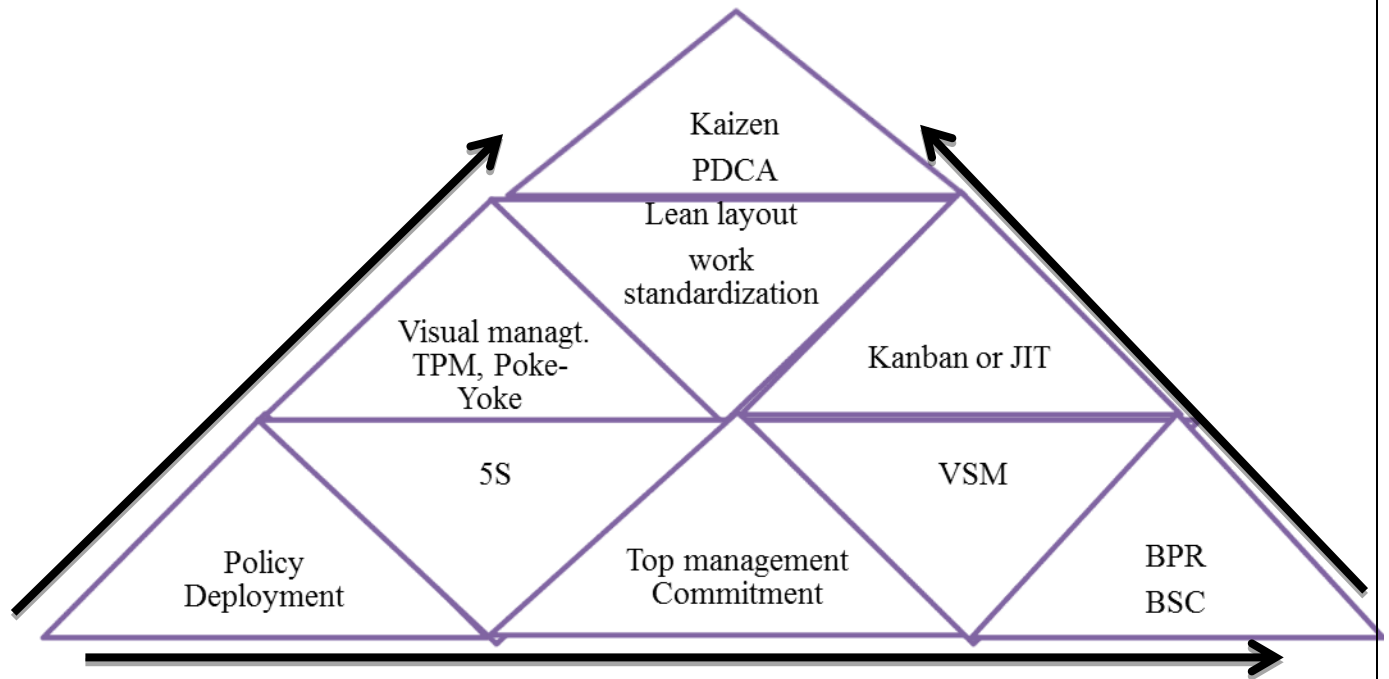


Figure 18: model for lean implementation in Ethiopia Health Care Facilities

At the base of this model Policy Deployment, Top management commitment and BPR and BSC act as input for lean implementation which facilitates implementations of 5S and VSM, and both act as an input for their inputs (vice versa). 5S and VSM can bring noticeable improvements and attract high level individuals within companies and facilitates the ‘philosophy of lean’ or the cultural change which must take place in order to base management decisions on what is best for the company in the long term instead of short term financial goals.

Visual Management tools such as Poke yoke and TPM, pull system and Just in Time tools which are used to improve flows of materials and patient reduce inventories, and lead times so the service can get to the customer when they want it, build a foundation of stability in the process, which enable lean layout and standardization of the work.

Kaizen, like all of the lean tools should be done constantly, For this reason, Kaizen and other improvement methods might not take into full effect until after employees have had enough experience using lean through tools such as 5s, TPM, and Value Stream Mapping that they understand how the system works.

The triangles in the same levels are codependent and their direction shows the relationship their effect and inputs. The arrows on each side of the triangle directs toward the sequence of implementations and continuous application of these tools. No matter how an organization decides to use lean or its tools, the key to remember is that its purpose is customer satisfaction and growth of the organization using continuous improvement processes.

If the desired result of any implementation phase based on the performance measure is not achieved:

- Identify the problems
- Rectify the causes
- Solve the problems, and
- Work again on the techniques.

If the desired result based on the performance measured for are achieved formalize a Plan for Spread and Sustainability.

In general, the implementation will be continued until all the LEAN techniques will be fully implemented and the Hospital is changed to LEAN operating Hospital.

5.3. Barriers to Lean Implementation

This section discusses the obstacles or challenges to carrying out Lean activities and the reasons for the possible failures to implement changes. These specific barriers to the implementation of Lean are varied and listed sequentially from strong to weak. These are:

- A. Negative Staff Characteristics:** Given that staff input, involvement, and engagement are at the core of the Lean approach, it is understandable that the characteristics of staff could pose a significant barrier to its successful implementation. These negative characteristics took several forms, such as resistance to change and lack of initiative or motivation to change. Also, change fatigue was identified as a barrier as some staff members had grown weary of constant changes implemented within their hospitals like BPR and BSC.
- B. Lack of Support or Direction from Top Management:** strong leadership and direction from top management is a key factor supporting the successful implementation of Lean. It

was not surprising that the lack of such support represents a key barrier to the success of a change initiative such as Lean. Specifically, leadership inaction and lack of enthusiasm and buy-in hinder the progression of Lean.

- C. **Organizational Culture:** it shows the impact of shared values, beliefs, and behaviors or culture of organizations on the implementation of Lean. Barriers related to organizational culture identified includes a top-down organizational management approach, the lack of encouragement or freedom for staff members to take the initiative to work on problems and challenges, and an environment in which change is not embraced or supported.
- D. **Lack of ownership for the improvement activity:** It is clear that improvements from improvement events can be difficult to sustain if post event ownership was poor, follow-up did not work and half implemented while harder ones have not. This lets people slide back into their comfort zones and causes resistance during the improvement process which prevent implementation of suggested improvements after the event. Small improvement that can be adopted on a personal level can left to wait till another such event is organized.
- E. **Slow natural pace of change:** Most of the study sites reports the historical tendencies of the slow pace of changes. Lack of quick response can result in crises that force radical change involving new management teams. Workers may suffer from this inertia problem with improvement ideas put back into existing bureaucracies. The ability of the organization to adopt changes quickly is clearly a necessary characteristic. Although this point is relevant for all service sector organizations, additional care should be taken where changes need to be formalized or adopted on a wide scale. This is especially relevant in healthcare where some changes may need to be authorized by committees that meet infrequently. The momentum for Lean has to be sustained during these delays and at times this may be difficult.
- F. **Lack of Capacity:** the lack of capacity within organizations is one of factor inhibiting Lean implementation. This lack of capacity was perceived on two levels. On the human resources level, lack of capacity was defined as either limited staff or reductions in staff and staff turnover. On the organizational level, lack of resources such as the “cost” of pulling away providers and staffs, and the physical space needed for team members to meet and perform Lean activities.

G. **Priorities:** the challenge of balancing daily patient demands and the focus on patient care with the need for dedicated time to apply Lean is other barrier. Workers frequently express a sense of being overwhelmed by the daily demands of working in a resource-constrained environment. The pressure of patient need is such that staff could do that all day long and not have time to think about anything else and not have the time to say, ‘Hey, could we do this better?’

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

In this chapter, the key aspects of this thesis cover the summary of the research work, Conclusions and recommendations. Conclusions have been drawn and recommendations are made for the Health care facilities to use in future. The contributions of this research are addressed and future directions are offered for the work.

3.1. Conclusion

In today's world, the need of having quality service in service areas is increasing. The improvement of service with respect to waiting time and other wastes has become more important in recent years because of the increased emphasis on customers satisfaction, especially this is ultimately needed in healthcare due to the lifesaving activity accomplished there. Due to this, different techniques are currently used throughout the world and here in our country.

In this work lean principles were implanted to provide better cost, quality performance delivery and flexibility. Particularly the lean principles were implemented in patient entry, registration, distributions to stations, operations, and flow design, etc. up to exit.

As HURH is giving service for more than 12 million peoples, much has been done and currently doing towards reforming health care activities. And the current activities towards improving the service quality of the hospital are encouraging. Among these activities; the quality team is trying to implement Kaizen and BSC since the design of BPR implementation in the hospital is completed and there are currently some beginning works for the implementation.

Bases on the assessment of the service provision process in the hospital, the thesis address the patient waiting time for the service needs great improvement as it is a vital waste and determinant factor to achieve intended objective. As an aid for the improvement in the waiting time of HURH patients, the thesis address the need of Lean implementation together with the right implementation of the BSC and BPR by giving great focus to continuous improvement using appropriate Lean tools and Techniques suitable for vital few case teams in hospital. Due to interdepartmental working system difference, which is the major problem in the implementation of the system in the hospital, adaption lean tools and technique from other department is difficult

and it is done within department. And the use of lean tools and techniques using current reform activity as a foundation for continuous improvement is expected to fill the gap which is hindering the achievement of better service in the hospital.

3.2. Recommendation

It is generally recommended that for a lean program to be effective:

Lean implementers should include a set of tools and techniques or provisions to ensure management commitment, employee involvement, identification of wastes, development of controls for wastes and training and education for employees.

They must reduce and manage failure to implement changes caused due to lack of resources, ownership for the improvement activity or commitment from both management and staff. Sustainability can be achieved through ensuring that there is enough organizational capacity, knowledge transfer, clear communication and strategic leadership.

They must know that BPR, BSC and other management tools acts as a foundation to implement it. These tools and lean techniques can act as a comprehensive lean implementation program which reduce the waste in the Health care facilities and enhances the profit and productivity.

3.3. Research Contributions And Future Directions

The major contribution of this research is the development of a systematic implementation model of Lean service system for HURH. Previously there was no effort to implement this innovative system in any of Ethiopian Hospitals.

The primary idea of this research is to help the HURH to take initiatives such as Lean servicing system in order to offer quality service with most cost-effective manner. The study has suggested generalized approach for Hospitals operating in Ethiopia working conditions and the work is fully in Ethiopian context. The approach may be generalized for use in all types of work conditions. The model developed for HURH can be readily extended to other Hospitals.

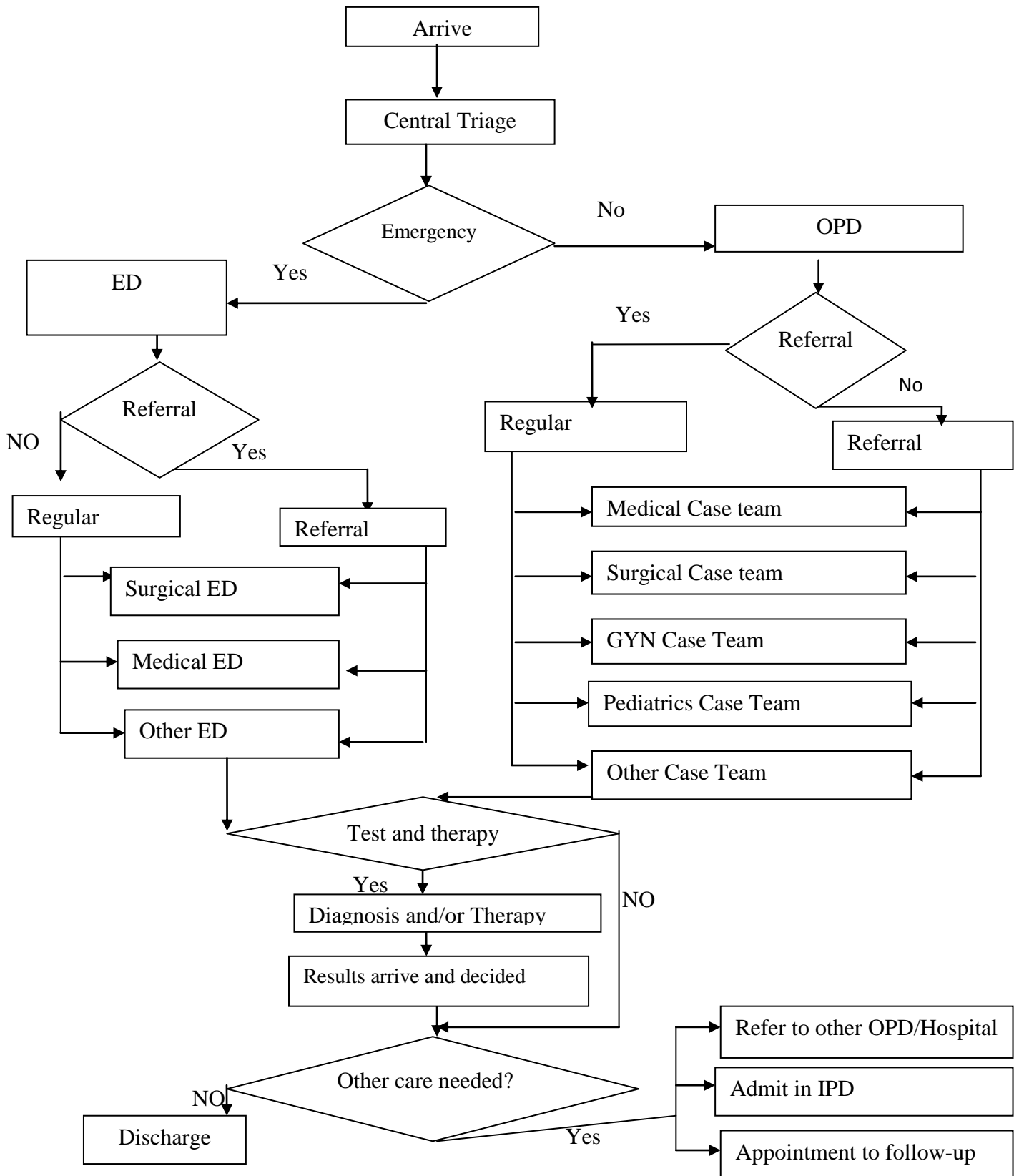
The VSM was conducted on the vital few OPD case teams. So a natural extension of this work is to map for each case teams patient families in the value stream and simulating patient flow with software's. It is also important to investigate how the patient appointment and workers assignment of the lean systems could be best accomplished. Finally, further efforts should be done to transform the current service system in to a pure lean servicing system.

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Appendix A: Patient Flow Diagram



Appendix B: Current and Proposed Layout

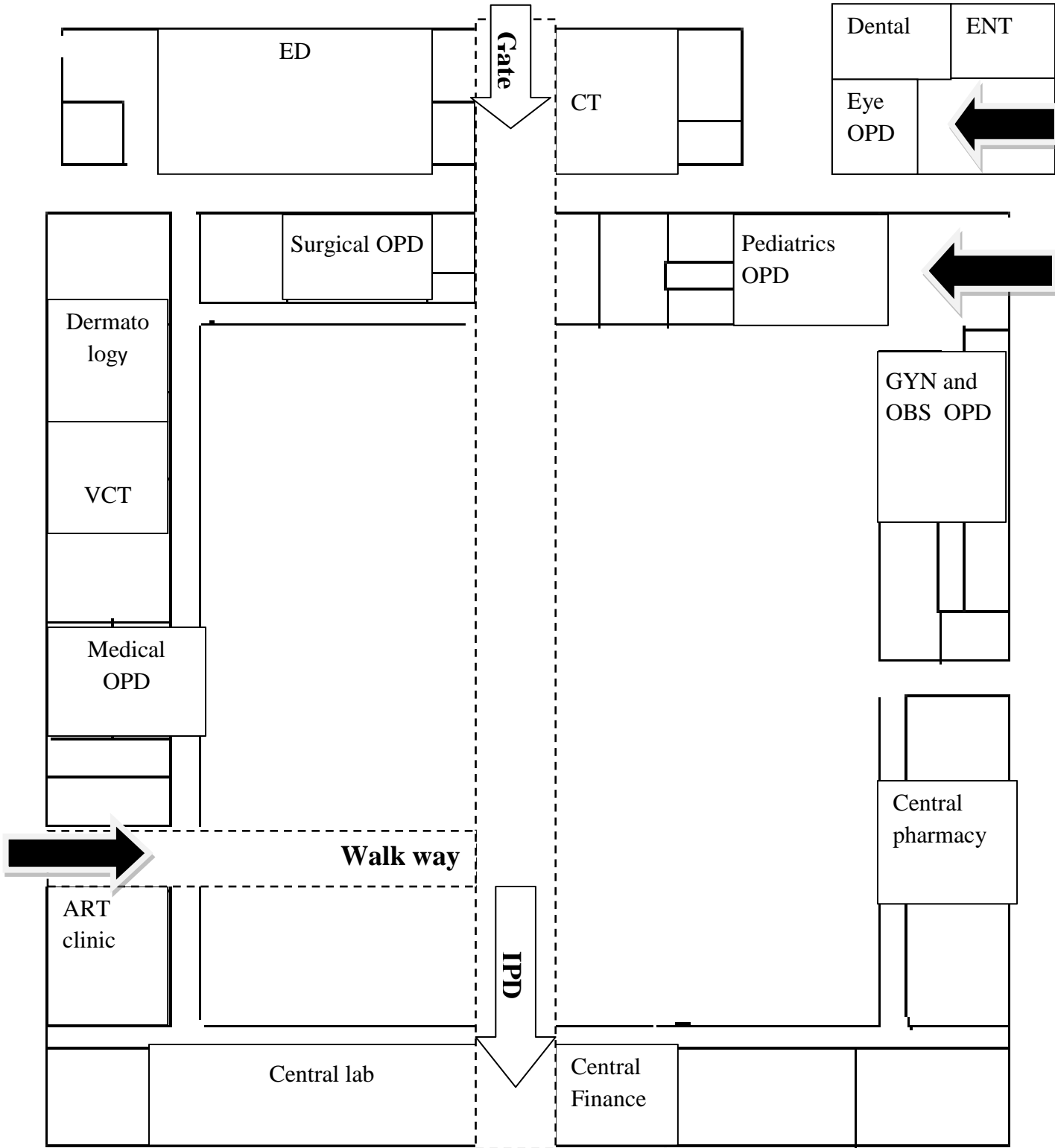


Figure 19: HURH Existing Layout

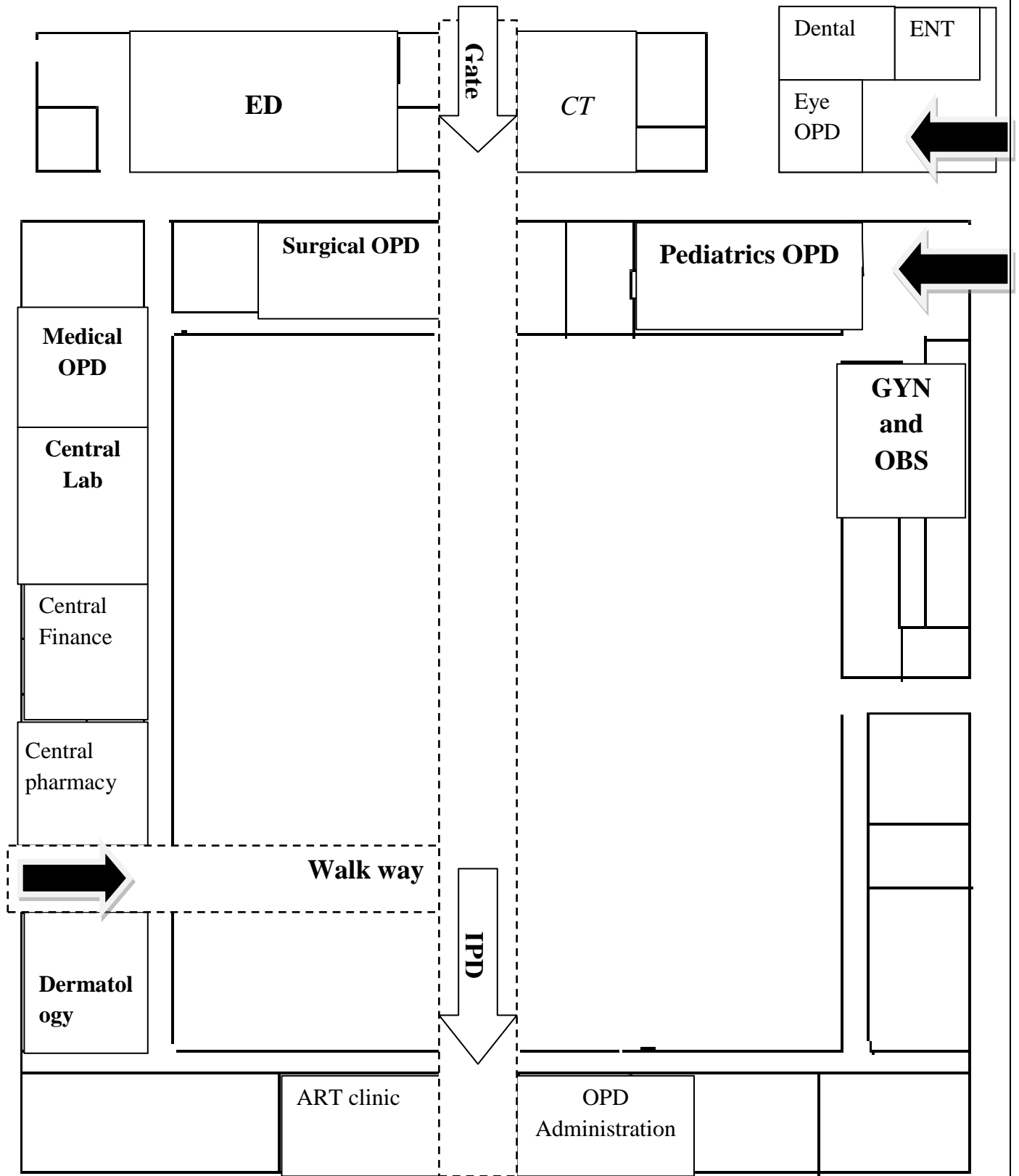

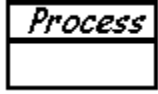
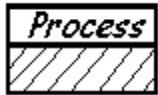
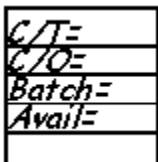



Figure 20: proposed layout

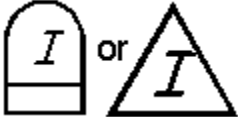
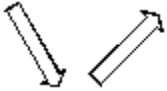

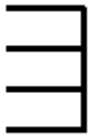
Appendix C: VSM symbols





Appendix.1. VSM Process Symbols

 <p>Customer/Supplier</p>	<p>This icon represents the Supplier when in the upper left, the usual starting point for material flow. The customer is represented when placed in the upper right, the usual end point for material flow.</p>
 <p>Dedicated Process</p>	<p>This icon is a process, operation, machine or department, through which material flows. Typically, to avoid unwieldy mapping of every single processing step, this icon represents one department with a continuous, internal fixed flow path.</p> <p>In the case of assembly with several connected workstations, even if some inventory accumulates between machines (or stations), the entire line would still be represented by a single box. If there are separate operations, where one is disconnected from the next by inventory between and batch transfers, then use multiple boxes.</p>
 <p>Shared Process</p>	<p>This is a process operation, department or workcenter that other value streams share. Estimate the number of operators required for the Value Stream being shared, not the number of operators required for processing all products.</p>
 <p>Data Box</p>	<p>This icon goes under other icons that have significant information/data requirements for analyzing and observing the system. Typical information placed in a Data Box underneath FACTORY icons is the frequency of shipping during any shift, handling information, transfer batch size, demand quantity per period, etc.</p> <p>Typical information in a Data Box underneath MANUFACTURING PROCESS icons is: C/T (Cycle Time) - time (in seconds) that elapses between one part coming into the process to the next part coming off, C/O (Changeover Time) - time to switch the process to produce another product, Uptime- percentage time the machine is available for processing EPE (a measure of production rate/s) - A</p>

	stands for "Every Part Every___". Number of operators - use OPERATOR icon process boxes Number of product variations Available Capacity Scrap rate batch size (based on process batch size and material transfer rate)
 Work cell	<p>This symbol indicates that multiple processes are integrated in a manufacturing cell. Such cells usually process a limited family of similar products or a single product. Product moves from process step to process step in small batches or single pieces.</p>

Appendix.2. VSM Material Symbols

 Inventory	<p>These icons show inventory between two processes. While mapping the state, the amount of inventory can be approximated by a quick count, amount is noted beneath the triangle. If there is more than one inventory accumulation, use an icon for each.</p> <p>This icon also represents storage for raw materials and finished goods.</p>
 Shipments	<p>This icon represents movement of raw materials from suppliers to the Raw Material dock/s of the factory. Or, the movement of finished goods from the Shipping dock/s of the factory to the customers</p>
 Push Arrow	<p>This icon represents the "pushing" of material from one process to the next. Push means that a process produces something regardless of the immediate needs of the downstream process.</p>
 Supermarket	<p>This is an inventory 'supermarket' (kanban stock point). Like a supermarket, a small inventory is available and one or more downstream customers come to the supermarket to pick out what they need. The upstream work center then replenishes stocks as required.</p> <p>When continuous flow is impractical, and the upstream process must operate in batches, a supermarket is used to decouple the processes.</p>

	batch mode, a supermarket reduces overproduction and limits total inventor
 <p>Material Pull</p>	Supermarkets connect to downstream processes with this "Pull" icon that i physical removal.
 <p>FIFO Lane</p>	First-In-First-Out inventory. Use this icon when processes are connecte FIFO system that limits input. An accumulating roller conveyor is an e Record the maximum possible inventory.
 <p>Safety Stock</p>	This icon represents an inventory "hedge" (or safety stock) against proble as downtime, to protect the system against sudden fluctuations in custom or system failures. Notice that the icon is closed on all sides. It is inten temporary, not a permanent storage of stock; thus; there should be a clear management policy on when such inventory should be used.
 <p>External Shipment</p>	Shipments from suppliers or to customers using external transport.