Université Sidi Mohammed Ben Abdellah - Fès
FACULTE DES SCIENCES ET TECHNIQUES

# RAPPORT DE PROJET DE FIN D'ETUDES

*Pour l'Obtention du*

## Diplôme de Master Sciences et Techniques
## Spécialité : Génie Mécanique et Productique

***Thème :***

***Using Lean Six Sigma and Design Thinking to improve the process quality in healthcare sector: Case study at CHU Fez***

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# Abbreviations

CHU : Centre hospitalière universitaire

LSS : Lean Six Sigma

DMAIC: Define/Measure / Analyze/ Improve/Control

CTQ: Critical to quality

SIPOC: Supplier/ Input/ Process/ Output/ Customer

CT scan: computerized tomography

TDM: Tomodensitométrie

TAP : Thorax / abdomen / pelvis

RCP: Réunion de concertation pluridisciplinaire.

# Résumé


- Parmi les problèmes majeurs rencontrés au service de chirurgie viscérale B au CHU de Fès : les longs délais d'attente. Ces retards peuvent être tolérés sauf pour les patients tumoraux. Même s'ils sont traités comme étant des cas urgents, ils attendent plusieurs jours pour être opérés.
- Pour traiter ce problème nous avons opté pour une stratégie de solution qui marie deux méthodologies robustes: Lean Six Sigma (un outil d'amélioration continue) et Design Thinking (une approche de l'innovation radicale).
- Cette étude nous a permis de :
  - ⇨ Proposer quelques solutions d'amélioration de processus par la méthode Lean Six Sigma.
  - ⇨ Proposer quelques solutions innovatrices par le biais de la méthode Design Thinking.
  - ⇨ Faire la convergence des solutions obtenues par les deux méthodes.

# Abstract

- Among the major problems encountered at the visceral surgery department B at the University Hospital of Fez: long waiting times. These delays may be tolerated except for tumor patients. Even if they are treated as urgent cases, they wait several days for surgery.
- To deal with this problem, we opted for a solution strategy that combines two robust methodologies: Lean Six Sigma (a tool for continuous improvement) and Design Thinking (an approach to radical innovation).

This study allowed us to:

- ⇨ Suggest some process improvement solutions using the Lean Six Sigma method.
- ⇨ To propose some innovative solutions through the Design Thinking method.
- ⇨ Converge the solutions obtained by the two methods.

# Introduction:

Les hôpitaux sont désormais confrontés à des exigences de plus en plus élevées en termes de qualité et de sécurité des soins. En effet, la majorité des organisations de santé dans le monde trouvent des difficultés à gérer convenablement leurs patients. Le problème majeur est d'une part les listes d'attentes encombrées, et d'autre part la difficulté de caractérisation de la qualité recherchée par le patient. Une piste pour répondre à ces problèmes se trouve très certainement dans la réorganisation et l'optimisation des processus ; pour ce faire, les organisations hospitalières pourraient s'inspirer des approches d'amélioration des processus issues du génie industriel. Celles-ci suscitent en effet un intérêt croissant de la part du milieu hospitalier, et parmi elles, l'approche Lean qui semble être de plus en plus adoptée notamment dans les pays anglo-saxons.

À cet égard, les méthodes Lean et Six Sigma suscitent beaucoup d'intérêt dans le secteur de la santé depuis le début des années 2000. Ces méthodes semblent avoir été implantées avec succès dans des environnements cliniques, notamment des hôpitaux de soins aigus, en majorité américains, et apparaissent comme les méthodes de réaménagement de processus les plus citées par la littérature spécialisée au cours des 10 dernières années.

Dans certains cas, l'amélioration du processus seule ne peut être suffisante pour la résolution des problèmes. En effet, la proposition de nouvelles solutions innovante peut remédier à ce défi : Le secteur de la santé innove. Mais pour qu'il se transforme réellement et durablement, les acteurs doivent collaborer d'avantage, embrasser de nouveaux concepts et rénover leurs approches méthodologiques. Les objectifs sont multiples : réduire les durées d'hospitalisation, favoriser d'autres modes de soin et d'accompagnement, éviter la redondance des actes médicaux, appréhender le patient dans la globalité de sa situation, y compris en trouvant des solutions pour accompagner sa famille. L'outil le plus convenable pour appliquer cette solution est le Design thinking, qui nous permet de bien comprendre ce que le patient cherche au service qu'on offre, et par conséquent de proposer un nouveau processus.

Dans notre recherche nous nous sommes basés essentiellement sur certaines études similaires à notre projet, y parmi un article qui vise « l'amélioration de la qualité des opérations et des soins » en appliquant les outils du Lean production. Cette étude a réussi à faire gagner 516 heures de temps total de traitement des patients par an [1]. D'autre part, P.F Lawrene e, MD, a visé « l'optimisation du temps de processus de chirurgie ainsi que l'amélioration de la qualité de chaque étape » en adoptant la méthodologie Lean Six Sigma, pour réussir à caractériser les pertes du processus et à réduire le temps d'exécution de certaines étapes [2]. C J. Warner, MD, MS, D B. Walsh, A J. Horvath, BA , T R. Walsh, RN,

D P. Herrick, BA, S J. Prentiss, MEng, et R J. Powell. A rédigé d'autre part un article à propos de « l'identification des causes qui se cachent derrière les opérations retardées », il a utilisé comme outils DMAIC/ Value Stream map/ PARETO et CONTROL CHARTS. Ce qui a mené à des résultats très satisfaisants : l'étude a souligné les actions qui n'apportent pas de valeur ajoutée au processus, d'autre part elle a réussi à caractériser les causes probables du problème [3]. Quant à E.V. Gijo, Jiju A. et J. Hermand ez, J. scaria se sont fixé l'objectif « réduction du temps d'attente des patients dans un hôpital de spécialités en Inde », par conséquent l'étude est parvenue à déterminer les actions sans valeur ajoutée et à les éliminer par la suite, et aussi à minimiser les temps d'attentes de certaines étapes [4].

Nous avons opté dans cette étude pour une stratégie mixte reliant Lean six Sigma et Design Thinking, afin de réduire les délais d'attentes des patients au sein d'un service de chirurgie au CHU de Fès, et d'optimiser la qualité des soins en proposant des solutions à la fois d'amélioration et de proposition d'un processus fondamentalement nouveau.

Pour réussir le projet actuel, nous avons choisi une démarche en adoptant les étapes suivantes :

- Chapitre I : présentation de l'organisation d'acceuil ;
- Chapitre II : littérature sur la méthodologie Lean Six Sigma;
- Chapitre III: littérature sur la méthodologie Design Thinking ;
- Chapitre IV: Lean Six Sigma et Design thinking dans le milieu de la santé et démarche de recherche.
- Chapter V: implementation de la méthodologie Lean Six Sigma
- Chapter VI: Implémentation de la méthodologie Design Thinking

# *Chapter I:*
# *Organization outline*

## Introduction:

The study presented in this report is carried out at the university hospital Hassan II of Fez and specifically the surgery unit B. Before starting, it is very important to present the service and its various components. This will allow us to better understand its structure and to know the problems that staff and patients encounter during the course of the work.

This first chapter is indeed a global description of the service (structure, organization chart ...) and the work done by the medical staff.

### 1- About the hospital:

The University Hospital Hassan II of Fez is a semi-public health institution. It was created in November 2001, and it is in January 2009 that HM King Mohammed VI inaugurated the new hospital complex. The university hospital Hassan II is designed to meet the needs of more than four million people including the Fez-Boulemane (which counts 977 946 people), Meknes-Tafilalet (2 141 527 people) and Taza-Al Hoceima-Taounate regions (1 807 113 people). It aims to improve the medical coverage of this population and to install a spirit of quality and patient satisfaction.

***Figure 1: The University Hospital Hassan II of Fez***

| | |
|---|---|
| ***Creation date:*** | 30 August 2001 |
| ***Date of commissioning:*** | 05 August 2002 |
| ***Organization:*** | The CHU center incorporates a direction and hospital services. |
| ***Composition:*** | Specialty Hospital;<br>Mother and child hospital;<br>External consultation block;<br>Laboratories;<br>Oncology;<br>Nuclear medicine;<br>Administration;<br>Technical galleries and locals. |
| ***Bed capacity:*** | 585 bed |
| ***Surface:*** | 45060 $m^2$ |
| ***Global cost:*** | 1, 200 billion DH |
| ***Financing:*** | General budget of the State: 20%.<br>Saudi Development Fund: 80% ready to 2% over 30 years. |
| ***Operating budget:*** | 645 323 509,8 Dhs. |
| ***Staff distribution:*** | 662 medical staff;<br>1048 nursing staff;<br>308 technical and administrative staff. |

***Table 1: Technical sheet of CHU Fez***

## 2- Organizational chart:

The CHU consists of a direction, three administrative and medical partitions and several services. (Fig2)

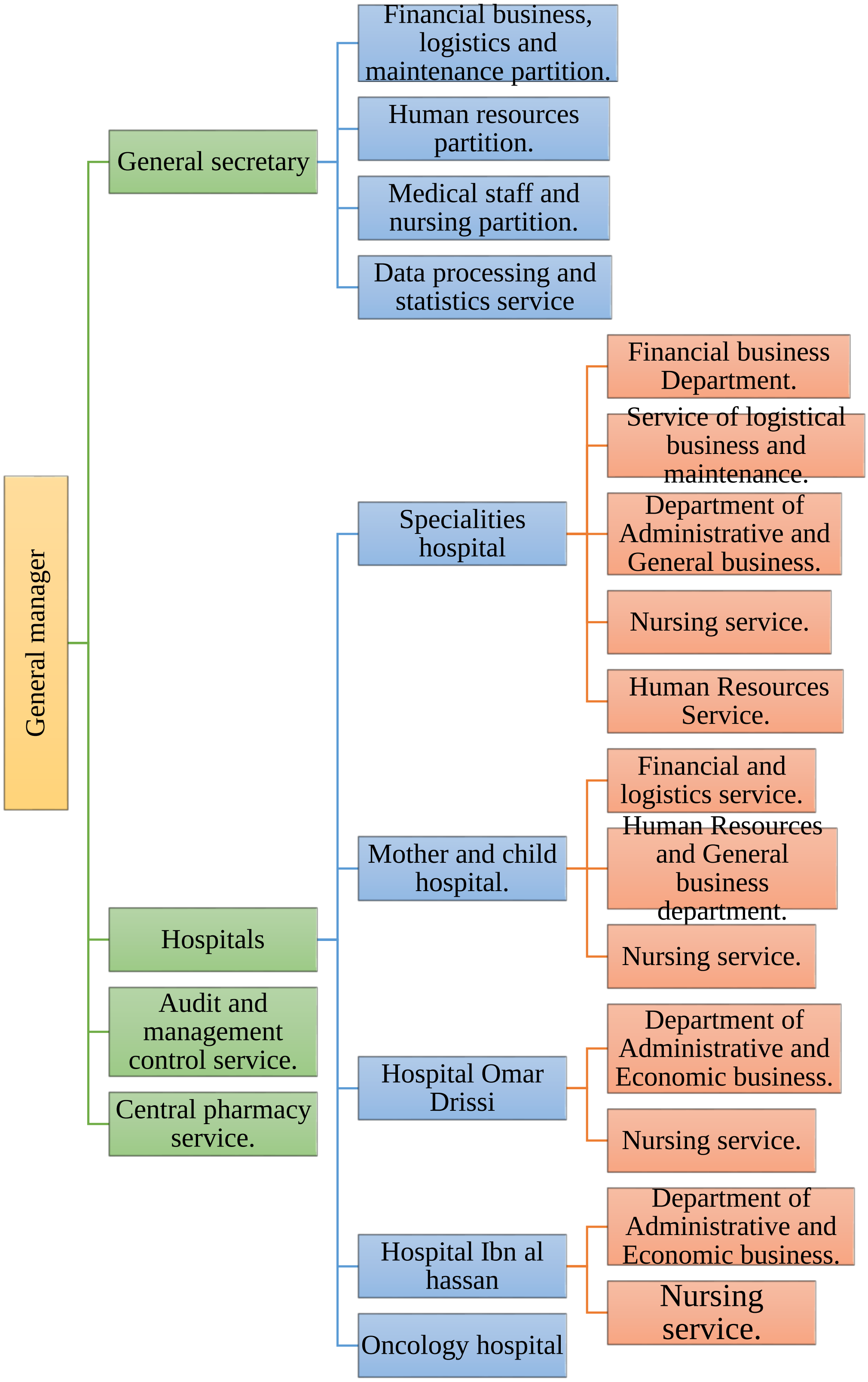



***Figure 2: CHU's Organizational chart***

## 3- CHU FEZ Map :


| | | | |
|---|---|---|---|
| A | Specialty Hospital | Z | Direction |
| B | Specialty Hospital | M | The unity of life |
| C | Specialty Hospital | N | agency |
| D | Specialty Hospital | O | The morgue |
| E | Specialty Hospital | S | |
| F | Specialty Hospital | V | Heliport |
| G | Mother and child hospital. | W | Mosque |
| I | External consultation | T | Nuclear medicine |
| J | central laboratory | U | Unity of life for patients families |
| P | Emergency room. | | |
| Q | Technical lobby | | |
| H | Oncology hospital | | |

***Figure 3: Map of CHU fez***

***Table 2: key of the CHU's map***

## 4- *The surgery unit B:*

As mentioned before, Chu-Fez includes various specialties. However our study will focus on the surgery unit B located in the building E of the specialties hospital.

The staff includes:

- 3 seniors surgeons and university professors
- 1 senior surgeon
- Medical team : 16 residents and 2 interns
- Nursing team: 9 nurses.

➢ Activities:

- Cancers Surgery
- Colorectal and proctologic surgery;

- Hepato-biliary and pancreatic surgery;
- Endocrine surgery;
- Surgery of the stomach and esophagus;
- Surgery of the abdominal wall;
- Surgery of obesity;
- Management of visceral surgical emergencies.
- Interventions at the central block;
- Interventions in the emergency room;
- External patient consultations;
- Training: The external doctors of the 3rd and 6th year, residents and interns.

The activities of the service are not limited to this point, there are various other actions that relate to surgery B classified according to the following table:

<table>
<tr><th colspan="2">Surgery</th><th>Activities within the service</th><th>training</th><th>Other activities</th></tr>
<tr><td rowspan="2">Central operating room:</td><td>Main room</td><td>Medical visit.</td><td>Surgical staff</td><td>Simulation centers</td></tr>
<tr><td>Ambulatory room</td><td>Medical consultation (professors, resident doctors).</td><td>Multidisciplinary consultation meeting.</td><td>workshops</td></tr>
<tr><td colspan="2" rowspan="2">Emergency operating room.</td><td rowspan="2">Surgical Staff.</td><td rowspan="2">Lessons: external, internal and resident doctors.</td><td>Round tables</td></tr>
<tr><td>Medical and surgical caravans</td></tr>
</table>

***Table 3: Activities related to the surgery service B***

## ***Conclusion:***

The surgery unit B performs many activities that are related to surgery (as indicated by its name). At this level, a pertinent question arises: Does the service have any problems? If so, what type are they? Is there an effective tool that will allow us to have a solution?

# *Chapter II:*
# *Introduction to Lean Six Sigma methodology*

# I- *Introduction:*

After briefly describing the service concerned by our study, we will present in this chapter the lean six sigma methodology, its historical development its advantages and disadvantages and also its application to the medical field.

# II- *Six Sigma:*

## 1- *Historical development of Six Sigma:*

Six Sigma as a measurement standard in product variation can be traced back to the 1920's when Walter Shewhart showed that three sigma from the mean is the point where a process requires correction.

The study regarding the evolution of Six Sigma would be incomplete without mentioning the valuable contribution from Motorola. In 1980, Six Sigma got a definitive form when a Motorola engineer coined the term Six Sigma for this quality management process. Motorola not only implemented this system in their organization, but they copyrighted it as well.

The society was facing extreme pressures from overseas competition, particularly Japan. Around 1987 Bill Smith (a reliability engineer) and others began improvement projects that in many ways looked similar to Total Quality Management (TQM) projects (Harry and Schroeder 2000). Mikel Harry and others helped Smith formulate this approach into an overall business initiative named "Six Sigma" based on the desire to reduce variation.

Motorola developed this new standard and created the methodology and needed cultural change associated with it, in order to measure the defects per million opportunities. Six Sigma helped Motorola realize powerful bottom-line results in their organization – in fact, they documented more than $16 Billion in savings as a result of our Six Sigma efforts.

Since then, tens of thousands of companies around the world have adopted Six Sigma as a way of doing business.

Today, Six Sigma has been widely accepted by a large number of manufacturing companies as well as service organizations, in particular financial services such as Bank of America, J P Morgan Chase, Citibank and Bank of Montreal and health services such as Commonwealth Health Corporation and Mount Carmel Health. A number of public sector organizations have also embraced Six Sigma as a strategy to achieve process excellence, and consistency in the delivery of services to customers.

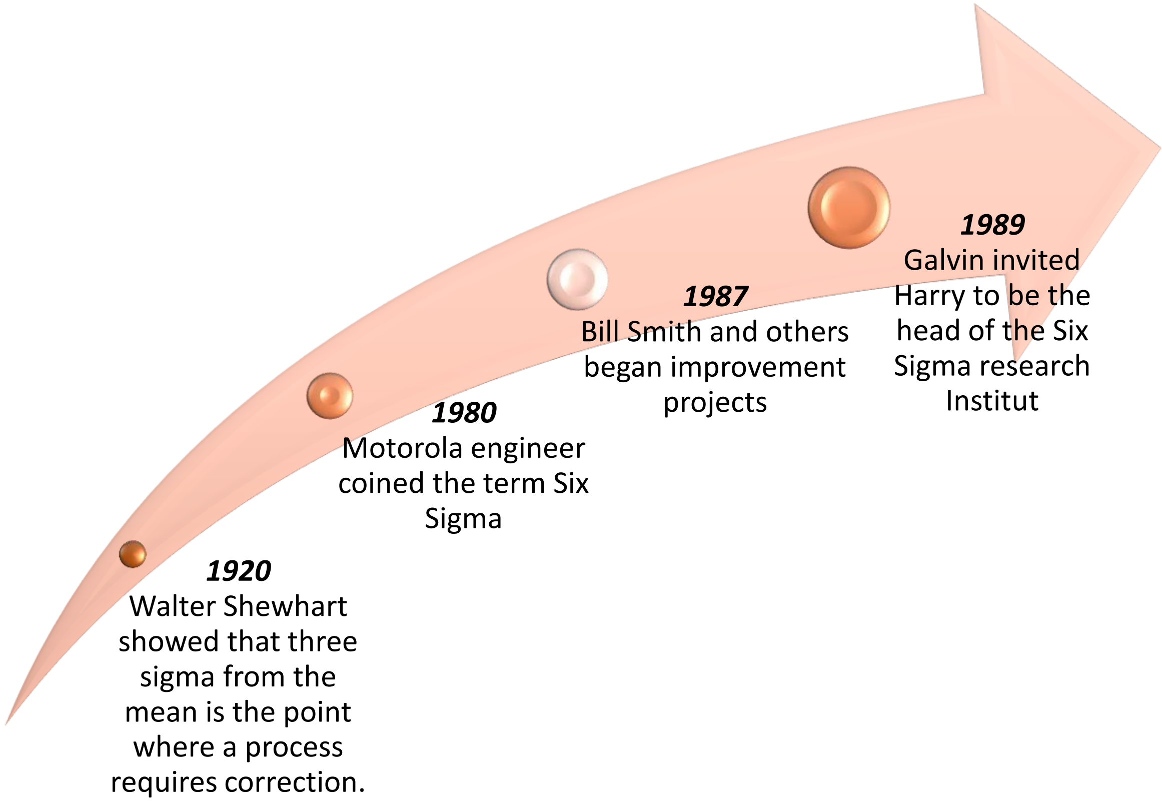



***Figure 4: Historical development of Six Sigma***

## 2- *Overview of Six Sigma:*

### *2.1 Definition:*

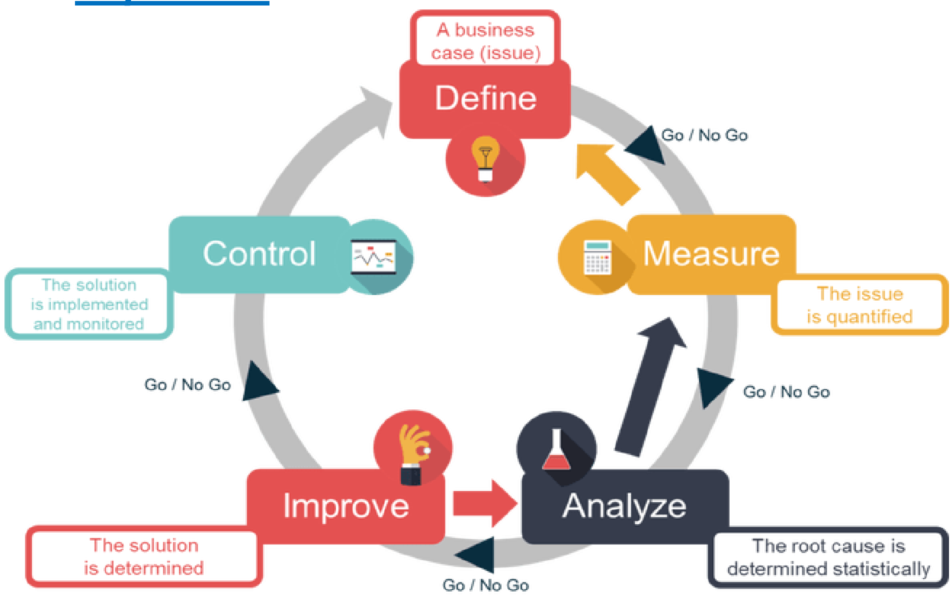



***Figure 5: Six Sigma methodology***

Six Sigma is a methodology and a philosophy that improves quality by analyzing data with statistics. It differs from other quality programs in its "top-down" drive and its rigorous methodology that demands detailed analysis, a control plan to ensure ongoing quality control of a process, and a fact-based decision making to all levels. The program changes the "DNA" of a company by

changing the way the leaders think, improving the management pipeline, developing management and communication skills in people.
A Six Sigma process will approach 'zero defects' with only 3.4 defects per million opportunities (DPMO) for a defect to occur.
Six Sigma has at least three meanings, depending on the context:

- It can be viewed as a measure of quality. Sigma is a Greek letter which measures the variation in a process. Achieving a Six Sigma measure of quality means that processes are producing less than four defects per million opportunities.
- It can be viewed as a business improvement strategy and a philosophy.
- It is a problem-solving methodology that seeks to find and eliminate the causes of defects or mistakes in business processes by focusing on process outputs which are critical in the eyes of customers.

All companies need methods and tools of measuring what they claim to value. In order to measure companies' processes, six sigma uses metrics that lead to tangible quantifiable results. The higher the Six Sigma level is, the better the process is performing. If a process operates at a Six Sigma value the resulting products and services are almost defect free. (Table below)

| Specification limit | Percent | Defective ppm |
|---|---|---|
| +/- 1 Sigma | 68.27 | 317300 |
| +/- 2 Sigma | 95.45 | 45500 |
| +/- 3 Sigma | 99.73 | 2700 |
| +/- 4 Sigma | 99.9937 | 63 |
| +/- 5 Sigma | 99.999943 | 0.0057 |
| +/- 6 Sigma | 99.9999998 | .002 |

**Table 4: The number of parts per million (ppm) outside the specification limits, normal distribution centered**

## 2.2 Objective:

The aim of Six Sigma programs is to create a higher perceived value of the company's products and services in the eyes of the customer. (Keller (2005)) to find the cause of quality problems, implement controls, center the process on the target and reduce process variation.

**Why should we use Six Sigma?**

- It enhances ability to deliver customer satisfaction and cost improvement results faster.

**Why do they call it Six Sigma?** The sigma are a way of measuring perfection:

- ➩ ***3 sigma:*** is a historical standard, with 93, 32% perfection.
- ➩ ***4 sigma:*** current standard, with 99.38% perfection.
- ➩ ***6 sigma:*** future standard, with 99.9997% perfection.

## 2.3 DMAIC:

Six Sigma utilizes a powerful five-stage data-driven methodology to improve processes. The five steps in the Six Sigma methodology are easy to understand,

and they are logical in their sequence. Moreover the steps allow a team to adequately scope the problem, measure the current performance by quantifying the problem, analyze the root causes of problems, test and verify improvement recommendations and then implement changes for sustainability over the long haul (Brassard et al. 2002).

The five stages of the Six Sigma methodology are:

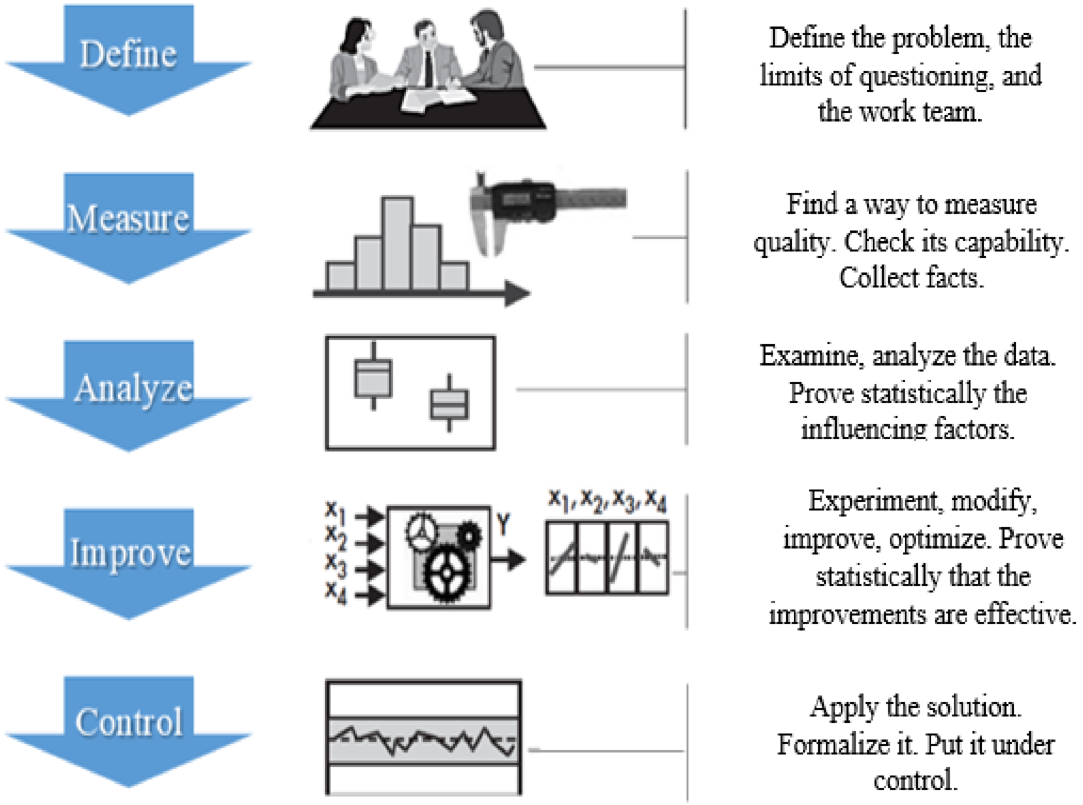



***Figure 6: The five steps of Six Sigma methodology***

- ***Define Phase:***

The aim is to define the scope of the project and obtain background information about the process where the problem lies and its customers. At this phase, it is recommended to follow the points below:

- *Develop a project charter:* It is important to develop a project charter in this phase to make sure that that the project champion reviews it and provides constructive feedback to the charter. It includes the voice of the customer (VOC), critical-to-quality (CTQ) characteristics and the specifications for CTQs.
- *Problem statement and goals:* Review existing data to confirm that the problem exists, and ensure that it is important to your customers as well as business.
- *Validate financial benefits:* It is critical to understand the potential benefits (both financial and non-financial) and the total investment to the project.

- *High-level process map:* It is very important to develop a high level process map also known as SIPOC, to understand the key inputs, outputs and the processes at a high level. SIPOC stands for suppliers, inputs, processes, outputs and customers.
- *Develop project plans:* A project plan should include the five phases: key milestones, schedule, team members, key deliverables and potential risks associated with the project.

Recommended tools in the define phase:

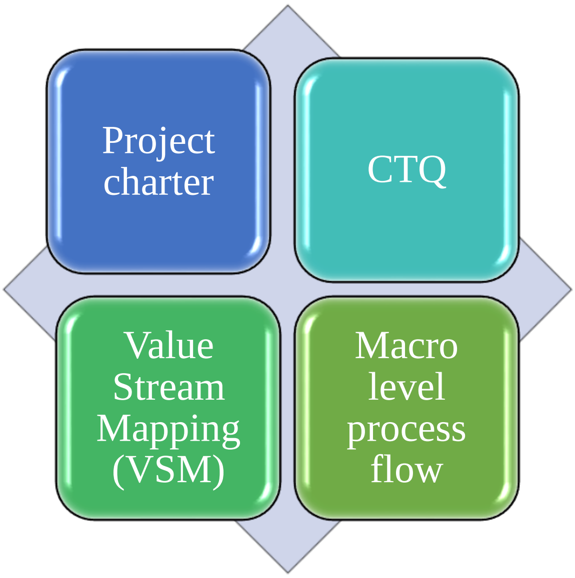



***Figure 7: Tools used in the define phase***

- ***Measure Phase:***

The goal of this phase is to quantify the problem by collecting information about the current situation. The following points are recommended to be taken into account:

- *Collect baseline data*: The baseline performance of the process must be established in the measure phase. The typical measures include defect rate (defects per million opportunities − DPMO), process capability indices ($C_p/C_{pk}$), sigma quality level (SQL) of the process, throughput yield or rolled throughput yield, process lead time, cycle time of process, etc.
- *Create a data collection plan*: one should think about the type of data to be collected, how the data are relevant to the problem at hand, how many samples should be collected from the process and how frequently these samples should be collected.
- *Operational definition for defects:* In the measure phase, we need to understand what to measure (also called CTQs), and once we identify the CTQs, we need to understand the operational definition for defects.

Recommended tools in the measure phase:

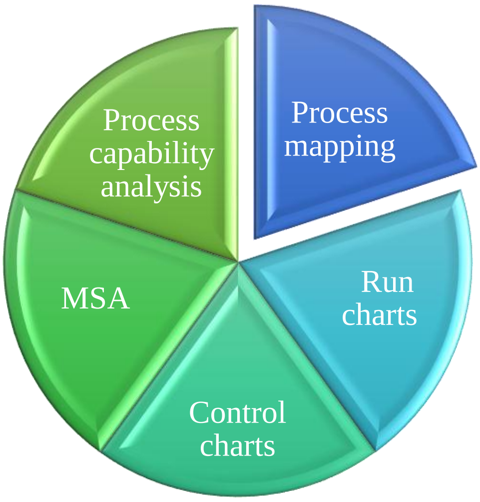



***Figure 8: Tools used in the measure phase***

- ***Analyze phase:***

The analyze step aims to identify, root causes and confirm them with data. The following points are recommended:

- *Analyze the process flow:* Understand the bottlenecks in the process, assess the value-added and non-value-added activities in the process from a customer's perspective, analyze the CTQs, understand the key drivers of CTQs, etc.
- *Verify significant relationships between causes:* Use scatter plots or more sophisticated tools, to verify significant relationships between causes.

Recommended tools in the measure phase:

- Ichikawa diagram;
- Brainstorming;
- Process analysis;
- GEMBA investigation.

- ***Improve phase:***

The goal of the improve step is to develop, try out and implement solutions that address root causes. In this phase, one may generate potential solutions, select and prioritize solutions, perform risk assessment, pilot the solution for its effectiveness and finally evaluate the benefits. This phase not only involves deriving solutions for the problem at hand but also using the plan-do-check-act (PDCA) cycle to evaluate and improve the solutions we want to implement.
The following points must be taken into account in the improve phase of the project:

- Evaluate and optimize the possible best solution;
- Implement pilot solution;

- Compare before and after scenarios.

Recommended tools in the *improve* phase include:

- Process capability analysis;
- Comparison study between before and after the implementation.

- ***Control phase:***

This final step aims to sustain the gains, by standardizing the work methods or processes, anticipating future improvements and capturing and documenting the key lessons learned from the project and exploring the opportunities of transferring the knowledge to other operations in the business. In this phase, one should document standard operating procedures, develop process control plans, create project storyboard and transit process ownership.

Recommended tools in the control phase:

- Recommendation;
- Standard the solutions;
- Perspectives : training for doctors, nurses and technical staff;
- Simulation.

## III- Lean management :

### 1- Historical development of Lean management:

The birth of lean was in Japan within Toyota in the 1940s: The Toyota Production System was based around the desire to produce in a continuous flow which did not rely on long production runs to be efficient. Taiichi Ohno had started work on the Toyota Production system in the 1940s and continued its development into the late 1980s unhindered by the advancements in computers which had allowed mass production to be further ‘enhanced’ by MRP Systems.

Ohno (1988) appointed that the fundamental goal of the Toyota production system is to eliminate waste; this is achieved by quality control and quality assurance. He emphasized the production of only the required type of units at the required time and in the required quantities. This enabled Toyota to become market leader in the worldwide automotive industry.

The term Lean manufacturing was coined in the 1990s when James Womack et al. (1990) wrote a book titled *The Machine That Changed the World* by This book combined production methods practiced in the US, Europe and Japan and referred to in the publication as ‘Lean manufacturing’.

Liker and Wu (2000) defined ‘Lean’ as ‘a philosophy of manufacturing that is based on developing the highest-quality products with lowest cost and delivered on time’.

Lean production techniques facilitate improvements in efficiency, response speed and production flexibility, which are realized by industrial enterprises such as Toyota.

## 2- Overview of Lean management:

### 2.1 About Lean approach:

The future of the company depends on its ability to keep customers and win new ones because they are the only source of earnings for the business. The company must therefore consider the requirements of its customers regarding to quality, time and costs.

The Lean Concept, which aims to increase profit by satisfying customer, uses these basic definitions of "added value" and "waste". (Lesure – zajkowska, 2004 a).

"Added value" represents the value of the good or service perceived by the customer. It's because the product exactly meets his needs that the customer agrees to pay the price claimed. Non-value-added activities increase costs without any added value for the customer: production, stock, transportation and capital costs.

According to the Toyota production system (TPS), wastes are classified into three different forms:

a) 'Mura' or waste due to variation;
b) 'Muri' or waste due to overburden;
c) 'Muda' also known as waste.

'Muda' are classified into two categories:

1- Type 1 Muda: includes operations that engage resources without creating added value. (Blaik, 1996; Hines et Taylor, 2000; Kot, 2001). The customer requires a product with maximum value for low cost.
2- Type 2 Muda: activities (waste) that do not add value but are necessary for the system or process to function properly. This type of waste can be minimized but not necessarily eliminated completely.

We can't talk about Lean technique without mentioning its several common metrics:

***Lean Common metrics***

- ***Waste*** : Waste implies an activity for which the customer is not willing to pay, it's an entity that consumes resources or time but does not enhance product value.
- ***Value***: Toyota's management principals define value as the quality of a product or service as defined by customers. On the other hand, in customers view, value governs the transformation of a product or service and creates willingness to pay. Womack and Jones affirmed that value is meaningful only when expressed in terms of a specific product, and that it is the critical initiation for Lean thinking.
- ***Flow:*** the movement of raw materials or information.
- ***Creating value****:* Lean principles emphasize value creation by specifying value from the customer's viewpoint, designing the product which can fulfil all issues desired by the customer, determining a value stream by mapping the processes, improving the value stream by enhancing its process capability.
- ***Value stream***: describes the sequence of the process from start to finish where the cost is incurred or value gets created. And it indicates all the activities required to develop a product or service.
- ***Value flow****:* Refers to the products produced or services delivered using the value stream based on customer requirements. The flow across the value stream must be smooth without any bottlenecks. The prevalence of bottlenecks in the value stream indicates the presence of waste and requires its removal. A smooth flow can be ensured with the involvement of all personnel associated with the process.

## *2.2 Key principles of Lean management:*

Lack of understanding of Lean manufacturing key principles will end in failure due to lack of commitment. Without commitment, the process becomes ineffective. There are f*ive principles of Lean manufacturing:*

- *Specify the value of the product/service:*

Customer value implies the difference between the values that the customer benefits from by using a product and the cost of obtaining the product. Value denotes customer willingness to pay and its attached cost. The best price does not imply the lowest price but rather the best integration of quantity, quality and delivery. To determine the product value, the process sequence from beginning to end needs to be analyzed.

- *Identify the value Stream:*

It is a sequence of activities needed to design, manufacture and develop a specific good or service, along which information, materials and worth flows. Value stream denotes product manufacture from the generation of an order until the product is delivered to the customer. It implies all essential steps to develop a product or service to the customer from start to end.

The process in value stream needs to be classified into:

- Value added activities : adding value to the customer;
- Non-value added activities: not adding value to the customer.
- Necessary but non-value added activities: needed for product completion.

The flow of value stream must be smooth, and obstacles in the value stream need to be eliminated.

- *Make the value flow through the processes uninterrupted or diminished:*

The value flow is the product production using value stream based on customer requirements. The company's management must ensure that there are no bottlenecks in the process and the flow of value stream is smooth. In addition, Obstacles reduce the velocity of flow, affect lead time and increase cost. They may be due to *improper layout*, *improper tooling*, *downtime*, *equipment breakdown* or *large quantity of stock*. Appropriate actions need to be effected to overcome the obstacles for flow velocity improvement.

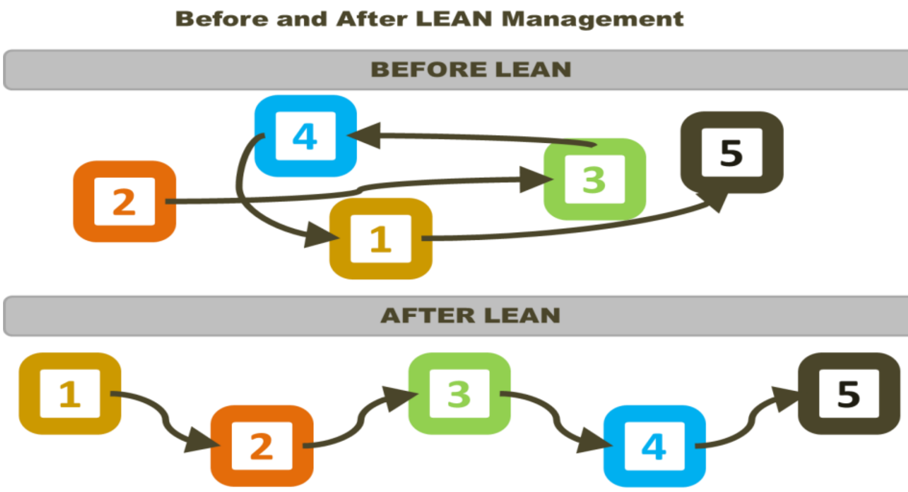



**Figure 9: Before and after application of Lean management**

- *Customer pull:*

In a push system, the product is manufactured without understanding the customer need and gets pushed to market so as to sell to the customer. While a pull system focuses on producing products purely based on customer requirement, it minimizes and eliminates inventory.

- *Continually improve and strive for perfection:*

"Continuous improvement" implies incremental improvement of products, processes or services over time, with the objective of waste reduction to improve workplace functionality, customer service or product performance. Perfection could be attained only by bringing about involvement from personnel involved in the process execution. Long-term management policy needs to be deployed for implementing Lean enterprise.

## 2.3 Wastes of lean management:

In general, there are seven forms of Lean wastes: [TIMWOOD]

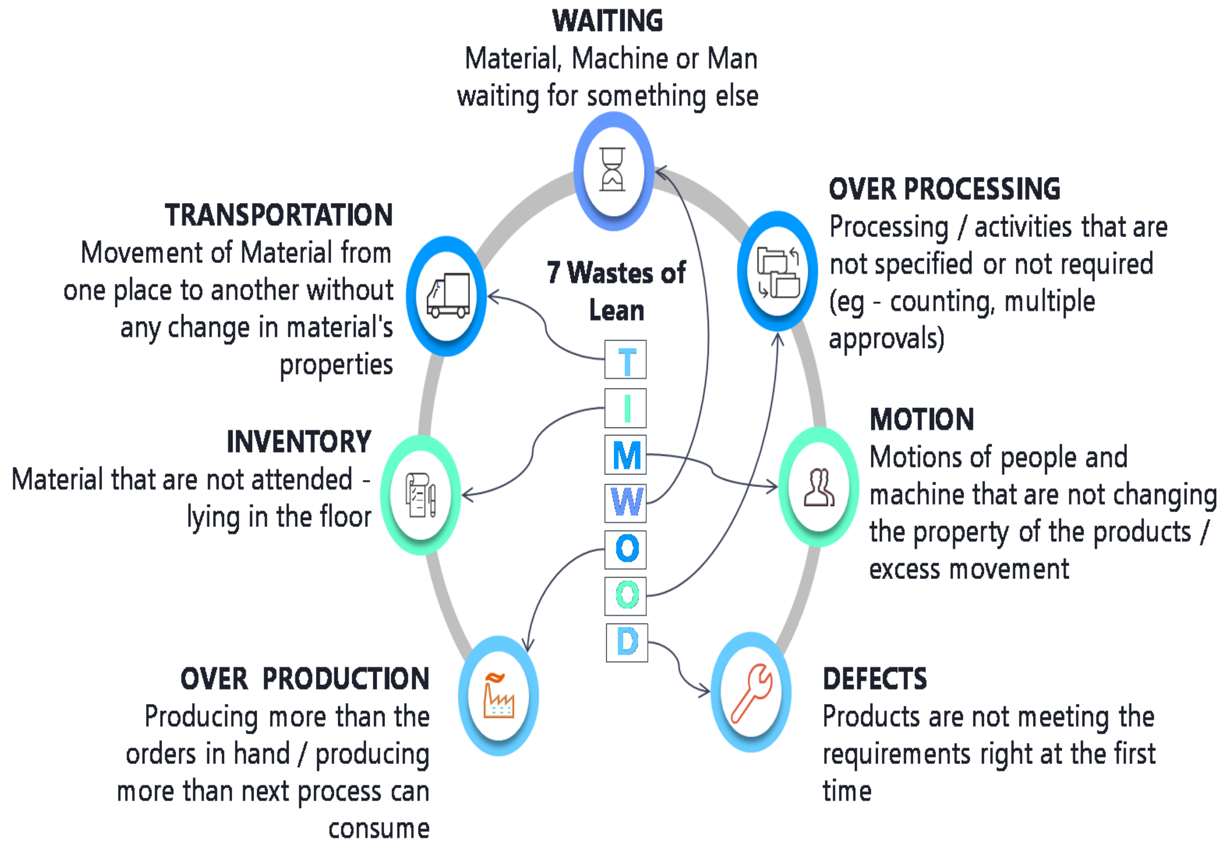



**Figure 10: the seven wastes of Lean**

## 2.4 Steps of lean:

To apply the lean approach, we should follow many steps:

***Step 1: Collect Data:***

Observe current processes and look for wastes/ non-value-added activities. Involve the people who run these processes daily.

***Step 2: Analyze Data:***

The team starts to diagnose the issues through data analysis, looks for undesirable effects, incidents which are a part of the current process but we don't want to occur.

***Step 3: Design the Change:***

A change can be designed based on the data analyses, which can eliminate waste and undesirable effects. The design will usually involve the cross functional team who have collected and analyzed the data.

***Step 4: Make the change:***

The new process is put in place with appropriate training and measures, so that the team operating the process have the ability to monitor the sustainability of the change and can make adjustments as necessary.

***Step 5: measure benefits:***

As the team running the new process, improvement can be made and a culture of continuous improvement is developed.

## ***What stops us from applying Lean?***

With the benefits so apparently obvious the question has to be—what's stopping us?

The figure bellow shows some of the drivers and resistors within the manufacturing sector of the process industries; the ultimate sustainability requires additional supporting forces to further reduce and eliminate opposition. Because it is only when the specific driving forces for an organization are greater than the opposing forces that the change will occur.

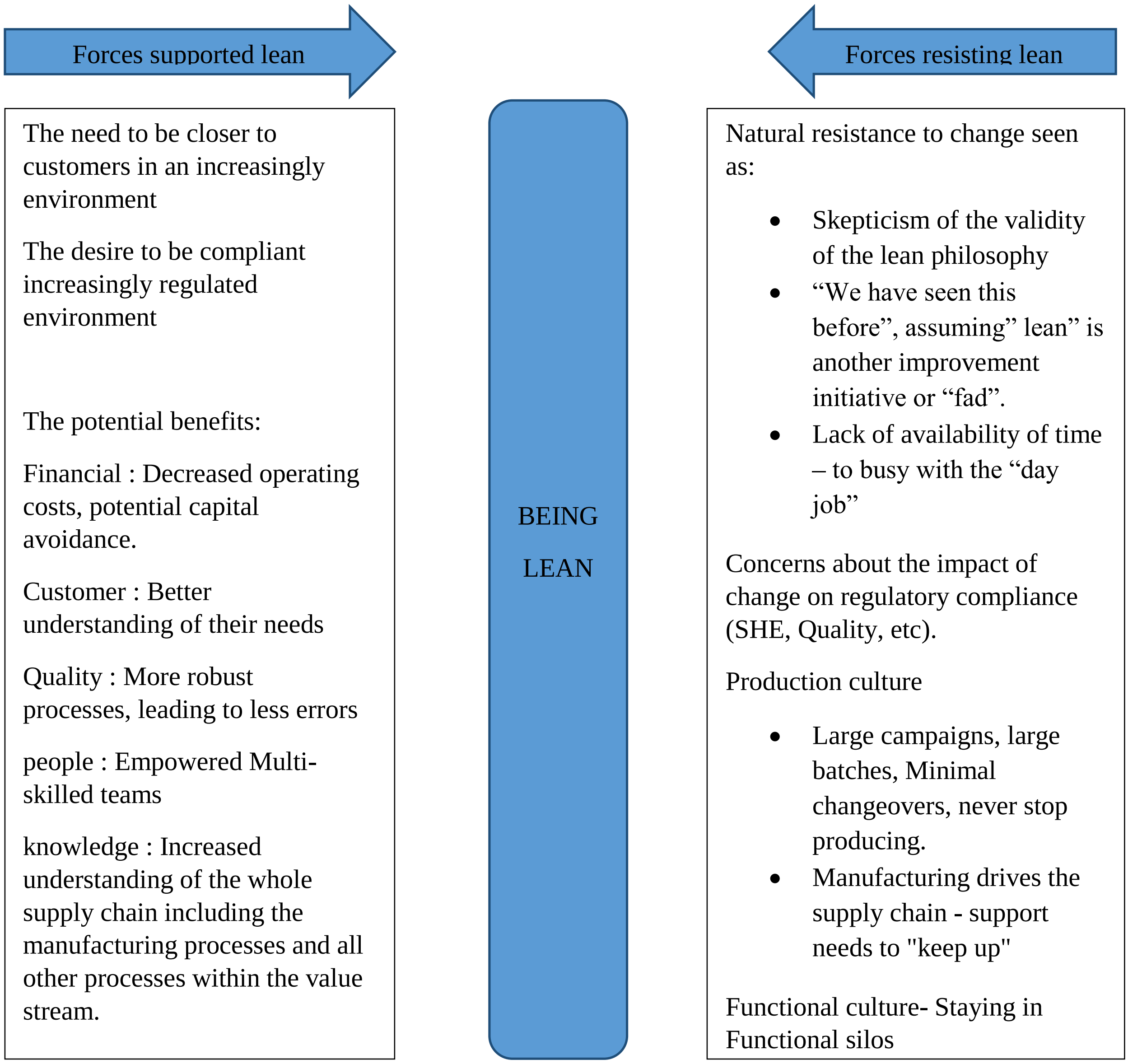



**Figure 11: The forces opposing and driving a change to ‘lean’.**

# IV- Lean Six Sigma:

## 1. Overview of lean Six Sigma:

Deploying Six Sigma in isolation cannot remove all types of waste from the business process, and deploying Lean management in isolation cannot bring a process into the state of statistical control and remove variation from the process (Corbett 2011). Therefore, some companies have decided to merge both of them to overcome the weaknesses of these two continuous improvement (CI) methodologies. The integration of these two approaches gives the organization more efficiency and effectiveness and helps to achieve superior performance faster than the implementation of each approach in isolation (Salah et al. 2010).


**Figure 12: Lean Six Sigma**

The ***first integration*** of Lean Six Sigma (LSS) were in the ***US*** by the George Group. The term LSS was ***first introduced into the literature in 2002*** as part of the evolution of Six Sigma (Timans et al. 2012).

Since that time, there has been a noticeable increase in deployment of Lean Six Sigma in industry, especially in large organisations such as Motorola, Honeywell, and many others (Timans et al. 2012; Laureani and Antony 2012) and in some small and medium sized manufacturing enterprises. (Kumar et al. 2006)

It is being widely recognized that LSS is an effective leadership development tool; it prepares leaders for their role, leading change.

## ***1.1 Why does Lean need Six Sigma?***

As robust as Lean is for dealing with lead-time and non-value-add costs, there are several critical problems you won't find addressed in the seminal books on Lean. Six Sigma provides robust solutions to these problems, which explains why Lean needs Six Sigma:

*Why Lean need Six Sigma?*

| | |
|---|---|
| *Lean doesn't explicitly prescribe the infrastructure needed to achieve results.* | Companies that only apply Lean are sometimes *unable* to deploy it across the whole organization and sustain results because they lack the well-defined Six Sigma cultural infrastructure to generate senior management engagement, formalize training…<br>Thus, the progress of Lean has been dependent on individual initiative. Many successful Lean implementations regress when a new manager takes over. |
| *Customer Critical-to-Quality needs are not front and center.* | The person creating the value stream map makes the decision as to whether an activity is value-add or not. In contrast, Six Sigma prescribes numerous places in improvement methods where the voices of customers and suppliers must be included.<br>Simply put, the customer is not front and center in Lean, yet is ever-present in Six Sigma work. |
| *Lean does not recognize the impact of variation* | Lean does not possess the tools to reduce variation and bring a process under statistical control. The speed and cost gains of Lean can |

| | |
|---|---|
| | be erased instantly by an increase in variation. Variation in the demand for an offering and variation in the time it takes to perform an activity that creates that offering both have a major impact on process lead-time, which Lean does not directly address. |

***Table 5: Why Lean need Six Sigma?***

Most descriptions of Lean methodologies dive into the Improve phase (in DMAIC terminology), going right to solutions and jumping over Define and Measure. Without a prescribed Define step to understand how big the problem is; and a Measure phase to quantify the size versus the resources.

## 1.2 Why does Six Sigma need Lean?

As many companies have demonstrated, you can make a lot of gains with Six Sigma. However, no matter what tool you pick, if you don't have a Lean component to it, if you're not focusing on improving speed any gains will eventually die. Here are four reasons why Six Sigma benefits from Lean:

*Identifying waste:*

Though process mapping is a Six Sigma tool, it doesn't prescribe the collection of data necessary to quantify which steps of which process contribute the most non-value-add work/costs to the service or product. Lean provides the powerful value stream map tool, which crosses functional silos and highlights waste and delays.

Six Sigma rarely gets into a discussion of classifying activities as value-added or non-value-added, nor is elimination of non-value-add activities a central principle of Six Sigma.

*Improving process speed or cycle time:*

Improvement in cycle time and responsiveness is often claimed as a result of Six Sigma. Six Sigma experts (and their books), however, do not make either a practical or theoretical link between quality and speed.

There are many speed-acceleration lean tools (Total Productive Maintenance, time value analysis, 5S, etc.) that have been developed and refined over decades of experience. To ignore them is to risk limiting the performance of your processes.

*Methods for rapid action (the Kaizen DMAIC process):*

Lean methodologies include a rapid improvement method called Kaizens, which are short, intensive projects where a group of people with relevant knowledge are isolated for four or five days and apply structured improvement methods on a targeted process or activity.

Kaizens have a real role to play in service environments, having a time-compressed, action-oriented improvement method in your arsenal provides a good accelerator of DMAIC projects.

*Six Sigma quality is approached much faster if Lean eliminates non value-add steps.*

## 2. Implementation of lean Six Sigma:

### 2.1 Benefits of Lean Six sigma :

Here are some of the benefits of using Lean Six Sigma:

- Reduced operational cost;
- Reduced cycle time;
- Reduced defects in processes;
- Reduced machine breakdown time;
- Reduced inventory;
- Increased profits and financial savings ;
- Increased customer satisfaction;
- Improved key performance metrics;
- Improved quality;
- Increased production capacity;
- Increased employee morale towards creative thinking;
- Reduction in workplace accidents as a result of housekeeping procedures.

### 2.2 Challenges of Lean Six Sigma:

Here are a few common roadblocks in successfully implementing LSS in an organization, and how:

- *Lack of understanding of Lean Six Sigma methodology*: the first challenge that we may face while implementing Lean Six Sigma is lack of understanding of the methodology, and a lack of belief that it will work. Successful projects silence the doubters, increase the self-confidence of the proponents of the approach and justify the leap of faith (Snee 2010).
- The first source of resistance experienced by many organizations is *the fear of change*, which can be part of an organization's culture that may not be readily visible.
- *Failure to recognize the need for change*: is another challenge, some contend that the current acquisition process is not broke; therefore, 'if it isn't broke, don't fix it!' Some may see LSS as just another passing 'quality management fad' that only serves to interfere with the traditional organizational culture and ways of doing things.

| ***Lean Six Sigma Challenges*** | ***% Selected*** |
|---|---|
| Significant Culture change required | 68 % |
| Data collection challenges | 44 % |
| Resistance from knowldege workers and middle management | 28 % |
| Continued commitment from Top management after initial stage | 26 % |

| | |
|---|---|
| Sustained Companywide training and certification program | 20% |
| Cost of training and certification program | 20% |
| Excessive time spent "Scrubbing data" | 19% |

**Table 6: Lean Six Sigma challenges**

To eliminate them we propose the following tasks:

Establish process ownership and make sure that people are accountable for their own processes across the business.

Make sure that employees are provided with the necessary tools for process improvement so that they can continuously improve their processes.

## 3. Lean Six Sigma toolbox:

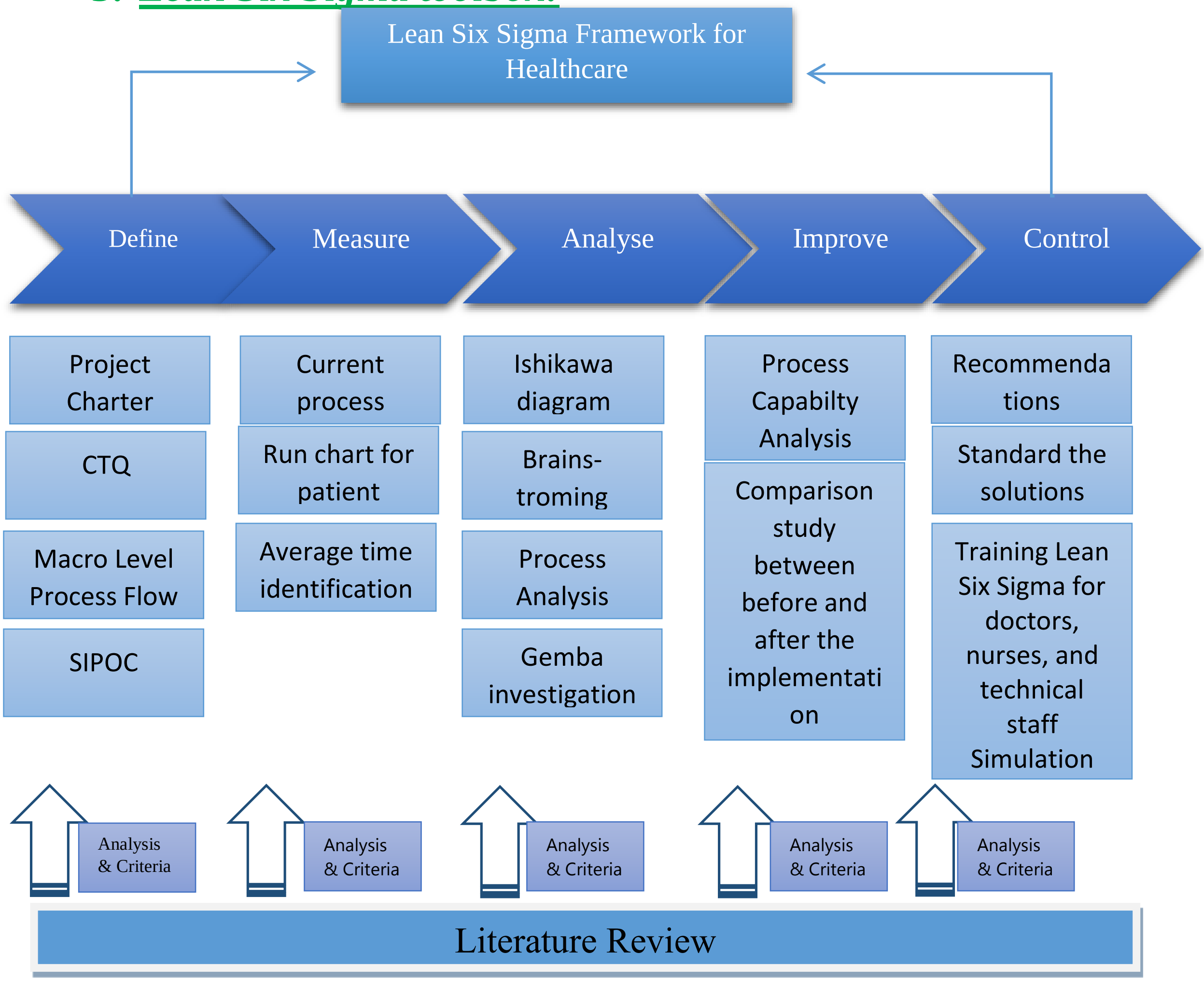



*Figure 13: Lean Six Sigma Toolbox*

### 3.1 Toolbox:

#### 3.1.1 Project charter:

The project charter is a "document issued by the project initiator or sponsor", it includes most elements of a preliminary project scope statement, which describes what is and what is not included in the project. It also helps to control changes to the scope of the project throughout its duration or life cycle.

It allows all parties involved reaching agreement and document major aspects of the project such as the objectives, the scope, the deliverables, and the resources required. The charter supports the decision-making process and is also often used as a communication tool.

## ☙ *How to make a Project charter?*

The following steps can be used in the development of a project charter:

**Step 1:** •Define the business case. Why is the project important, and why now?

**Step 2:** •Define the problem statement. Quantify the problem and its impact on the business and its customers.

**Step 3:** •Define the project scope. What are the boundaries of the project, what is in scope, and what is outof scope?

**Step 4:** • Define the goal(s) of the project. What are the tangible performance improvements that the team has as a target?

**Step 5:** •Define the roles and responsibilities of each team member of the project.

**Step 6:** •Define the key deliverables of the project along with the milestones.

**Step 7:** •Review the project charter with the project champion and gain approval. If any changes are required, it is essential to make changes and get them approved by the champion.

**Figure 14: steps of the Project Charter**

PROJECT CHARTER

| | | | |
|---|---|---|---|
| **PROJECT TITLE:** | | | **Date:** |
| **PROJECT DESCRIPTION** ( history, goal, purpose, scope, assumptions, time frame, priorities, costs ) | | | |
| **BENEFIT AND EXPECTED EFFECT (Key Deliverables):** | | | |
| **ASSUMPTIONS, RISKS AND RISK MITIGATION PLAN:** | | | |
| **STAKEHOLDERS** | | | |
| CHANGE SPONSOR: | | | |
| TARGET AUDIENCE: | | | |
| **PROJECT TEAM MEMBERS:** | | | |
| **KEY EVENTS / MILESTONES:** | | | |
| START DATE: | | FINISH DATE: | |
| IS PROJECT PLAN CREATED? | IF NOT; WHEN WILL BE CREATED? | | |
| **RESOURCES REQUIRED:** | | | |
| OPERATING BUDGET: | | | |
| CAPITAL BUDGET: | | | |
| External costs ( consulting, licenses, etc. ) | Internal expenses ( equipment, installation, training, etc. ) | Materials ( supplies, facilities ) | |
| **Approval/ Review** | | | |
| **Role** | **Name** | **Date** | **Signature** |
| Project Leader | | | |
| Team Members | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| Change Sponsor | | | |
| Change Facilitator | | | |

***Figure 15: Example of a Project Charter***

### 3.1.2 Critical to Quality:

The CTQ (Critical To Quality) concept is an essential part of LSS projects. CTQ characteristics are developed in order to fulfil the needs of valuable customers. The customer is typically the one who dictates the output specifications, in other words, the more that is known about the customer's needs, wants, and expectations, the more precise and accurate the project requirements will be to satisfy them.

This means that the more that is known about the customer's needs, wants, and expectations, the more the project can be aligned to satisfy the CTQ requirements as well as focus on variable measurements for evaluating success.

CTQs analyze the characteristics of the service or product that are termed by both the internal and external customer. A CTQ tree reflects what the customers of your process cite as absolutely essential to success, this helps clarify what constitutes a defect in the process, moving from general needs to more specific ones. Which enable us to focus on certain quality characteristics that are critical to our customers, especially when they are broad, vague and complex.

To construct a CTQ tree we can follow the following steps:

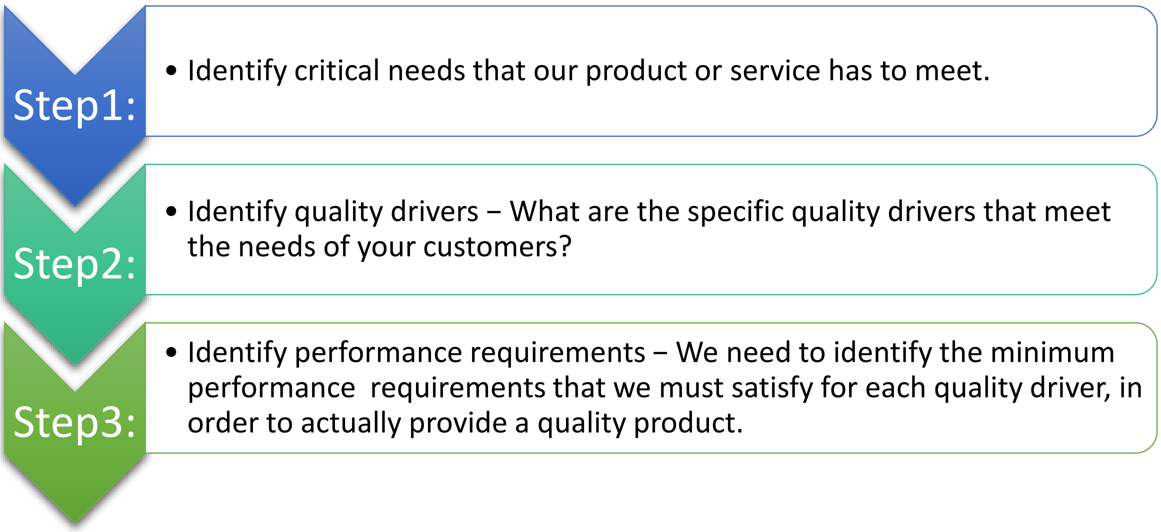



**Figure 16: how to make CTQ tree**

Example of CTQ tree:

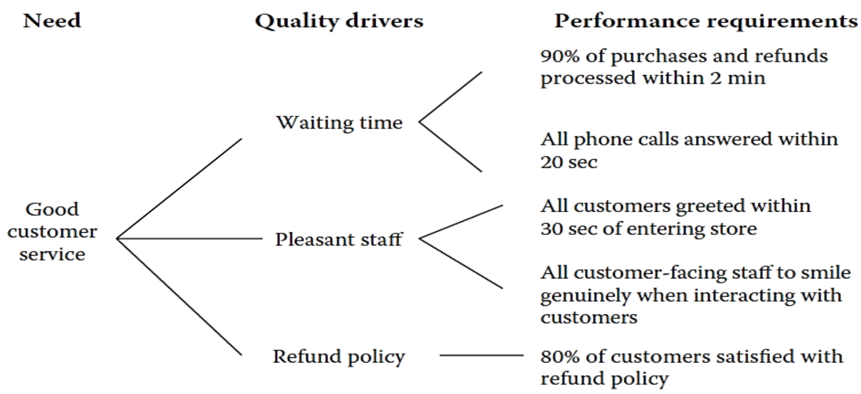



**Figure 17: Example of a CTQ tree**

### 3.1.3 Process Flow chart:

The Process Flow chart provides a visual representation of the steps in a process. They are also referred to as Flow Diagrams. Constructing a flow chart is often one of the first activities of a process improvement effort, because of the following benefits:

- Gives everyone a clear understanding of the process;
- Helps to identify non-value-added operations;
- Facilitates teamwork and communication;
- Keeps everyone on the same page.

There are many symbols used to construct a flow chart; the more common symbols are shown below:

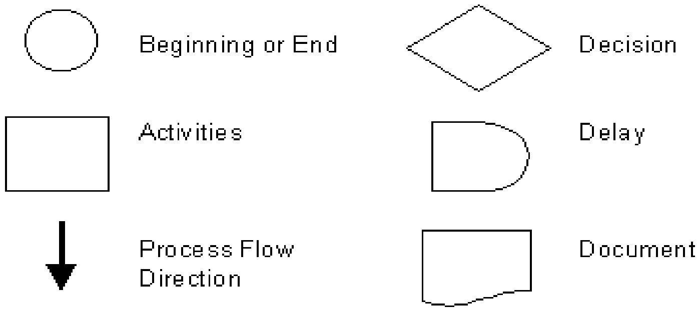



***Figure 18: Symbols used in a Flow chart***

We can make a flowchart more useful by adding information beside the boxes, like it's shown at the following example:

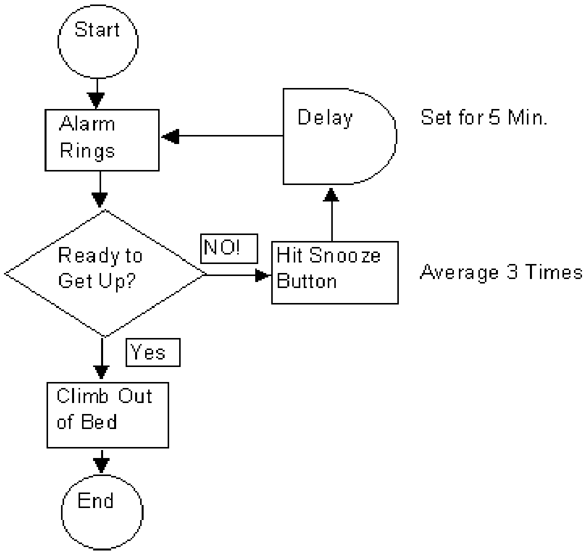



***Figure 19: Example of a Flow chart***

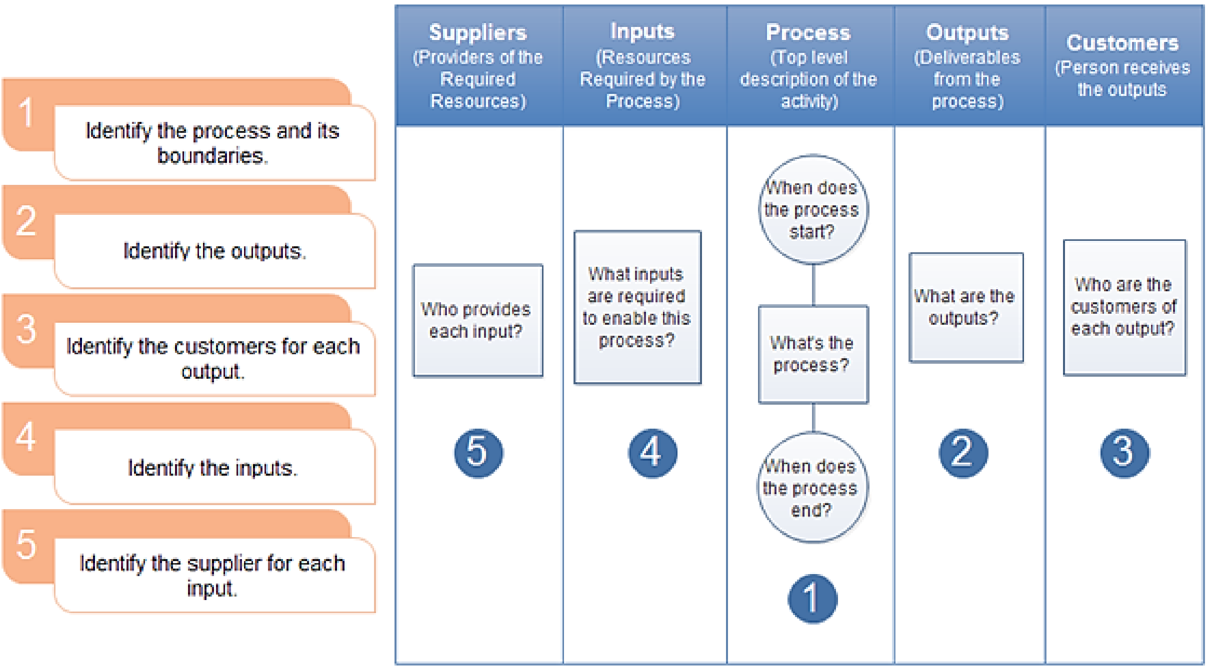
### 3.1.4 SIPOC:

SIPOC is a process improvement tool that provides a key summary of the inputs and outputs of one or many processes in tabular form. The word SIPOC is indeed an abbreviation that refers to suppliers, inputs, processes, outputs and customers, which represent the columns of the table. It is a vital tool for documenting a business process from start to end, in fact it was widely used in Six Sigma, Lean

manufacturing, and other business process improvement strategies. SIPOC is used in the define phase of the define-measure-analyse-improve-control (DMAIC).
We use a SIPOC diagram to:

- Define the scope of the project.
- Obtain a high-level understanding of a process during the initiation of a process improvement activity. It helps the process owner and and those related to the process to arrive at a consensus on process boundaries.

Steps of creating the SIPOC:




***<u>Figure 20: Steps Of SIPOC</u>***

An example of SIPOC table:

| **Purpose: Productivity Improvement**<br>**Owner:** | | | | |
|---|---|---|---|---|
| **Supplier** | **Inputs** | **Process** | **Output** | **Customer** |
| ABC castings | Motor body | Motor body machining ↓ | Submersible pump | MN Pumps<br>Southern Pumps |
| Hi-tech enamels and PVCs | Windings | Winding ↓ | | |
| PQR bearings | Impeller | Motor assembly ↓ | | |
| Cast tech | Casing | | | |
| Bright plastics and polymers | Fan and blower | Pump assembly ↓ | | |
| XYZ switches and electricals | Starter | Testing and inspection | | |
| | Bolts and nuts | | | |

***<u>Figure 21: Example of SIPOC diagram</u>***

## ***Conclusion:***

As we can see, lean six sigma is a very powerful tool for improving the process, used in different fields and for several years. . But before starting the integration, is there a tool - whose steps are similar - that could complement lean six sigma?

# *Chapter III:*
# *Introduction to Design thinking*

## Introduction:

One other useful tool that helps to find the main problems and that may help us find a solution is Design thinking.

Design thinking is a design methodology that provides a solution-based approach to solving problems. It's extremely useful in tackling complex problems that are ill-defined or unknown, by understanding the human needs involved, by reframing the problem in human centric ways, by creating many ideas in brainstorming sessions, and by adopting a hands-on approach in prototyping and testing.

### 1- Overview of Design thinking:

In his 1969 seminal text of design thinking methods, "*The Science of The Artificial*", Nobel Prize laureate Herbet Simon outlined one of the first formal models of Design Thinking process. Simon's model consists of seven major stages, and was largely influential in shaping some of the most widely used Design thinking process models today, and while they may have different numbers of stages ranging from three to seven, they are all based upon the same principles featured in Simon's 1969 model.

We will focus on the five-stage model proposed by the Hasso-Plattner Institute of Design at Stanford (d.school). The d.school is the leading university when it comes to teaching Design thinking.

### 2- Stages of Design thinking:

Understanding the following five stages of Design thinking will empower anyone to apply the methodology in order to solve complex problems that occur around us – In our companies, our countries, and even our planet.

The 5 stages of the methodology according to d.school, are as follow: Empathize, Define (the problem), Ideate, Prototype, and Test. Let's make a closer look at the five different stages of design thinking.

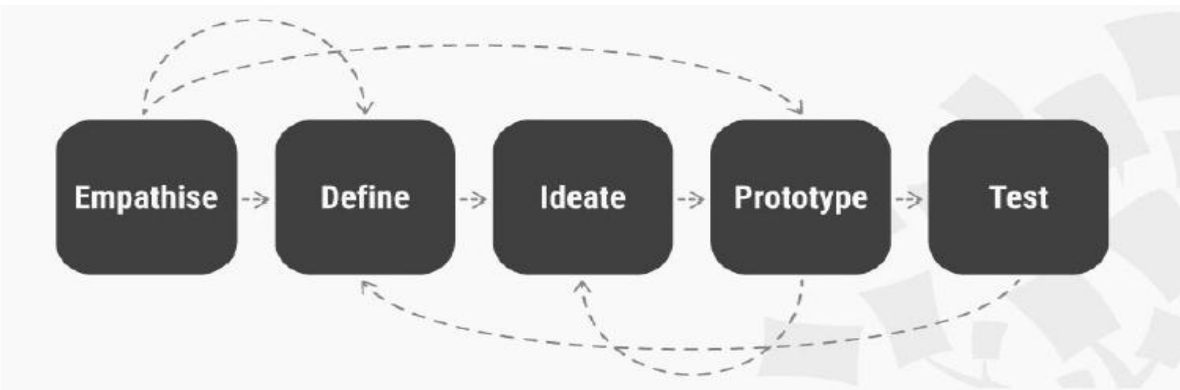



***Figure 22: 5 stages of Design thinking process***

#### a) Empathize:

The first step of the Design thinking process is to gain an empathic understanding of the problem you are trying to solve. This involves consulting experts to find

out more about the area of concern through observing, engaging, and empathizing with people to understand their experiences and motivations.
A substantial amount of information is gathered at this stage to use during the next stage and to develop the best possible understanding of the users, their needs, and the problems that underlie the development of that particular product.
For this first phase, we are going to use the "Empathy map".

### ◌ *Empathy map:*

It's a tool developed by visual thinking company XPLANE. This tool, which we also like to call the "really simple customer profiler," helps you go beyond a customer's demographic characteristics and develop a better understanding of environment, behavior, concerns, and aspirations. Ultimately, it allows you to better understand what a customer is truly willing to pay for.

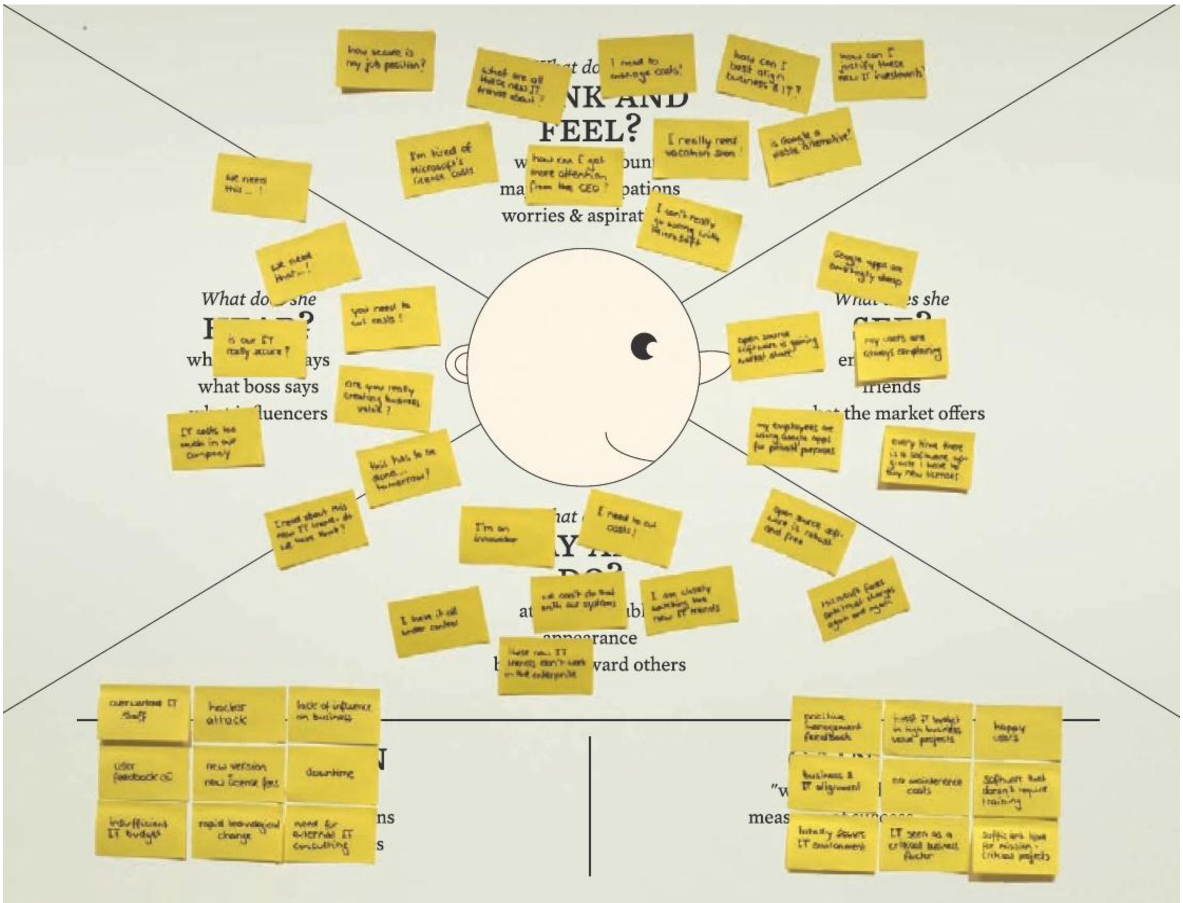


***Figure 23: Example of Empathy map***

We should answer the following questions about customers:

- What do they think and feel?

- What do they see?
- What do they hear?
- What do they say and do?
- Pain.
- Gain.

### b) Define:

During the define phase, you put together the information you have created and gathered during the Empathize stage. You will analyze your observations and synthesize them in order to define the core problems that you and your team have identified up to this point. You should seek to define the problem as a problem statement in a human-centered manner.

The Define stage will help the designers in your team gather great ideas to establish features, functions, and any other elements that will allow them to solve the problems or, at the very least, allow users to resolve issues themselves with the minimum of difficulty.

For this phase, we will need to use the tools:

#### ☙ Customer Profile :

The Customer (Segment) Profile describes a specific customer, in a more structured and detailed way. It breaks the customer down into its jobs, pains, and gains.

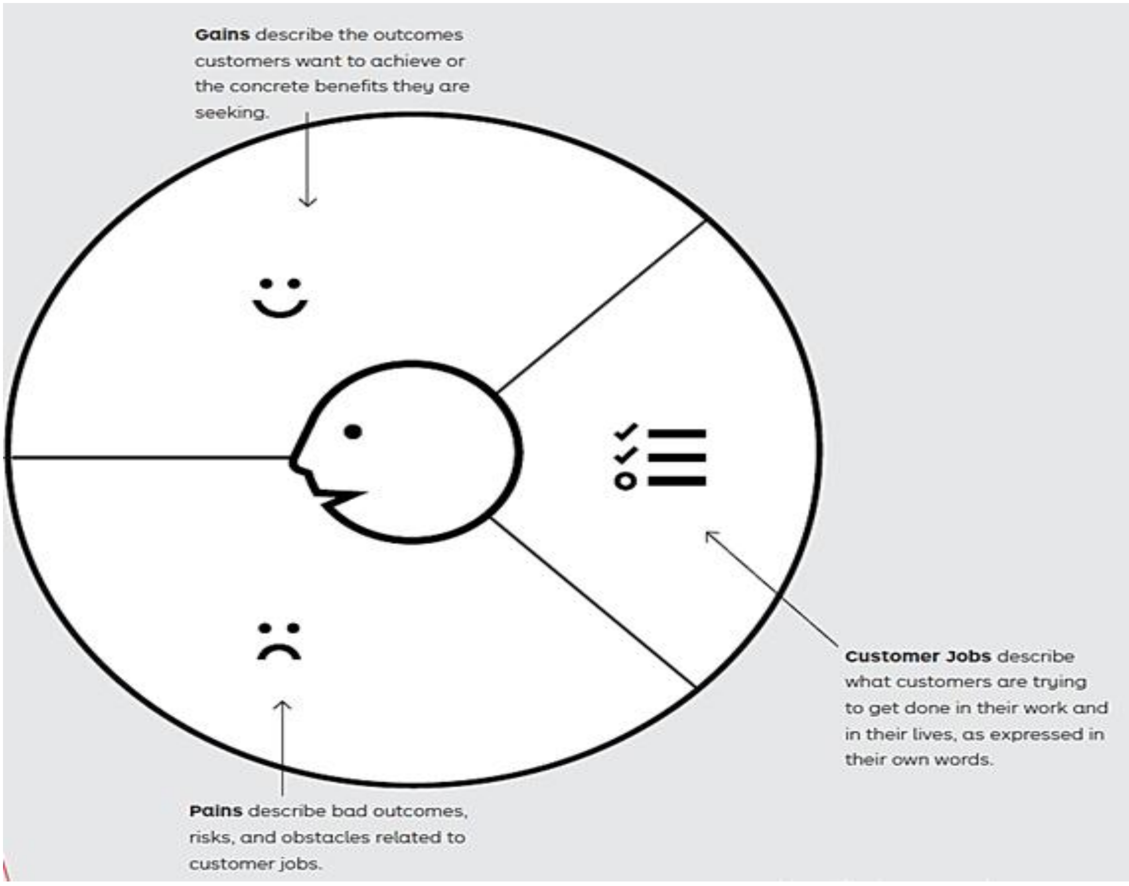



*Figure 24: Customer Profile Canvas*

## ☙ Value Map :

The value map is in general as follow:

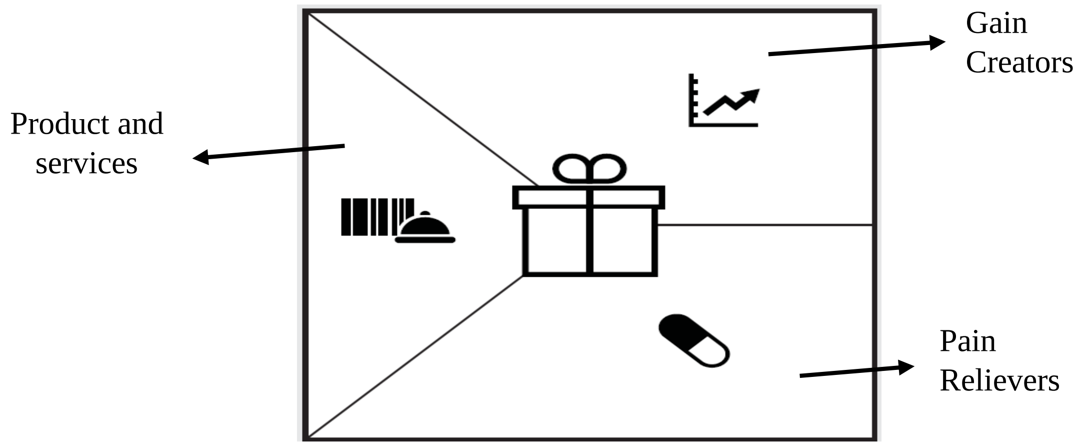



***Figure 25: Value Map***

### c) Ideate:

During the third stage of the design thinking process, designers are ready to start generating ideas. There are hundreds of ideation techniques such as Brainstorm, brain write, Worst Possible Idea, and SCAMPER. It is important to get as many ideas or problem solutions as possible at the beginning of the ideation phase. We should pick some other ideation techniques by the end of the ideation phase to help us investigate and test our ideas to find the best way to either solve a problem, or provide the elements required to circumvent the problem.

### d) Prototype:

This is an experimental phase, and the aim is to identify the best solution for each of the problems identified during the first three stages. The solutions are implemented within the prototype and, one by one, they are investigated and either accepted, improved and re-examined, or rejected on the basis of the users 'experiences.

### e) Test:

This is the final stage of the 5 stage-model, but in an iterative process, the results generated during the testing phase are often used to redefine one or more problems and inform the understanding of the users, the conditions of use, how people think, behave, and feel, and to empathize.

## 3- The Non-Linear Nature of Design Thinking:

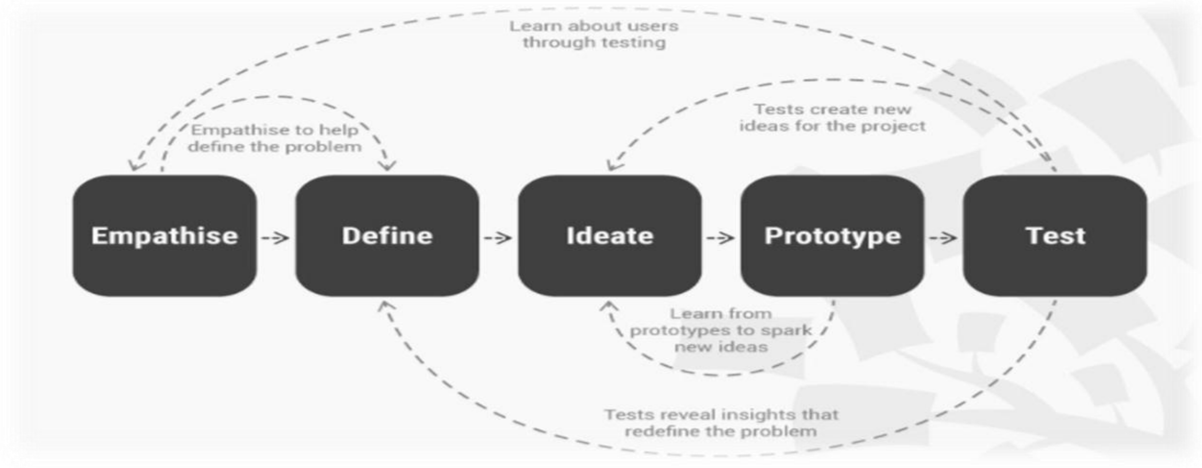



***Figure 26: Design thinking is a Non-linear methodology***

The 5 stages are not always sequential, they don't have to follow any specific order and they can often occur in parallel and be repeated iteratively.

As you will note from the image above, one of the main benefits of the five-stage model is the way in which knowledge acquired at the later stages can feedback to earlier stages. Information is continually used to both inform the understanding of the problem and solution spaces, and to redefine the problem(s).

## Conclusion:

The question is: can lean six sigma and design thinking be used in the healthcare industry? If so, is such a study done before? And what are the benefits of such an application?

# *Chapter IV:*
# *Research methodology*

## *Introduction:*

Initially, healthcare institutions will constantly have numerous priorities to deal with. One of them is to provide high quality care in the most economic manner. Quality in healthcare can have different interpretations, as it extends from service satisfaction up to the clinical outcome of the patients treatment. Hence, the medical treatment should be both safe and effective.

While other traditional quality initiatives, like TQM (Total Quality Management) or CQI (Continuous Quality Improvement) involve the use of statistics and data collection to measure and improve quality, aiming only on simpler operational issues, Six Sigma has proven to be a customer-focused, data driven and robust methodology to improve process and reduce costs.

## *I- Lean Six Sigma:*

### *1. Lean Six Sigma in healthcare:*

The concept of Lean Six Sigma quality policy is increasingly being used in the healthcare industry in order to re-design and re-define patient care processes, correct reporting errors, as well as eliminate defects and variations in processes that can be fatal. In healthcare environments, a defect is defined as a factor that leads to patient dissatisfaction. Examples of defects may range from long waiting lists to incorrect diagnosis or treatment.

Furthermore, Lean Six Sigma is the perfect quality assurance program for the healthcare industry, as it provides a comprehensive framework for in-house training and certification, while it determines a systematic organizational culture. So it will be an effective approach which facilitates a healthcare organization to offer advanced healthcare services to their patients.

Lean Six Sigma offers time and cost savings, revenue management and a set of indices that recognize patient outcomes and improve the "critical to quality" (CTQ‟s) characteristics that are vital to patients expectations. Finally, a successfully implemented Lean Six Sigma program depends on long-term vision, commitment, leadership, management and training. Providing the requisite training to doctors, nurses, administrative staff and technicians, as well as developing an awareness on Six Sigma quality policies would greatly help create a path to quality improvement.

Some examples of correct implementation of the Lean Six Sigma approach would be the patient waiting time in emergency departments, charges for billing in patient financial services, delinquent medical records, inaccurate diagnostic outcomes, patient's length of stay, and medication errors.

### *2. Research Methodology:*

A structured approach was adopted to search the published literature regarding lean six sigma in Healthcare. It involved searches from the well-known research databases like, Emerald, Google scholar, Science direct. The literature search is limited to English language. The search years included is from 2012 to 2018.

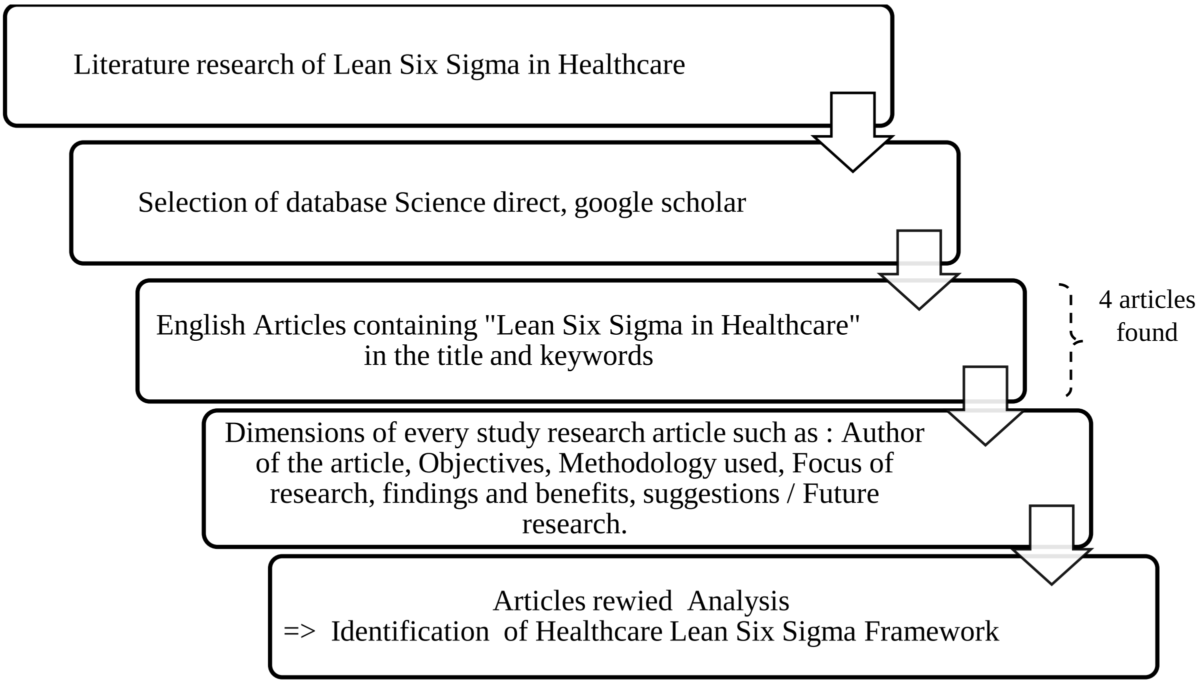



***Figure 27: Research methodology Framework***

## 3. Analysis

From the reviewed articles, we found out that few studies was interested in applying lean six sigma in Healthcare around the globe and most of them are English speaking countries (USA, UK and India) as illustrated in the table below, in order to identify the suitable Framework for our study, we put some criteria, first of all the implemented solution has to be simple with great benefits for the Healthcare organization second to choose similar study case with the nearest healthcare system used in our country.

| Article N° | Methodology used | Tools | Country |
|---|---|---|---|
| **1** | Lean | Value Stream mapping, PDCA, Pareto Analysis, Cause-Effect Diagrams, Affinity Diagrams, Five Whys, Spaghetti Diagram | Brazil |
| **2** | Lean Six Sigma | Value stream mapping | USA |
| **3** | Lean | Value stream maps, process flow, Pareto diagram, Control Charts | UK |
| **4** | Lean Six Sigma | SIPOC, Project Charter, P-value, Box-Cox transformation, Process Analysis, Cause and effect diagram, Micro level flowchart, GEMBA investigation, t-test, f-test, Box plot. | India |

***Table 7: Reviewed article analysis***

## 4. Healthcare Lean Six Sigma Framework

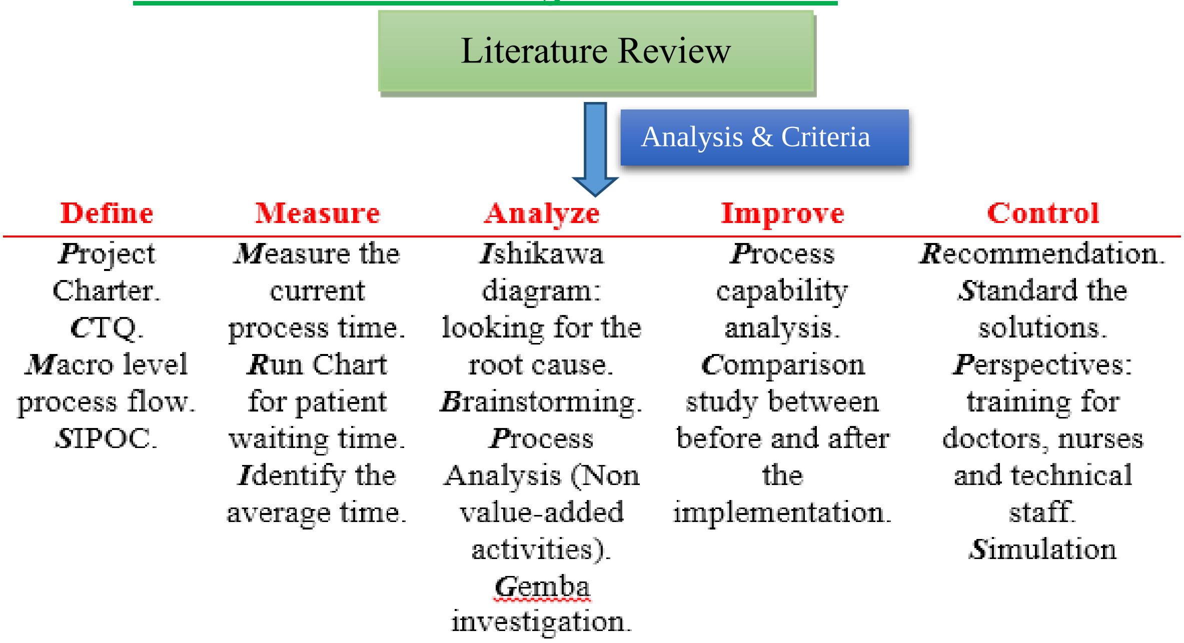



***Figure 28: Study stages***

The literature search is summarized by the state of art presented in (appendix 2).

## II- Design thinking:

As we can see, design thinking is an approach that allows us to better understand our client to know what is bothering him and what he might like in the service or product we are proposing, in order to come out with solutions that could solve our problem.

*"Design thinking has transformed the world we live in—from how we shop or how we consume to how we learn and how we live and play. It's only natural that design has a key role to play in healthcare. Applying design thinking in healthcare is now a strategic imperative."*- Josette Galiano, Co-founder and Executive Director of The Institute of Healthcare Design Thinking.

### 1- Design thinking in healthcare:

Design thinking is a human-based approach to innovation that includes different methods. It is catalyzing creativity in healthcare, challenging the delivery of care, the interactions of providers and patients, and the ways healthcare organizations understand the communities they serve.

Several large hospitals and health actors (Mayo clinic, Kaiser Permanente and GE Healthcare for example) have adopted this mode of thinking (Design thinking) to develop more effective solutions, focused on the patient.

*"By adopting the principles of design thinking, healthcare leaders, strategists, and marketers can transform their organizations to meet the demands of a new consumer-driven healthcare landscape."*- David McDonald, Co-founder of The Institute of Healthcare Design Thinking.

The field of health meets several challenges:

- The number of patients is constantly increasing;
- Many types of diseases;
- The high price of treatments;
- Technology is developing very fast in medicine.

To be at the level of these challenges the only solution is innovation which allows to:

- Have the satisfaction of the patient;
- Ensure the safety of the patient and the hospital;
- Be more focused on the disease, since we will focus on the patient.


***Figure 29: the impact of innovation on the quality of care***

## 2- How are we going to provide a more effective quality of care to patients?

To answer this question, we first point out that the role of the engineer is to guide the staff to think outside the box, and to see things from an external point of view as they have never done before! In fact the approach is the following:

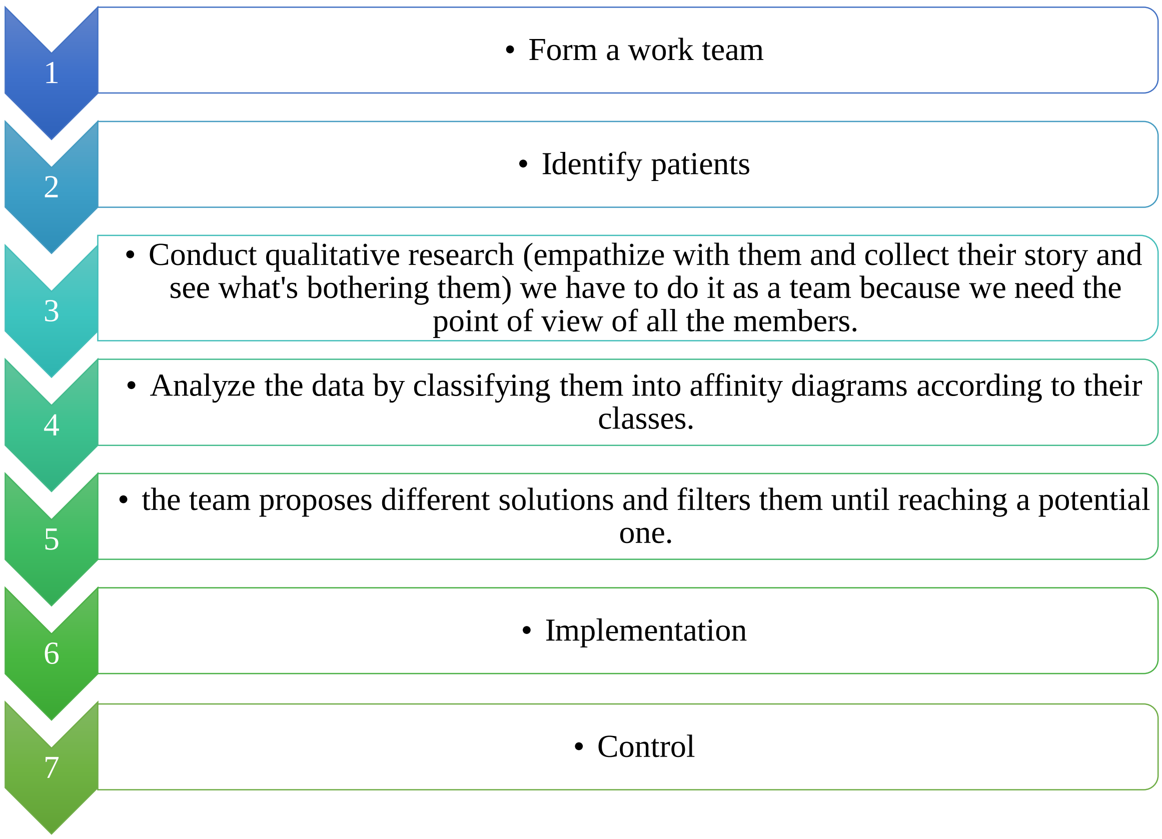



***Figure 30: Steps of design thinking in healthcare***

## 3- Comparing Lean Six Sigma and Design thinking:

| Design thinking | Lean Six Sigma |
|---|---|
| - Practitioners observe people;<br>- They watch how they behave and interact;<br>- They talk to people about how they are doing and how they are feeling;<br>- The empathize and define phases of design thinking help practitioners develop a sense of empathy | - Lean Six Sigma follows the 5 DMAIC process;<br>- The define and improve phases are similar to the define and ideate phases of design thinking;<br>- While Lean Six Sigma process empathize measurement in these phases, design thinking process add more qualitative research to create empathy for the customer. |

***Table 8: Design thinking VS Lean Six Sigma***

## *Conclusion:*

Lean six sigma has been used in the healthcare industry, its integration has given very satisfying results (reduction of waiting times, improvement of the process...). In the following chapters, we will implement the method at the CHU FEZ (Morocco) following the steps of the studies presented in state of art.

# *Chapter V:*
# *Solutions using Lean Six Sigma Methodology*

## Introduction:

The study presented in this report, as simple as it seems, is the result of several stages of the work (Literature review, abstract of reports about similar studies, measurement, analysis, proposal of solutions and control)

Several brainstorming sessions were held with the staff of the service to complete tables and charts by which the problem was dealt with.

The most important step in the entire study is the data collection, a research was conducted at the archives of the unit gathering about 300 files (years: 2015-2016-2017-2018) and subsequently eliminating those who don't verify the inclusion criteria that were proposed by the work team. After filtering, we had as a resulted 100 remaining files.

## The sample size:

Before starting work, the first thing to do is to calculate the number of patients that will be included in our project.

The sample size is given by the following expression:

$$n = \frac{\frac{Z^2 \times p(1-p)}{e^2}}{1 + (\frac{Z^2 \times p(1-p)}{e^2 N})}$$

$n$ : Sample size;

$N$: Size of the population;

$e$ : Margin of error;

$p$: estimated proportion of the population presenting the characteristic. (When unknown, we use p = 0,5)

$Z$: Z-score ;

***Confidence level***: measures the certainty that the sample reflects the population within its margin of error. The standards commonly used by researchers are 90%, 95% and 99%.

Z-score is the number of standard deviations of a given proportion from the mean. To find the right Z-score to use, consult the table below:

| Desired level of confidence | Z-score |
|---|---|
| 80% | 1,28 |
| 85% | 1,44 |
| 90% | 1,65 |
| 95% | 1,96 |
| 99% | 2,58 |

***Table 9:The Z-Score***

In our case the size of the population N = 100. Since we don't have the value of the estimated proportion of the population we consider p = 0.5. If we want to have a 95% confidence level then according to Table Z = 1.96.

Error margin at 95%≈ $^{0,28}/_{\sqrt{N}}$

So e= $\frac{0,28}{\sqrt{N}} = \frac{0,28}{\sqrt{100}} = 0,028 = 2,8\%$

$$n = \frac{\frac{1.96^2 \times 0.5(1-0.5)}{0.028^2}}{1+(\frac{1.96^2 \times 0.5(1-0.5)}{0.028^2 \times 100})} = 92,45 \approx 93$$

The study will consider a significant sample of about 93 distinct cases, at the service of visceral surgery unit B within the Chu of Fez, specifically cancer patients.

# I- Lean Six Sigma:

## 1- Define:

### 1.1. Project charter:

| Project | Using Lean Six Sigma And design thinking to improve the process quality in healthcare sector: Case study CHU Fez |
|---|---|
| **Project manager** | Mouna SQUALLI HOUSSAINI |
| **Lean Six Sigma Black belt** | Youssef SABBANI |

| *Project description* |
|---|
| Among the major problems encountered in the department of surgery unit B CHU Fez: the overcrowding of patients, which is due to long waiting times. This delay could be tolerated except for tumor patients, who despite being treated as an emergency case, wait several days to be operated. That's why we propose to focus on this type of patients, and to try to find a suitable solution to solve the problem by applying the Lean Six Sigma and design thinking methodology. |
| *Scope of the project* |
| Patients with cancer as illness. |
| ***Out of scope*** |
| All patients without cancer. |
| *Objective of the project* |
| The objective from this study is to implement Lean six sigma and design thinking Framework in CHU-Fez in order to reduce the patient curing process using the two methodologies. |
| ***Expected benefits*** |
| Time and cost minimized, quality optimized. |
| *Project's team* |

| ***Name*** | ***Function*** |
|---|---|
| Pr. Imane TOUGHRAI | Professor at FMP-Fez and surgeon at CHU Fez, visceral surgery service-B. |

| | |
|---|---|
| Pr. Ahmed ABOUTAJEDDINE | Professor at FST-Fez. |
| Mr. Youssef SABBANI | Lean Six Sigma Black belt |
| Mouna SQUALLI HOUSSAINI | student |

| *Planning:* | *DEFINE* | *MEASURE* | *ANALYZE* | *IMPROVE* | *CONTROL* |
|---|---|---|---|---|---|
| Time requested : | 3 days | 1 month 15 days | 7 days | 4 days | 1 day |

***Table 10: Planning Of DMAIC phases***

### .1 Inclusion criteria:

Patients with digestive, pancreatic hepato-biliary cancer.

### .2 Exclusion criteria:

- Non-operated cancer patients;
- Patients who executed some or all of the para-clinical examinations outside Chu-Fez;
- Patients who had preoperative procedures or treatments.

### 1.2 Critical to quality (CTQ) tree:

Once we have defined the different axes of the project, it is necessary to know what the customer wants to have as a service (patient in our case) in order to properly characterize the problems of the unit.

CTQ tree is a very useful tool that meets this need. Indeed, it highlights all the actions and benefits that the patient seeks to have during his process.

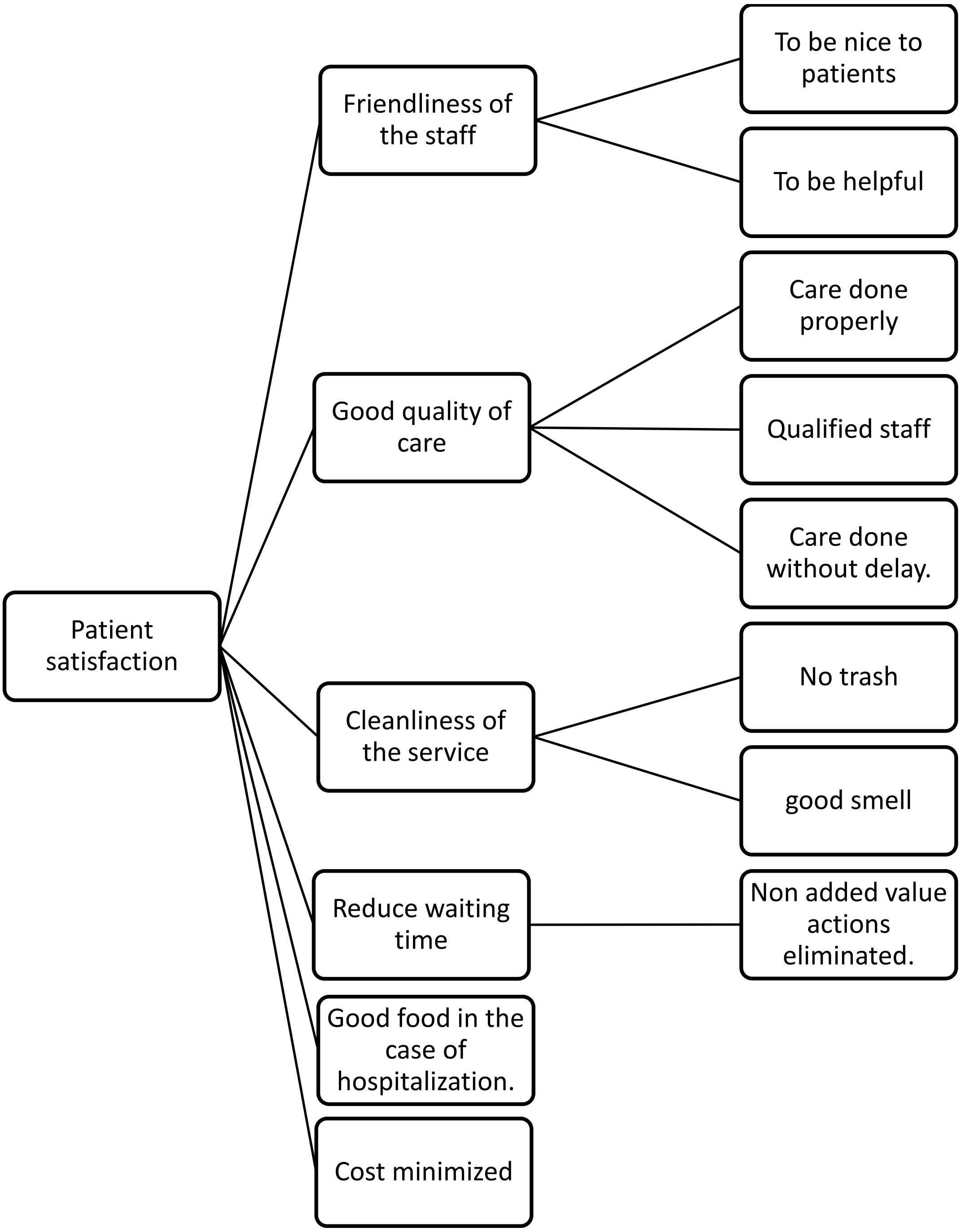



***Figure 31: CTQ Tree***

As we can see, patient satisfaction depends on several criteria. During this study we will focus on reducing the waiting time of patients, since the methodology is indeed a tool for improving the process, working on the measurable criteria only.

## 1.3 Flowchart:

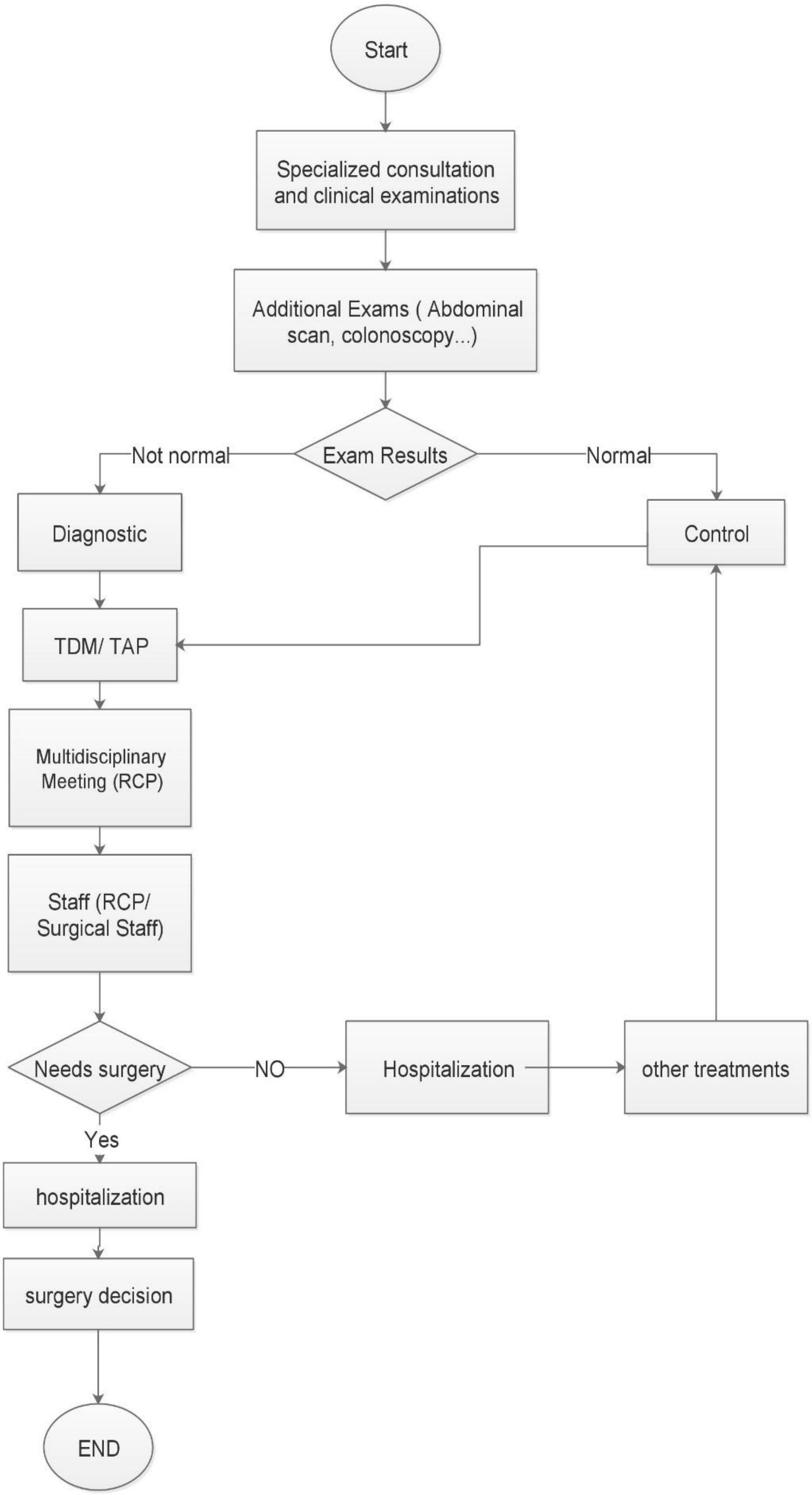



***Figure 32: Flow chart of the patient process***

### *1.4 SIPOC:*

The SIPOC diagram is very important for the definition of the problem, it gives us a vision on the details of the process (Suppliers-Inputs-Process-Output-Customer). We will consider the process we have represented for the construction of our SIPOC table.

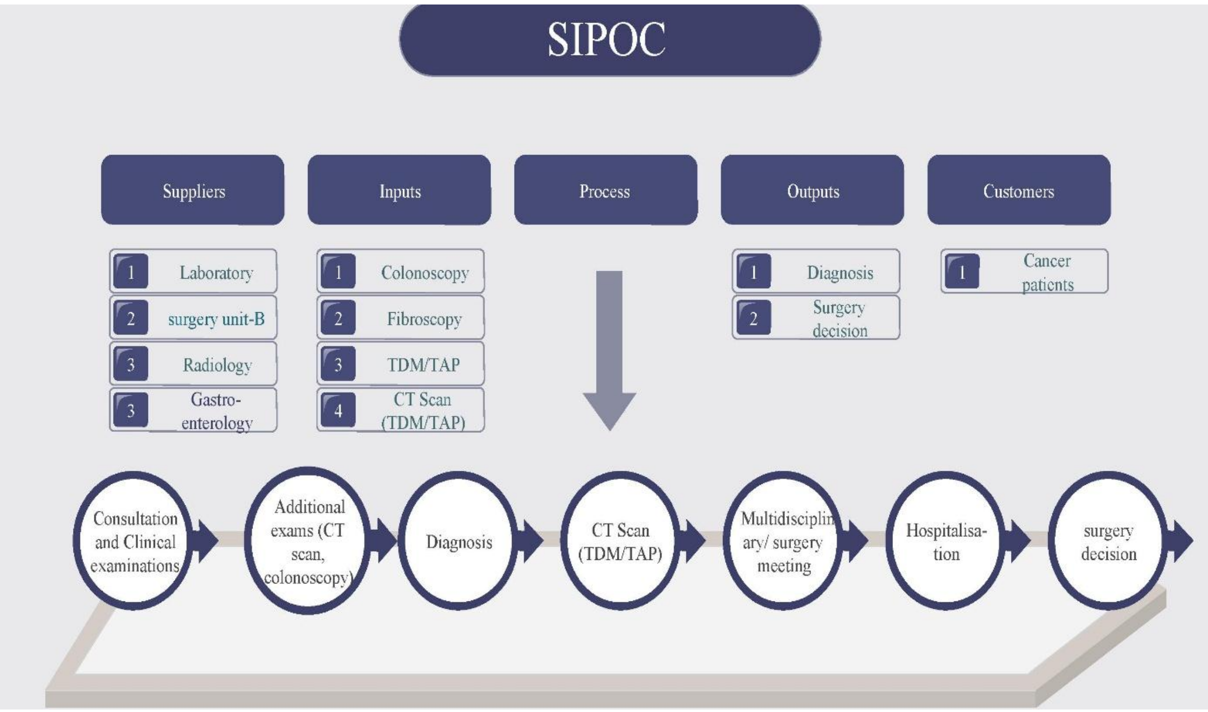



***Figure 33: SIPOC***

## 2. Measure:

### *2.1 The current process time:*

The "measure" part consists in verifying if the process studied has problems or not, and to set a goal of the project. The first step is to take dates of the main steps of the process:

- Diagnosis ;
- CT Scan (Tdm/TAP);
- Multidisciplinary / surgery meeting (RCP/ Staff);
- Surgery.

Here are some of the measures of the current process time, for more details check the Appendix 1.

| **Patient num-ber** | **Patient code** | **Diagnostic** | **Date of histological diagnosis** | **Date of CT scan (TDM/ TAP)** | **Multidisciplinary/ surgery meeting (RCP/ Staff)** | **Date of surgery.** |
|---|---|---|---|---|---|---|
| 1 | 12105147 | Tumor of the rectum. | 15/04/2015 | 29/12/2015 | 12/01/2016 | 14/01/2016 |
| 2 | 1412988 | Tumor of the liver. | 01/06/2015 | 21/07/2015 | 31/12/2015 | 13/01/2016 |
| 3 | 99791211 | Tumor of the stomach | 16/12/2015 | 22/12/2015 | 12/01/2015 | 19/01/2016 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | 12141411713 | Colon tumor | 26/12/2015 | 19/01/2016 | 26/01/2016 | 28/01/2016 |
| 5 | 11141491112 | Tumor of the stomach | 02/01/2016 | 15/12/2015 | 12/01/2016 | 04/02/2016 |
| 6 | 135126911 | Tumor of the rectum. | 17/02/2016 | 07/12/2015 | 23/02/2016 | 21/06/2016 |
| 7 | 1355141212 | Gallbladder tumor. | 10/03/2016 | 04/02/2016 | 08/03/2016 | 21/03/2016 |
| 8 | 1358775 | Sigmoid tumor | 21/03/2016 | 03/02/2016 | 24/03/2016 | 31/03/2016 |
| 9 | 109714210 | Biliary canal tumor. | 30/03/2016 | 24/03/2016 | 22/03/2016 | 08/04/2016 |
| 10 | 1010135610 | Tumor of the rectum. | 22/02/2016 | 04/04/2016 | 05/04/2016 | 20/04/2016 |

***Table 11: Current Process Time***

## *2.2 Time series plot of total process time:*

Once the necessary measures have been taken, we begin with a curve representing of the values distribution of the study. The axes of the curve are the patients in abscise and the total time of the process in ordinates.

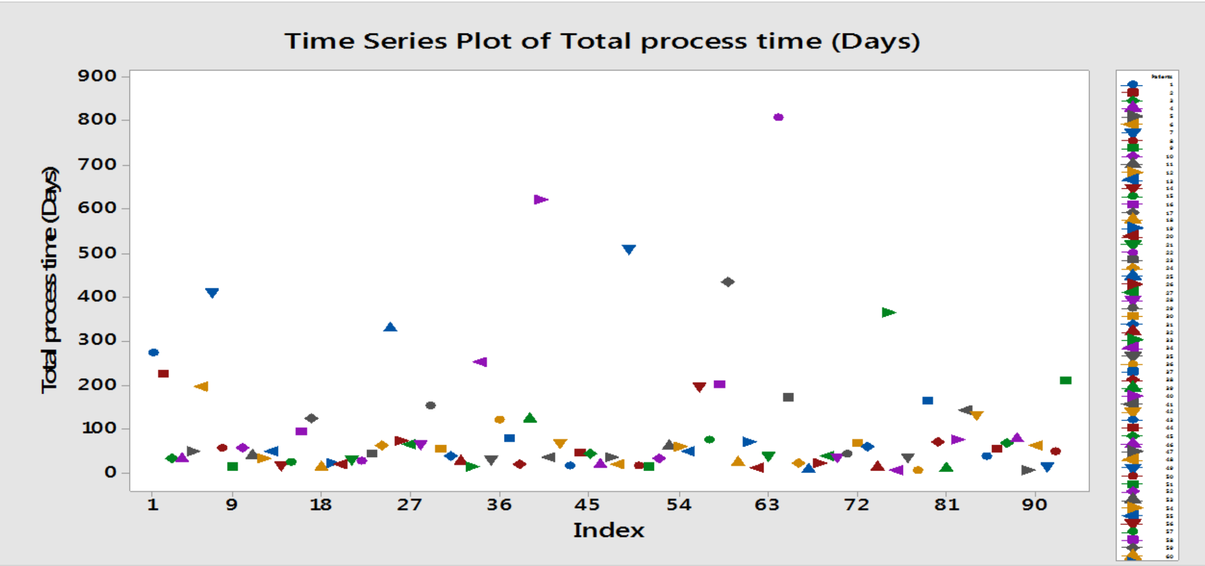



***Figure 34: Time series plot of total process time***

We notice that there is a large distribution of the measures which means that ***there is a problem in this process***.

## *2.3 Run chart of total process time:*

This curve has the same axes as the previous one, except that now we connect the points, and we draw the line which passes by the value of the mean which is in our case:

$$\mu = mean = \frac{\sum_{i=1}^{93} x_i}{n} = 97{,}30 \approx 97\ days$$

***Equation 1: the mean of the process***

$x_i$: Total time of the patients process (Days).

$n$ : The sample (n=93 in this case).

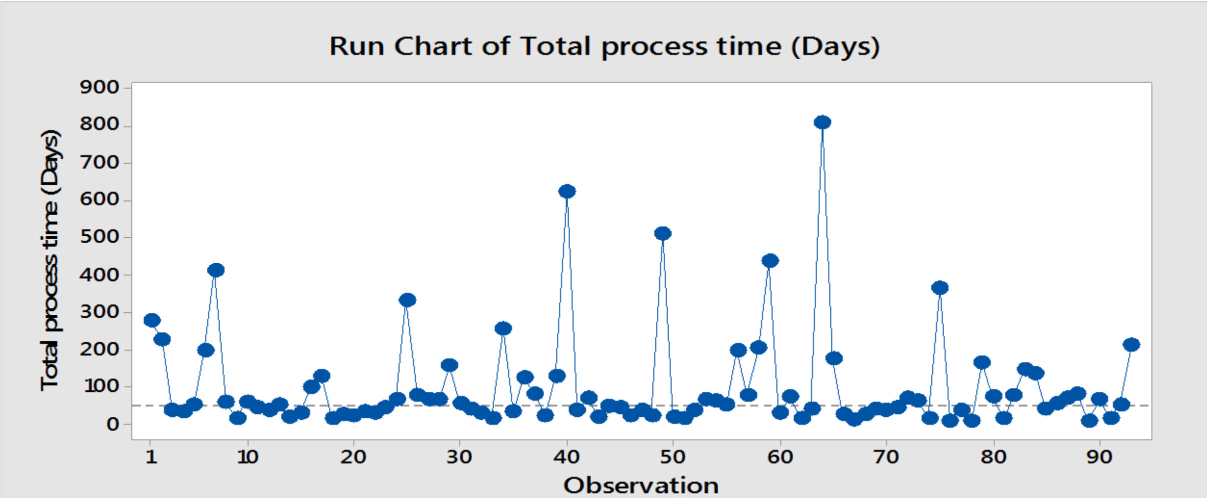



*__Figure 35: Run chart of total process time__*

We notice that there are several points that do not pass next to the line. So there is a ***large dispersion that must be corrected***.

### *2.4 Process capability report:*

The histogram describing the process (done by Minitab software) is as follows:

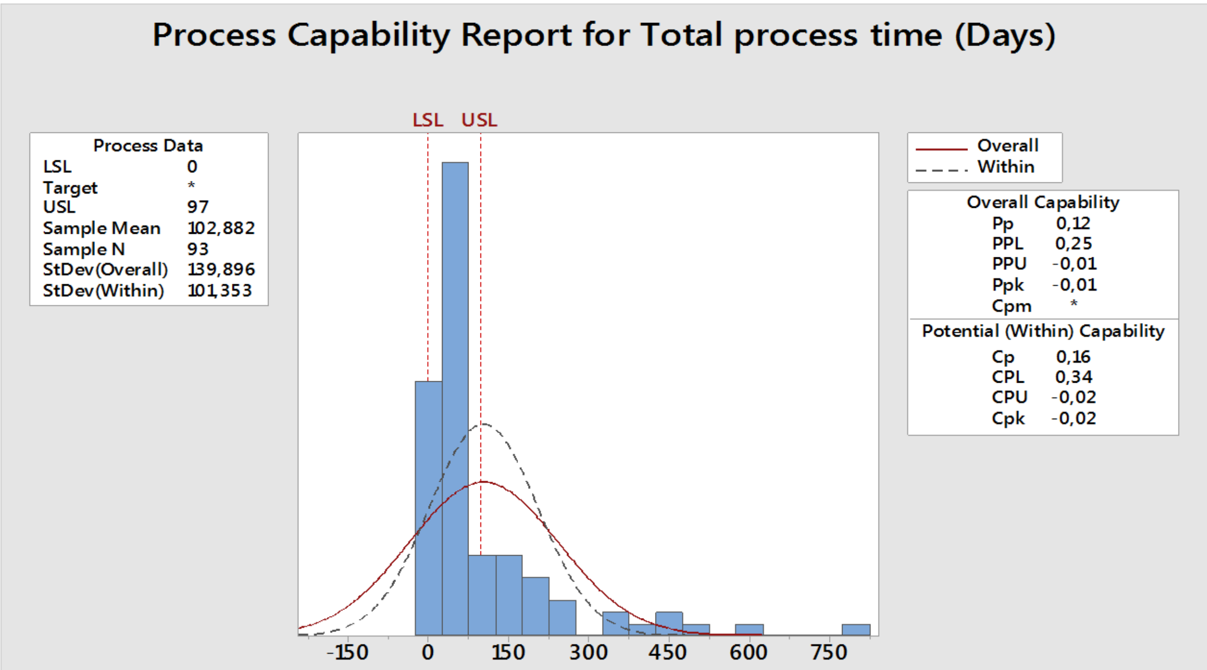



*__Figure 36: process capability report__*

The curve obtained isn't in the shape of the gauss curve. We can therefore conclude that our problem doesn't follow the normal law.

Also, considering the values of Cp and Cpk we can say that:

- Cp ≠ Cpk => ***non-centered process***;
- Cpk < 1,33 => ***process that needs to be improved.***

### 2.5 Probability plot:

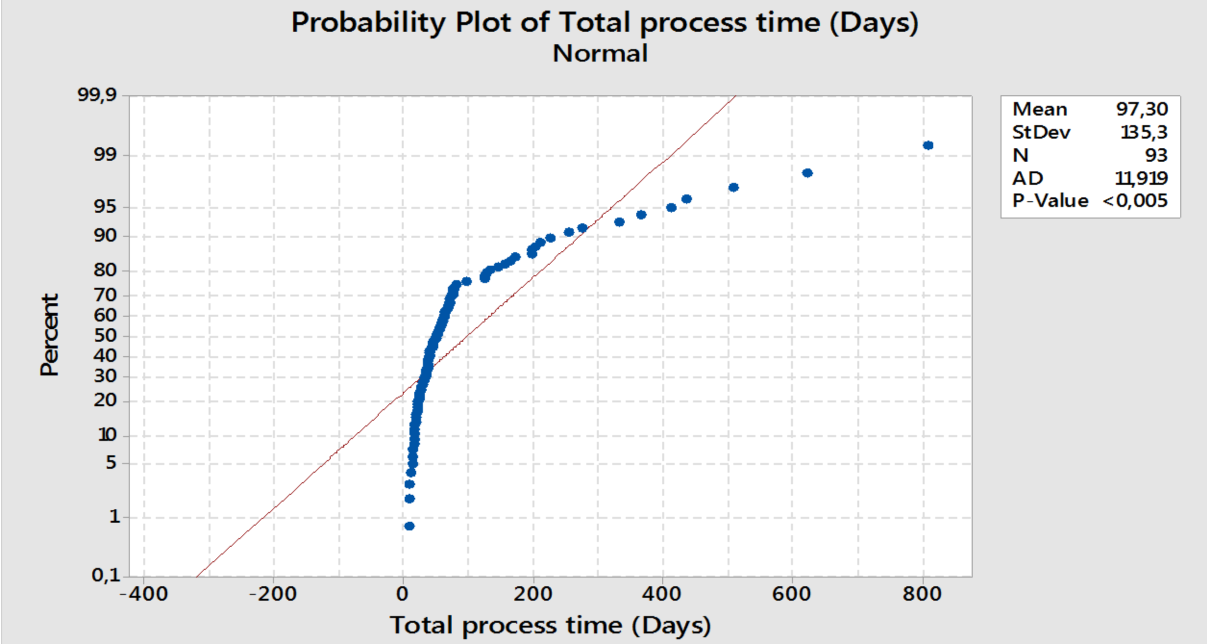



***Figure 37: probability plot***

This curve represents the "scaled paper in normal probability". Once we associate each point with its percentage.

We notice that the majority of points don't pass through the red line, therefore the process is ***out of statistical control*** and ***needs to be improved***.

### 2.6 Goal of the study:

The proportion of patients who have a total time ≤ Mean of days is calculated as follow:

$$P(x \leq 97.30) = P\left\{z \leq \frac{97.30 - \mu}{\sigma}\right\} = 1 - P\left\{z \geq \frac{97.30 - \mu}{\sigma}\right\}$$

On the other hand, we have:

$$\mu = \frac{\sum x_i}{N} = 97.30$$

$$\sigma = \sqrt{\left(\frac{\sum_{i=1}(x_i - \mu)^2}{N-1}\right)} = 135.3$$

$N$: Number of measures in the population;

$\mu$: The mean;

$\sigma$: The standard deviation.

$$P(x \leq 97.30) = 1 - P\left\{z \geq \frac{97,30 - 97,30}{135.3}\right\}$$
$$= 1 - P\{z \geq 0\}$$

According to the table (Apendix 5) the value of $P\{z \geq 0\}$ is 0,50.

So $P(x \leq 97.30) = 1 - 0.5 = 0.5 = 50\%$

We can conclude that only 50% of the sample is ≤ 97,30 days.

The objective of this study is ***to have a process 100% less than 97,3 days.***

## 3. Analyze:

The aim from this phase is to identify the root causes of the problem in order to eliminate them and to eliminate the non-value added activities, to achieve this target we made two different things, the first one we made a Micro-level flow chart as process analysis and the second things is Ishikawa diagram in order to identify the main causes of the problem.

### 3.1. Ishikawa Diagram:

This diagram graphically represents the causes leading to an effect. It can be used as a moderating tool for brainstorming and as a tool for synthetic visualization and communication of identified causes. It can be used at researching cause of a problem or identification and risk management when setting up a project.

We have made the diagram associated with our study with "variation of the process" as main effect, the figure bellow is the result of a brainstorming with the staff.

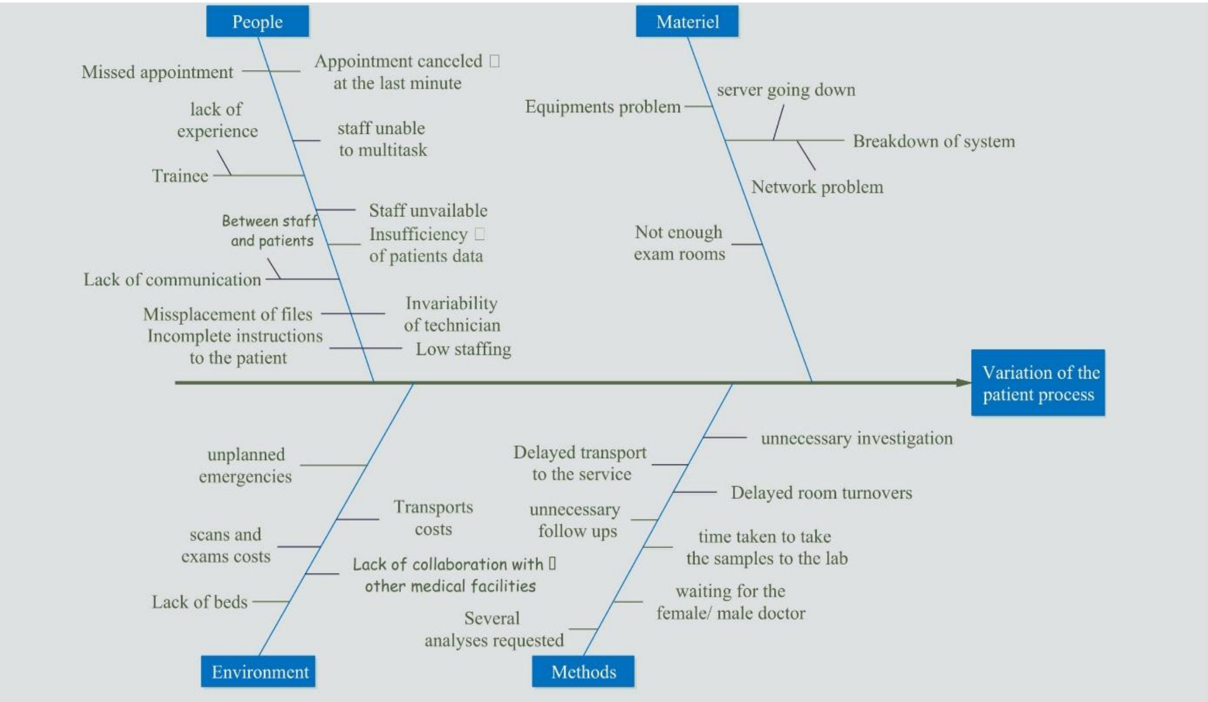



***Figure 38: Ishikawa Diagram***

Brainstorming session was made in order to identify the root causes of the problem, all the causes identified were classified in 4 categories (Method, Material, Staff, Environment) and weighted by each team Member using a 5 point liker scale (1 = minimum, 5 = maximum in order to identify the main root causes) Unimportant = 1, slightly important =2, Important = 3, very important =4, Critical = 5

| ***Causes*** | | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** |
|---|---|---|---|---|---|---|
| **Material** | Equipment Problem | | | x | | |
| | Breakdown of system | | | x | | |
| | Not enough exam rooms | | | x | | |
| **Staff** | Missed appointment | | | x | | |
| | Trainee (lack of experience) | | | x | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Staff unable to multitask | | x | | | |
| | Appointment canceled at the last minute | | | | x | |
| | Lack of communication | | | | | x |
| | Insufficiency of patients data | | | x | | |
| | Incomplete instructions to the patients | | | | x | |
| | Lack of beds | | | x | | |
| **Environment Methods** | exams costs | | x | | | |
| | Transports costs | | | x | | |
| | Lack of collaboration with other medical facilities | | | | | x |
| | Waiting for the female/ male doctor | x | | | | |
| **Methods** | Time taken to take the samples to the lab | x | | | | |
| | Delayed room turnovers | x | | | | |
| | Delayed transport to the unit | x | | | | |
| | Unnecessary follow ups | | | x | | |
| | Unnecessary investigation | | | x | | |

***Table 12: Ishikawa liker scale***

## *3.2 5 whys of some Ishikawa causes:*

The following table represents the 5 Whys for the main causes of the process variation, found by the Ishikawa tool and evaluated by the liker scales table.

| | ***Why*** | ***Why*** | ***Why*** | ***Why*** | ***Why*** |
|---|---|---|---|---|---|
| ***Equipment's problem*** | lack of corrective maintenance | Invariability of technician | busy technician | the technicians are in charge of the whole hospital | the CHU includes several units |
| | lack of palliative maintenance | Invariability of a person in charge | we don't often think about it | There are no awareness campaigns | |
| ***Breakdown of system*** | connection problem | network failure | Failure due to the telecommunication company | | |
| ***Not enough exam rooms*** | Too many patients hospitalized | limited service space | we must leave space for professors offices and study classrooms | Space should be reserved for external doctors Lessons; | |
| | | | | Professors must have an office within the unit | |
| ***Missed appointments*** | Patients forget | Too busy for his/her appointment | Patient underestimate his cancer | | |
| | | | Patient loses hope to be cured | | |
| | Patients can't pay the transport costs | He lives so far from the hospital | Chu Fez includes 3 big regions | There are not enough regional hospitals | |

| | | | | | |
|---|---|---|---|---|---|
| ***Appointment canceled at the last minute*** | Unexpected emergencies | Invariability of doctors | Lack of organization | | |
| ***Trainee(lack of experience)*** | lack of training | | | | |
| ***Lack of communication*** | Most doctors are used to use scientific terms | the patient doesn't understand | A big proportion are illiterate | | |
| ***Insufficiency of patients data*** | File not found among the archives | The patient takes his file and loses it | Carelessness of the staff | | |
| | | Poorly sorted archives. | Files not laid in their place after use. | The doctors don't care about this action | |
| ***Incomplete instructions to the patients*** | This is often a patient emotional shock | Patients have false thoughts | They have the idea: cancer = death | | |
| | We are afraid of patients lack of understanding | | | | |
| ***Lack of collaboration with other medical facilities*** | Few Hospitals Treat Cancer (studied) in the Region | lack of human and material resources | | | |
| ***Unnecessary follow ups*** | Too much exams requested | To be reassured of the reliability of the results | The results can be wrong sometimes | | |

***Table 13: 5 whys of Ishikawa causes***

## 3.3 Micro level Flowchart:

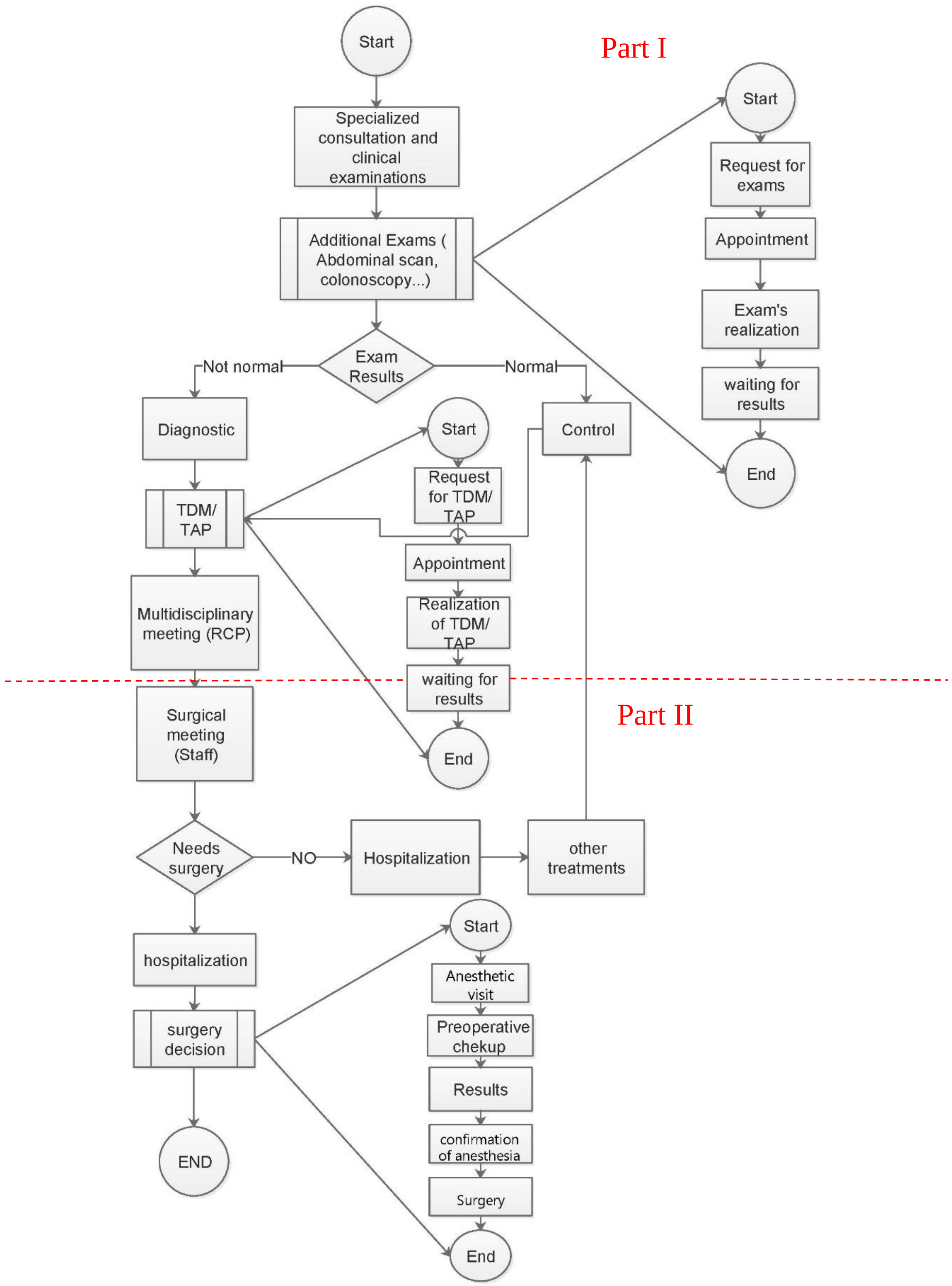



***Figure 39: Micro level Patient's flow chart***

Patients in our sample needs to go through this whole process to have their surgery, except that the real work of the unit starts after the multidisciplinary meeting (RCP). All the steps before are done in order to have the missing exams for the patient's file, and therefore the steps "Start => RCP" are only additional actions of the surgery unit B.

It is then necessary to study every step of the process along in order to characterize the critical phase of the process, the one that request the longest delay.

- ***Diagnosis to CT scans:***

The first phase of the patient's process is to diagnosis the cancer by many exams done at the radiotherapy service. Here are some charts that describes the variation of this phase:

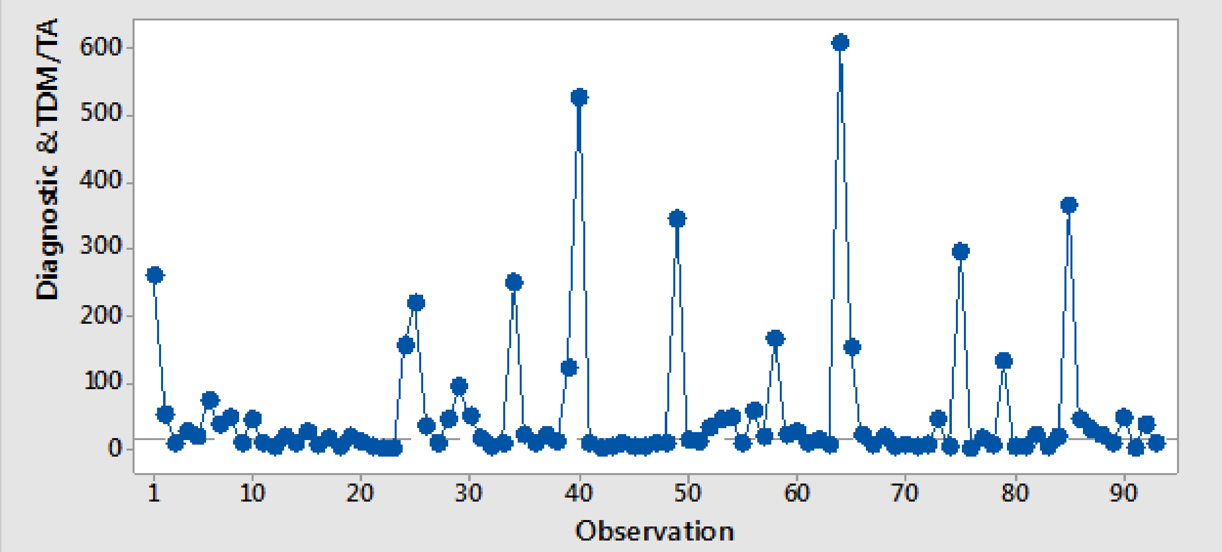



***Figure 40: Run chart of the process dispersion***

This first run chart shows that there is a large dispersion at this phase, moreover, we notice that several points are far from the mean. So there is a problem at this step that we must handle.

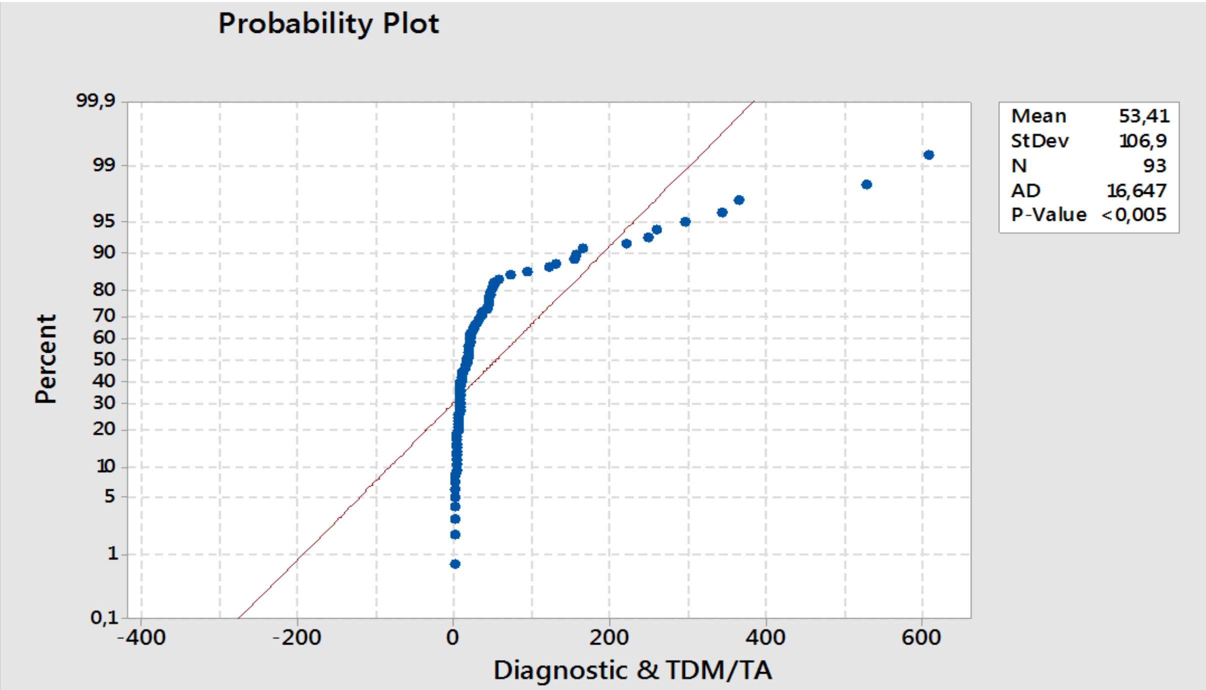



***Figure 41: Probability of time between Diagnosis and TDM/TAP***

This chart shows the following data:

1. Mean of time between Diagnosis and TDM/Tap : $\mu_1$= 53,41 days ;
2. Standard deviation $\sigma_1 = 106{,}9$;
3. P-value < 0,005 => the phase doesn't follow the normal law.

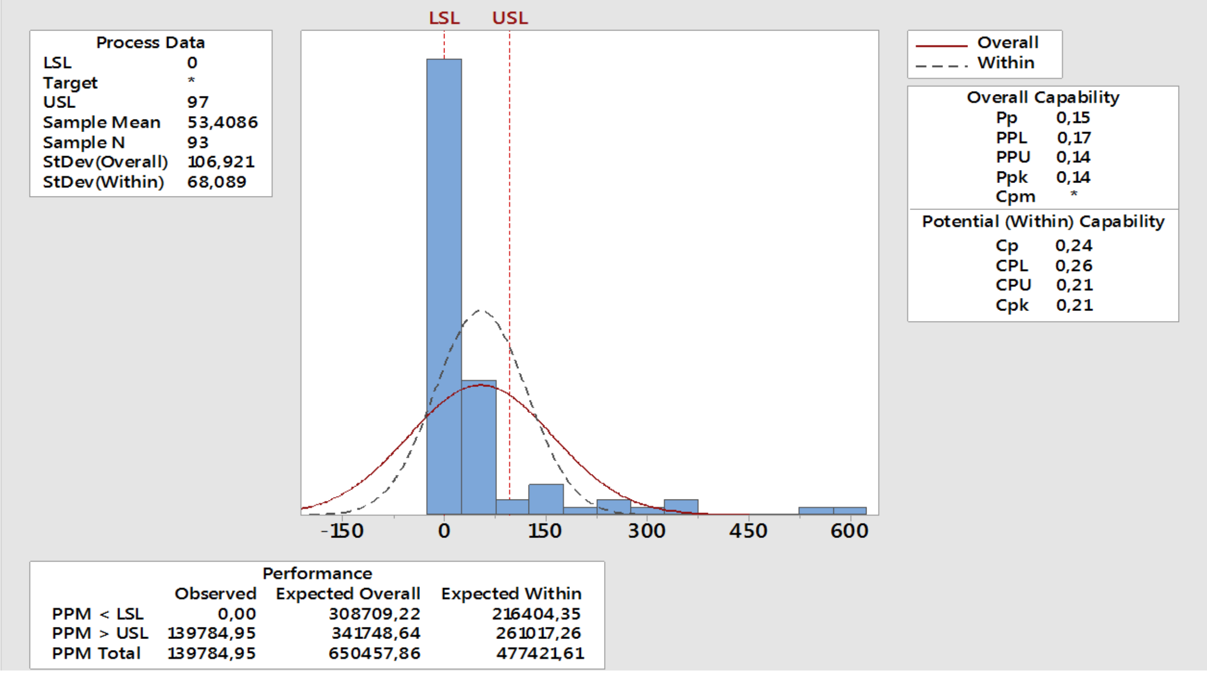



***Figure 42: Process capability report of time between Diagnosis and TDM/TAP***

At this level, we choose the following specification limits:

- LSL= 0 days;
- USL= Mean of the process= 97 days.

Also, considering the values of Cp and Cpk we can say that:

- Cp ≠ Cpk => ***non-centered phase***;
- Cpk < 1,33 => ***phase needs to be improved.***

➢ ***CT scan to Multidisciplinary/ Surgical Meeting:***

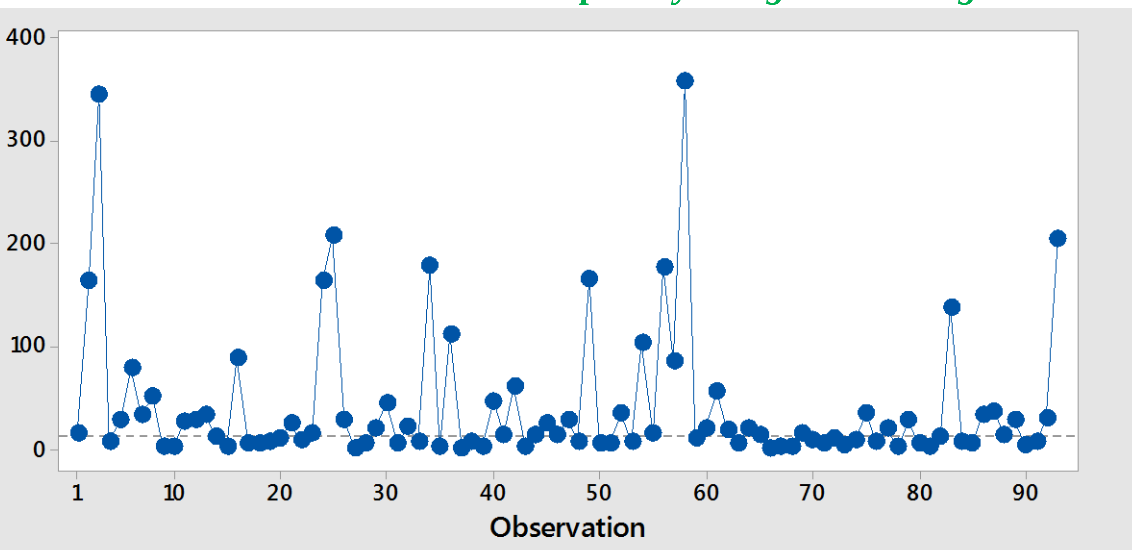



***Figure 43: Run chart of time between TDM/TAP and RCP/Staff***

The run chart of time between TDM/TAP and RCP/Staff shows that there is a large dispersion at this phase. Also, we notice that several points are far from the mean. So there is a problem at this step that we must handle.

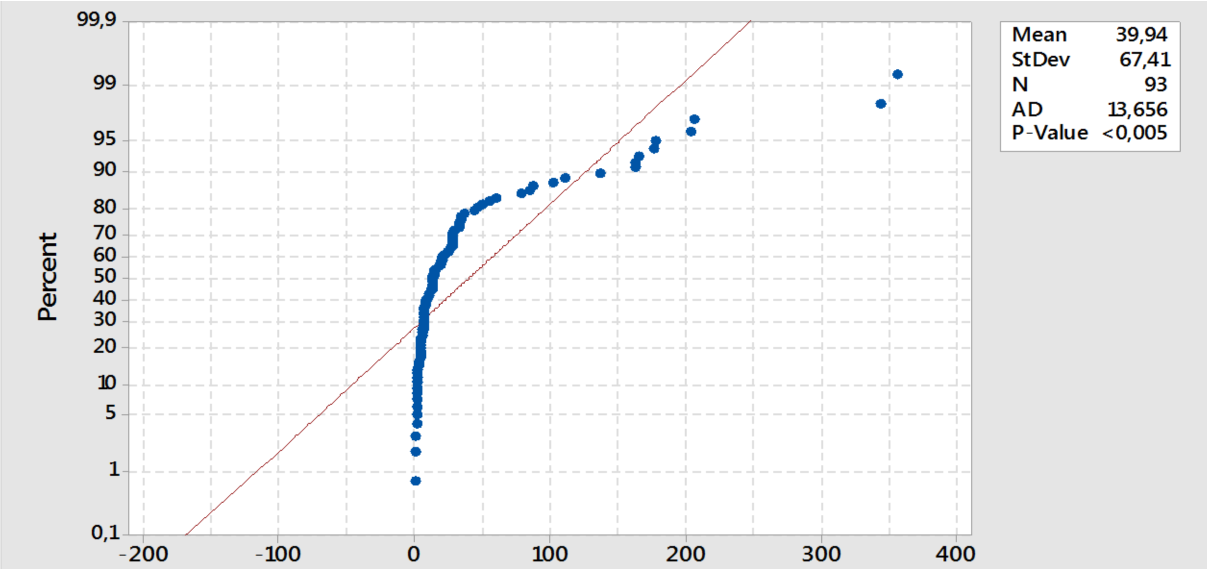



***Figure 44: Probability plot of time between TDM/TAP and RCP/Staff***

This chart shows the following data:

1. Mean of time between TDM/TAP and RCP/Staff : $\mu_2$=39,94 days ;
2. Standard deviation $\sigma_2 = 67{,}41$
3. P-value < 0,005 => the phase doesn't follow the normal law.

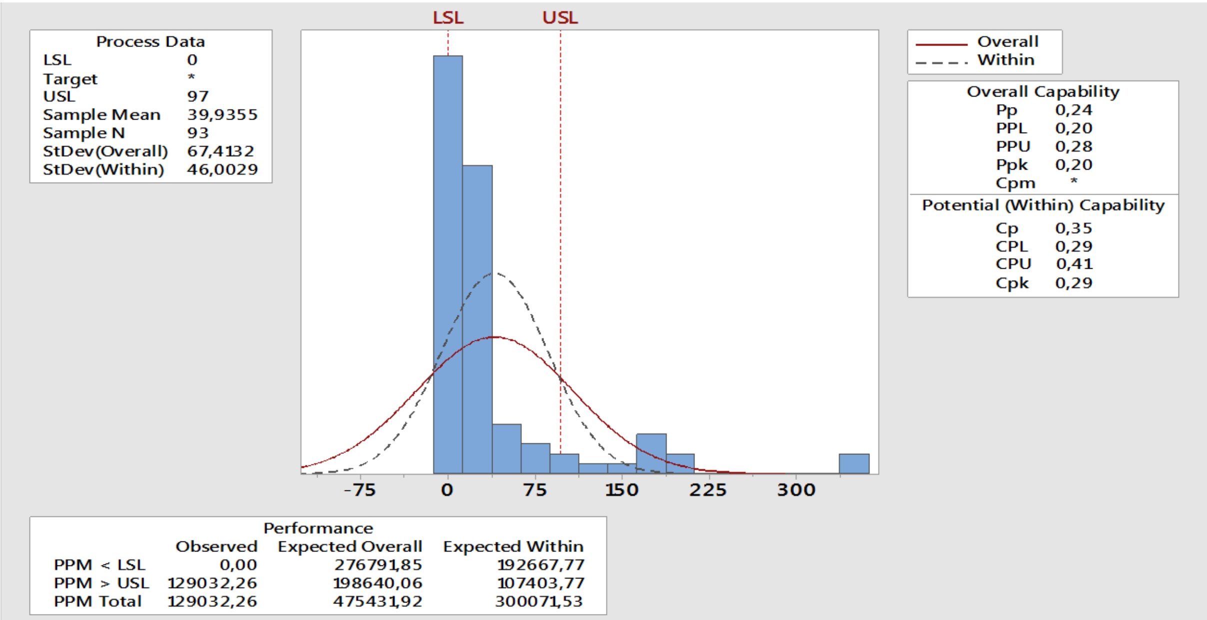



***Figure 45: Process time capability report for time between TDM/TAP and RCP/Staff***

We can say that:

- Cp ≠ Cpk => ***non-centered phase***;
- Cpk < 1,33 => ***phase needs to be improved.***

## ➢ *TDM/TAP to Surgery:*

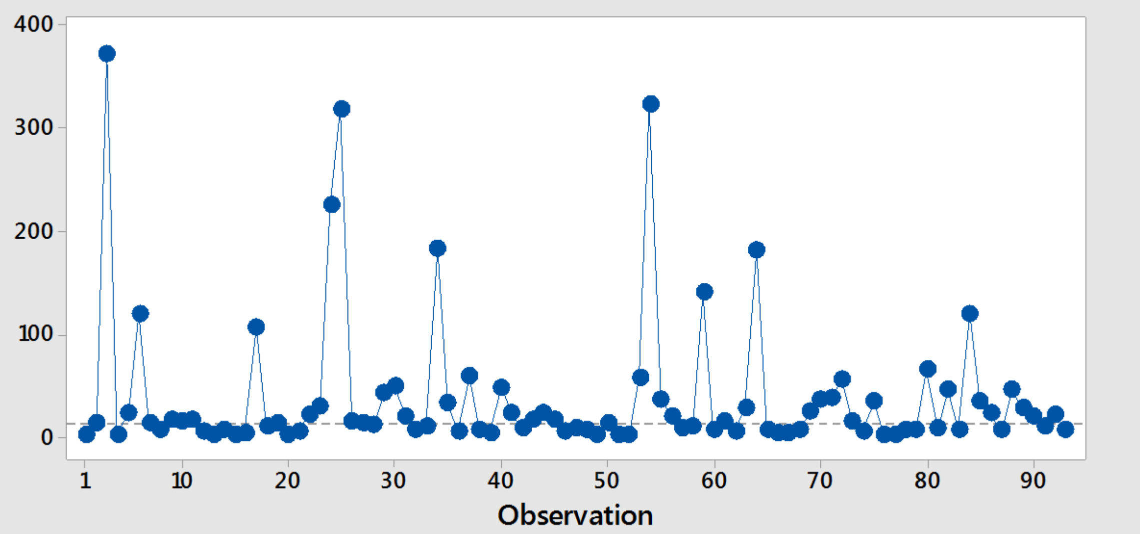



***Figure 46: Run chart of the time between TDM/TAP and surgery***

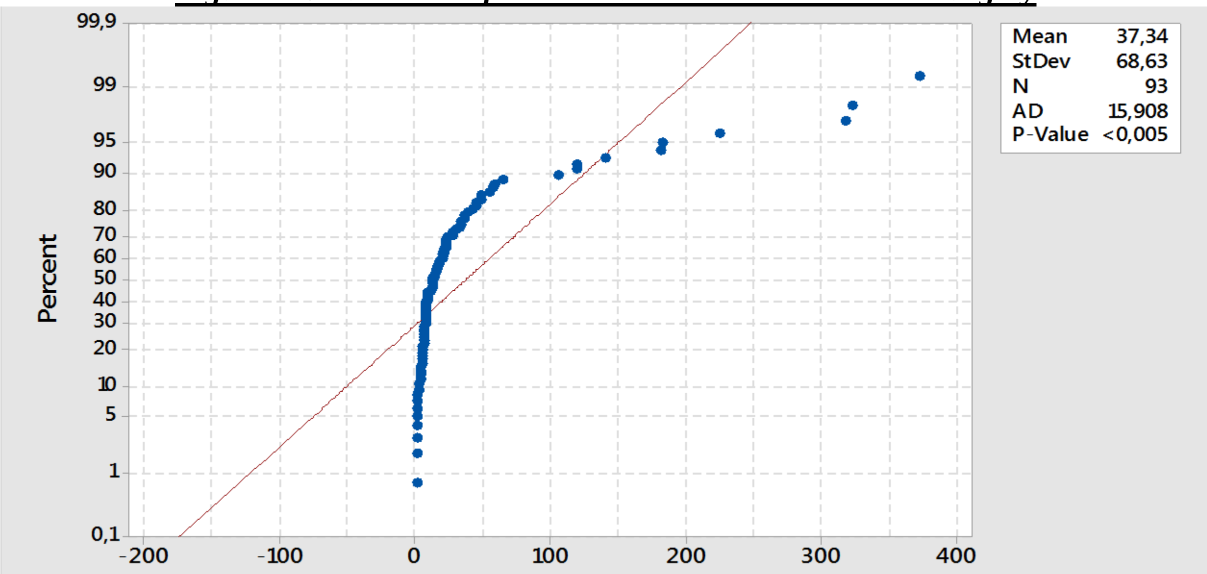



***Figure 47: Probability plot of time between RCP/Staff and Surgery***

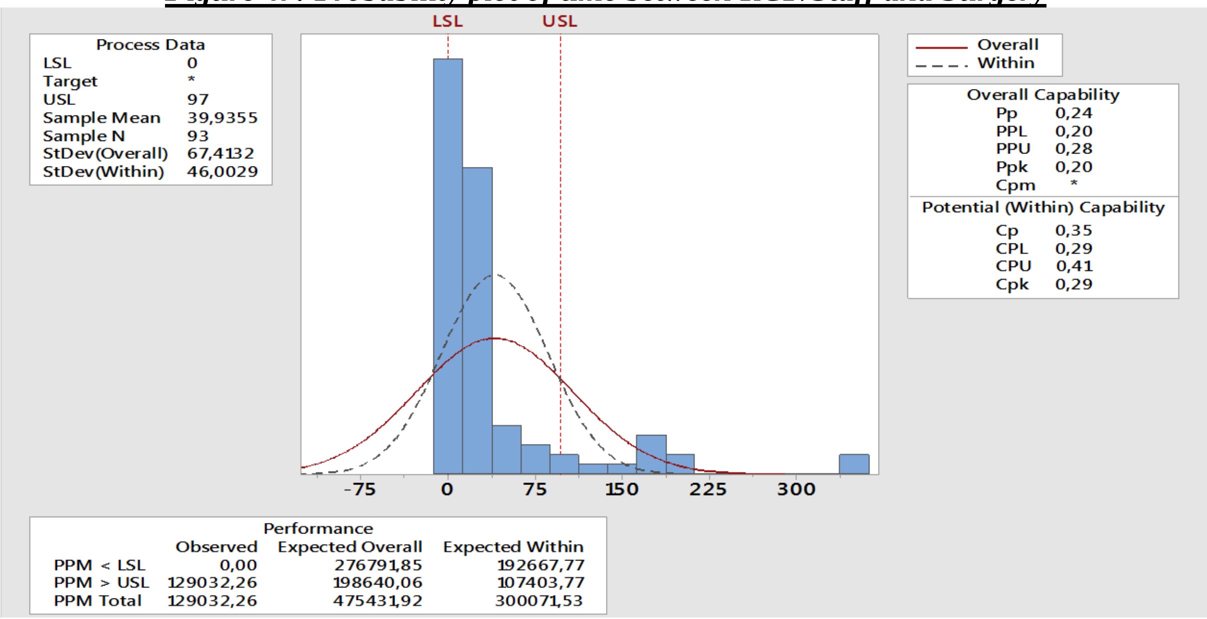



***Figure 48: Process time capability report for time between RCP/Staff and surgery***

Similar to the previous steps, the conclusions are as follows:

- Mean of time between RCP/Staff and Surgery: $\mu_3$=37,34 days ;
- Standard deviation $\sigma_3 = 68{,}63$;
- P-value < 0,005 => the phase doesn't follow the normal law.
- Cp ≠ Cpk => ***non-centered phase***;
- Cpk < 1,33 => ***phase needs to be improved.***

➢ ***Conclusion of the detailed study of the process:***

The results of the detailed study of the process show that:

- $\mu_1$= 53,41 > $\mu_2$ ;
- $\mu_1$= 53,41> $\mu_3$ .

We can conclude that the most critical phase in the whole process is the one between diagnosis and TDM/TAP.

We are then going to focus on this phase in order to optimize the process

### *3.4 Minimizing the delay between Diagnosis and CT Scan (TDM/TAP):*

Since the first phase of the process is the most critical one, we propose to minimize it. In other words, we are going to suppose that we have the results of the exams on the same day.

This phase includes:

1. Request for TDM/TAP;
2. Appointments;
3. TDM/TAP realization;
4. Waiting for results;
5. Results of TDM/TAP.

It is obvious that the long delay between the two steps is due to the appointments and waiting for the results. These two actions add no value for the process, they are then ***wastes*** and they have to be reduced.

In other words, we can classify the sub process of the first phase into actions with and without added value as shown in the following table:

| ***Actions with added value*** | ***Non-added value actions*** |
|---|---|
| Request for TDM/TAP<br>TDM/TAP realization | Appointments<br>Waiting for Exams results<br>Waiting for TDM/TAP results |

***Table 14: Actions with and without added value***

## 4. Improve:

The study shows that the most critical part of the process is the step between "diagnosis results and those of Ct scans". It is then on this part that the study will focus.

After minimizing the delay of the first phase, we have recalculated the new total process time. The question is: ***Is there an improvement in the process?***

The following charts are the answer:

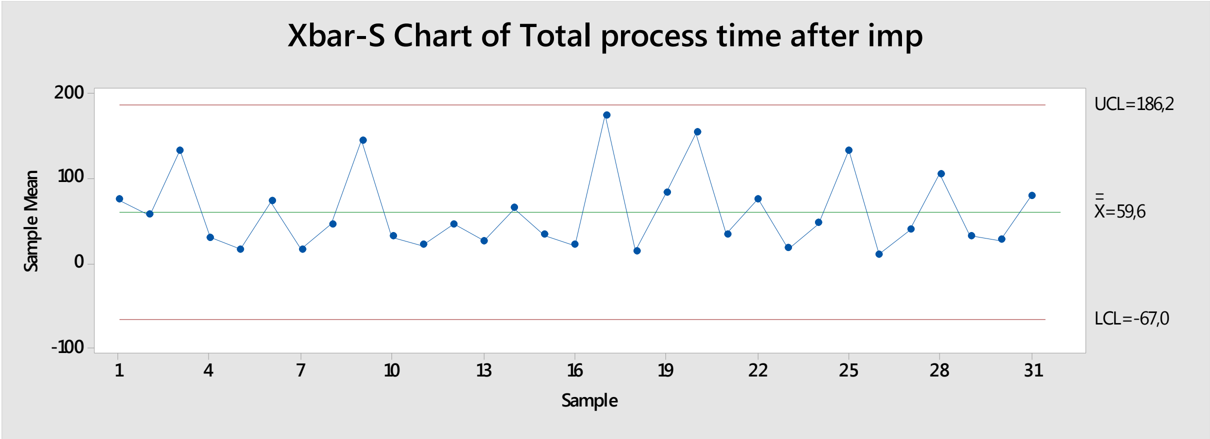



***Figure 49: Chart of total process time after improvement***

- ➪ All the measures are inside the specification limits;
- ➪ Process under statistical control.

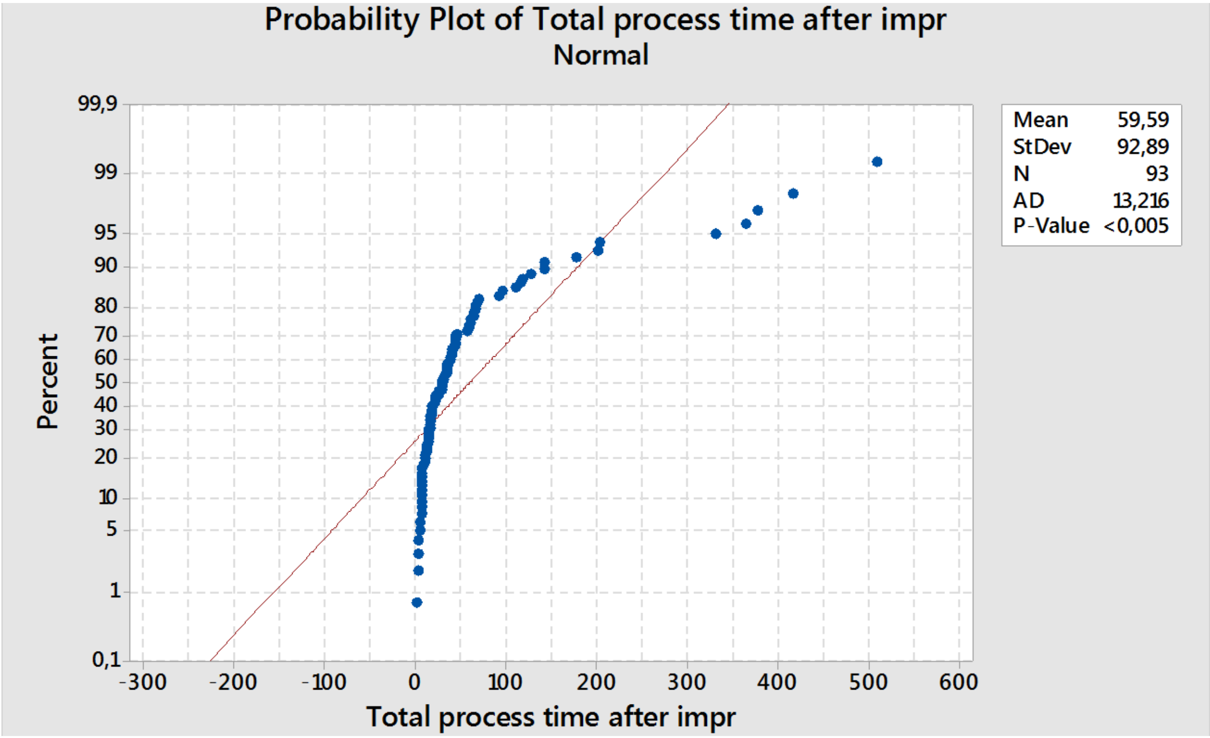



***Figure 50: Probability plot of total process time after improvement***

- ➪ P-value <0,005: the Process doesn't follow the normal law.
- ➪ New mean of the process: 59, 59 days.

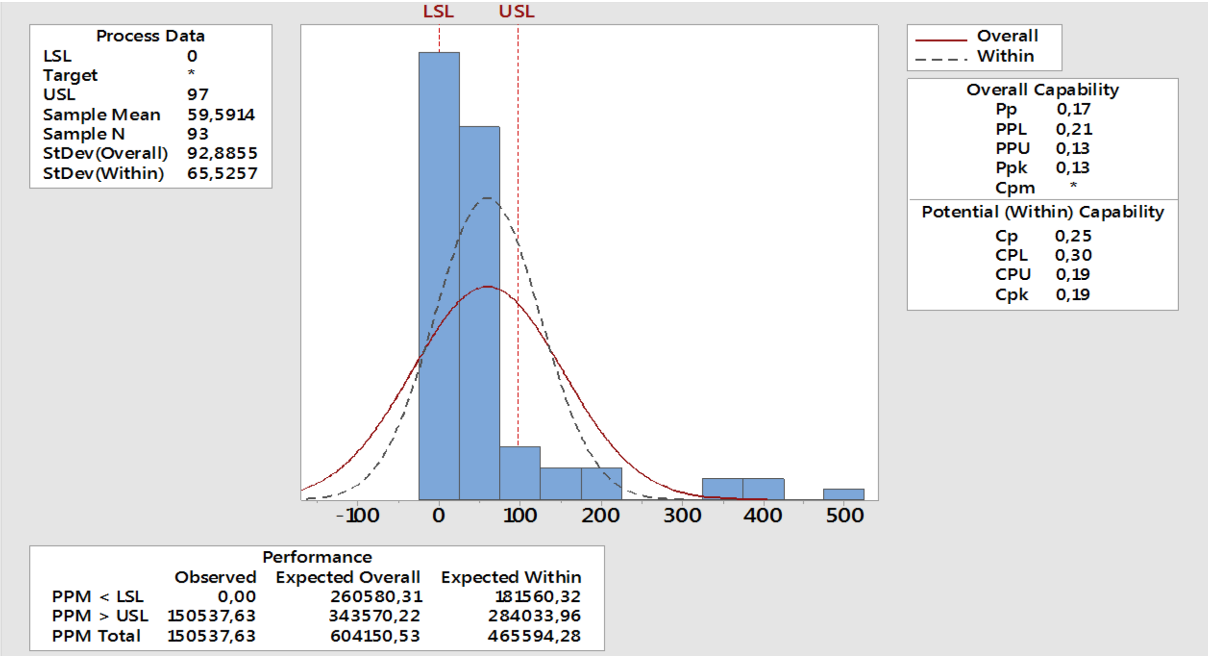



***Figure 51: process capability report for the new total process time***

➪ Cp ≠ Cpk => non-centered process;

➪ Cpk < 1,33 => the process still needs to be improved.

***Before and after implementation:***

The table below is a comparison of the total process time before and after implementation:

| | **Before the study** | **After the study** |
|---|---|---|
| Average (Days) | 97,3 | 59,59 |
| Standard deviation (Days) | 135,3 | 92,89 |
| PPM (with upper specification limit as 97.30 days) | 258 064 | 150 537 |

***Table 15: total process time before and after implementation***

The new probability of measures under 97,30 days:

$$P(x \leq 97.30) = 1 - P\left\{z \geq \frac{97{,}30 - 59{,}59}{92{,}89}\right\}$$
$$= 1 - P\{z \geq 0{,}40\}$$

According to the table (Apendix 5) the value of $P\{z \geq 0{,}40\}$ is 0,340.

So $P(x \leq 97.30) = 1 - 0.340 = 0{,}66 = 66\%$

We can conclude that 66% of the sample is ≤ 97,30 days.

Even if we have not achieved our goal (having 100% of the measures <97.30 days), we observe a noticeable improvement in our new process.

## 5. Control:

The analysis phase shows that we can consider two types of solutions for each part of the process, (I for the additional actions, and II for the main missions of the service):

- Part I: process improvement;
- Part II: standardization.

We haven't yet implemented the solution in Chu Fez, however we propose the following solutions to implement it successfully:

### 5.1. Process improvement:

***To improve the process traceability:***

- Design a paper that includes a table similar to the following model:

| ***Steps of the process*** | ***Check (x) on the appropriate box*** | ***Date*** |
|---|---|---|
| Step (1) | | |
| Step (2) | | |
| … | … | … |
| Step (n) | | |

***Table 16: Proposed model of traceability table***

The paper will be attached to the yellow card, so that it cans follow all the activities of the patient (from diagnosis to surgery). At each stage of the process, the patient must give the doctor the paper in order to complete the chart by checking the accomplished step, and mentioning its date.

***Improvement of the radiology department:***

Increase the reliability of the scanner by improving its maintenance (corrective / preventive):

- Balance the work of technicians;
- The recruitment of technicians as needed.

***Determine the radio capacity:***

- Establish the order of priority of the B surgery department.
- Calculate the patient quota / day:
  - ➪ Determine the average waiting time for patients of each unit.
  - ➪ Depending on the capacity of the radiology per day, determine the number that each unit has the right to send there per day (quota).
  - ➪ The visceral surgery unit B will send a specific number to the radiology every day.
- Give the number of quotas to the radiology unit.
- Patient flow management.

### 5.2. Standardization of the part II:

***Standardization of the second part of the process:***

- To determine the time of each one of the part II steps.
- Calculate the average of the total time for each sub step.
- Set standards.

Once the standards are set, we must know how to motivate the staff to follow them:

- Employee of the month: each month a paper is prepared containing some information on whoever has followed the proposed standards. And it is subsequently stuck somewhere on the walls of the service. This can have a suitable effect on employee behavior.

## ***Conclusion:***

The Lean Six Sigma has given very good solutions. Except that this methodology is limited by the existing process. Maybe we have solved in some ways the problem of the long waiting time, but nothing was reported about the other factors defining the quality sought by the patient. Is there a tool that can complement the results obtained in this chapter?

# *Chapter VI:*
# *Solutions using Design thinking*

## *Introduction:*

Talking about a patient-based process, it's really important to define first which quality is he looking for at the unit. Lean Six Sigma mentioned it in CTQ tree but we did not work with it for the rest of the phases.

In order to define the quality one must first go through the KANO model:

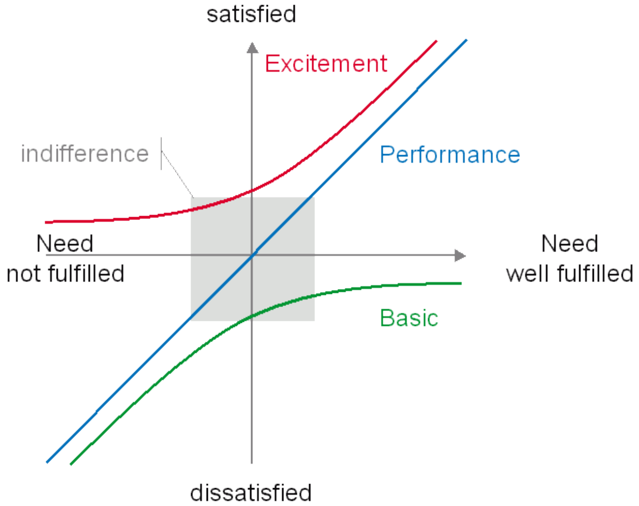



***Figure 52: Kano***

According to Kano the patient satisfaction depends on the existence of 3 types of quality:

- Basic;
- Performance;
- Excitement.

While Lean Six Sigma methodology focused on the performance and basic functionalities, Design thinking is a tool that will allow us to focus on the innovational part and then we can propose a completely new process.

### *1- Empathize:*

It's really important to understand who is concerned by this study before defining the problem.

This is the first phase of design thinking. It allows us to understand our client (who is the patient in this case). The empathy map is a very powerful tool that focuses on patient's pain /gain, and what do they see? Hear? Feel? (For more details see appendix 3)

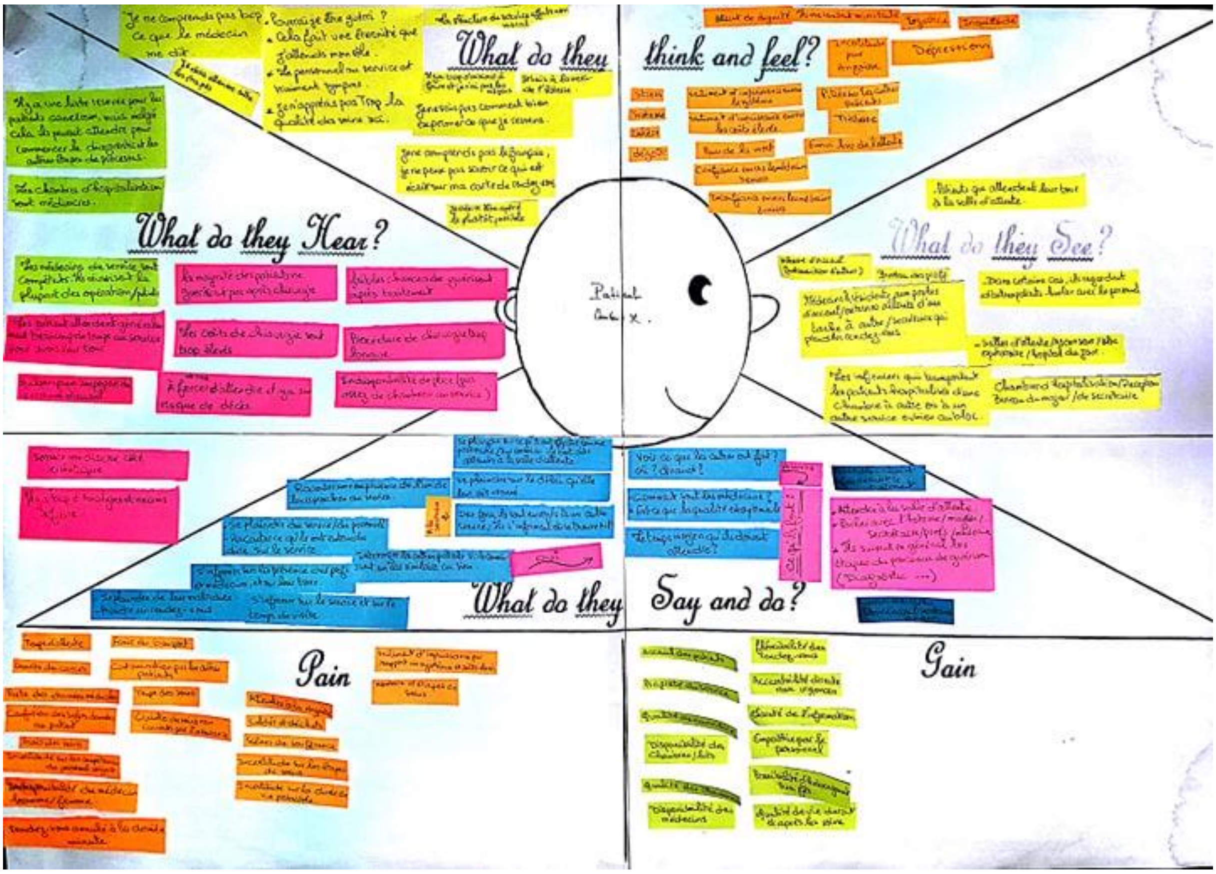



*Figure 53: Empathy map*

## 2- Define:

### 2.1 Customer profile:

Customer profile is a way of describing a customer categorically so that they can be grouped to better define our problem. Before even starting to analyze the process, it's important to take the time to carve out the ideal consumer profile for the service we propose (operating cancer patients).

We tried to build the customer profile canvas as a preliminary step in defining our problem. The canvas covers the categories of patients studied, what they don't appreciate in the service, and the things they would have liked to see and to have. (appendix 4)

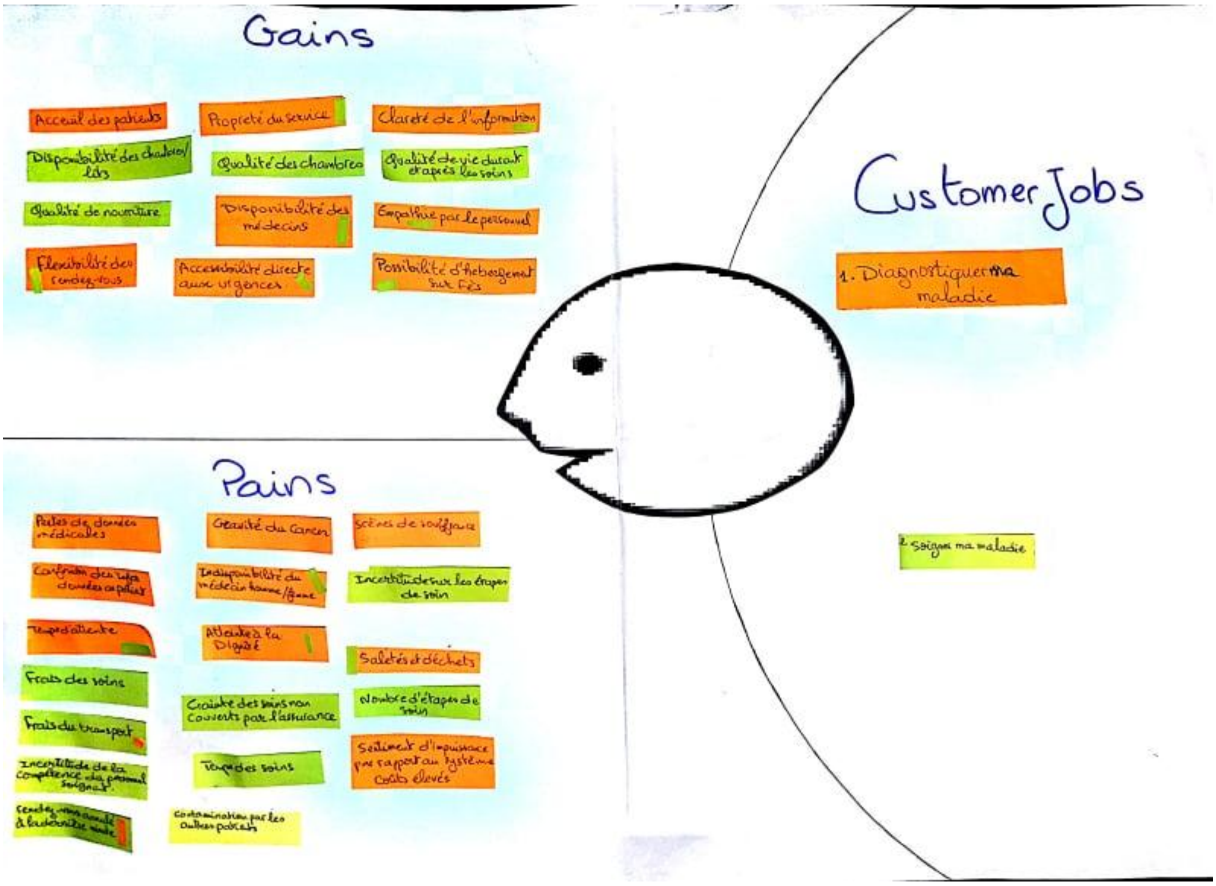



*__Figure 54: Customer profile Canvas__*

### *2.2 Value map:*

The value map is the second part of the customer profile, it’s a canvas where we treat pains and gains mentioned before, by proposing some pain relievers and gain creators while mentioning the product or service we offer to our patients.
The figure bellow represent the value map of our study: (For more details check appendix 4)

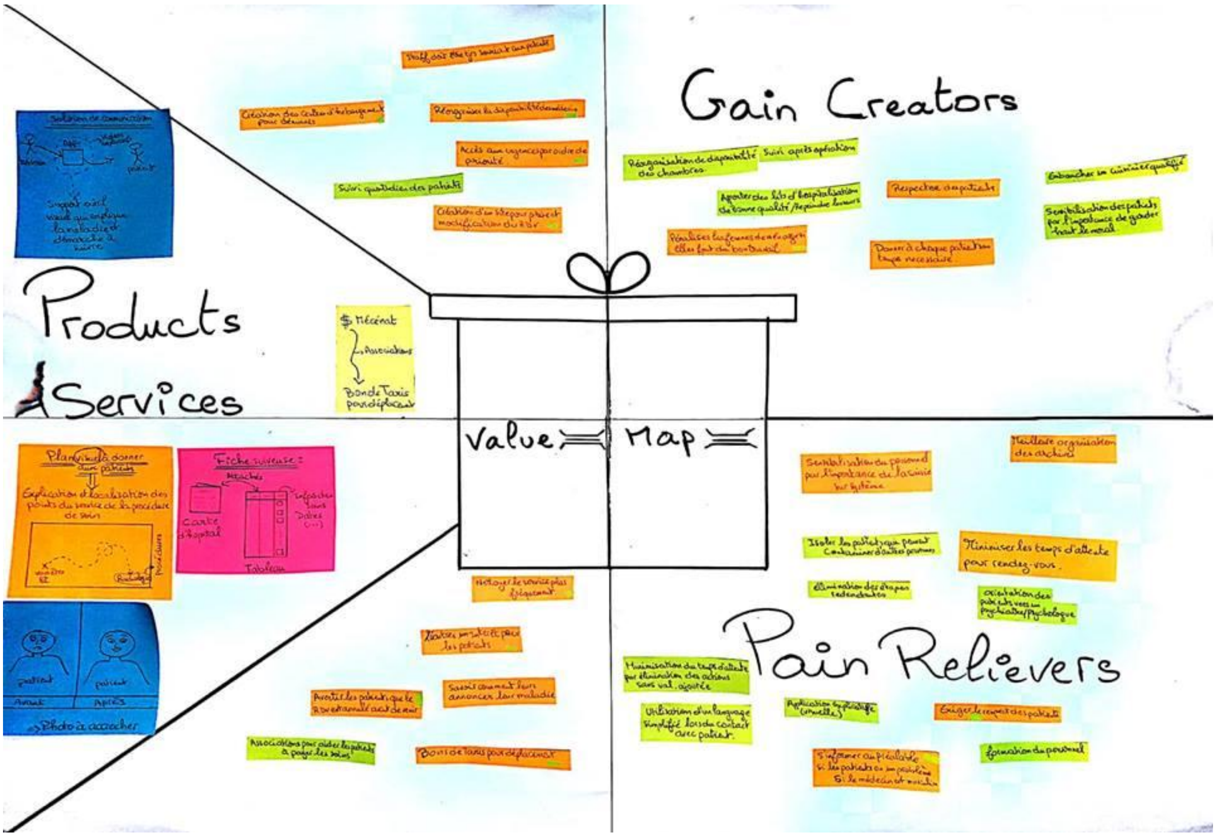



***Figure 55: Value map***

### 3- *Ideate:*

The canvas that we have presented before have clarified the vision. They allowed us to have an idea on the actions to propose in order to correct the patient's problems. So we propose the following tasks:

a) ***Visual support to facilitate the communication between staff and patients.***
b) ***A before and after picture of a patient that operated successfully.***
c) ***Map of the process.***
d) ***Application on patients phone containing explication videos.***
e) ***Make a paper containing a table (where we note informations about steps done and their date)***

## f) Remove actions without added value:

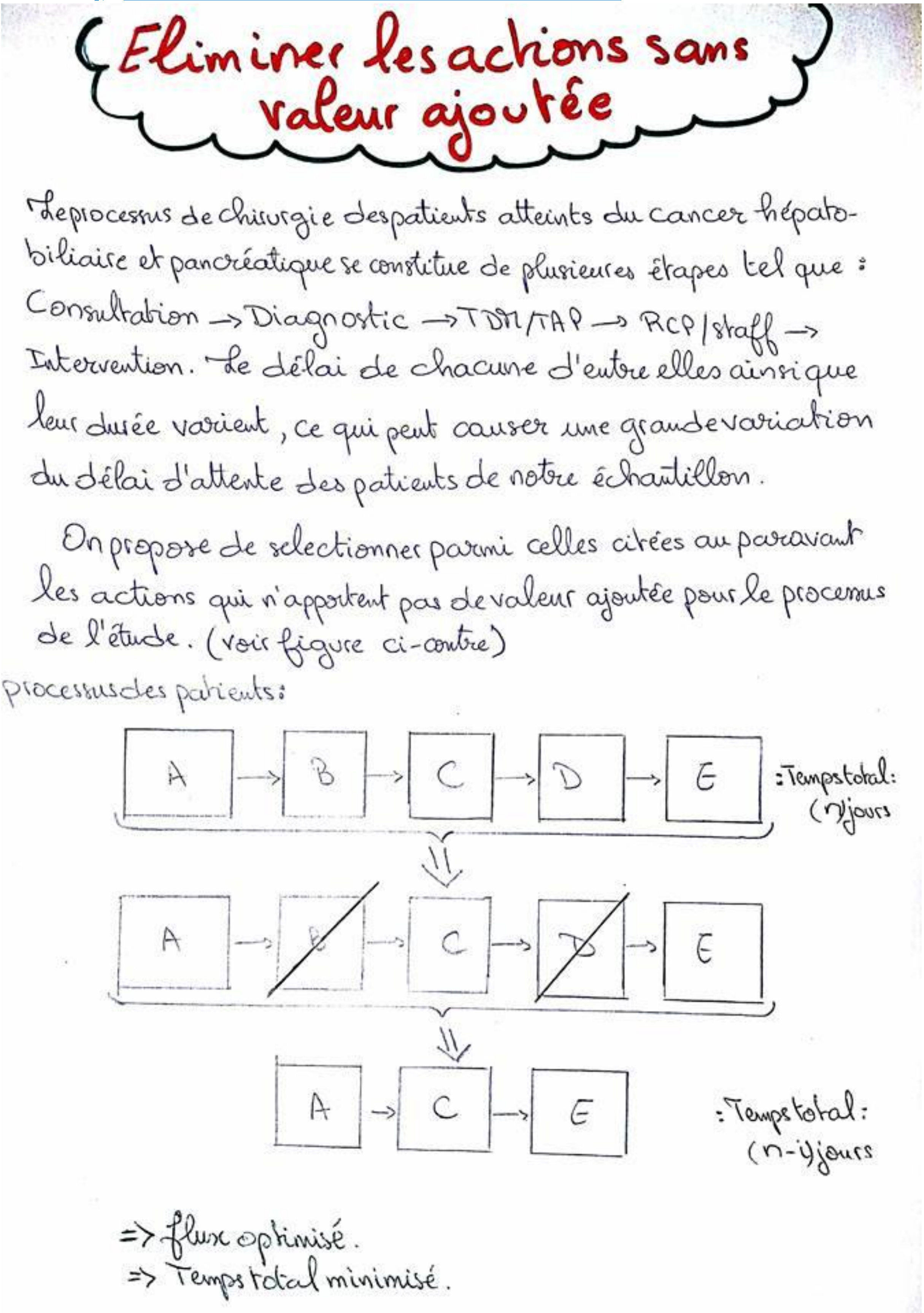



***Figure 56: remove non-added value actions***

## g) Free reception centers:

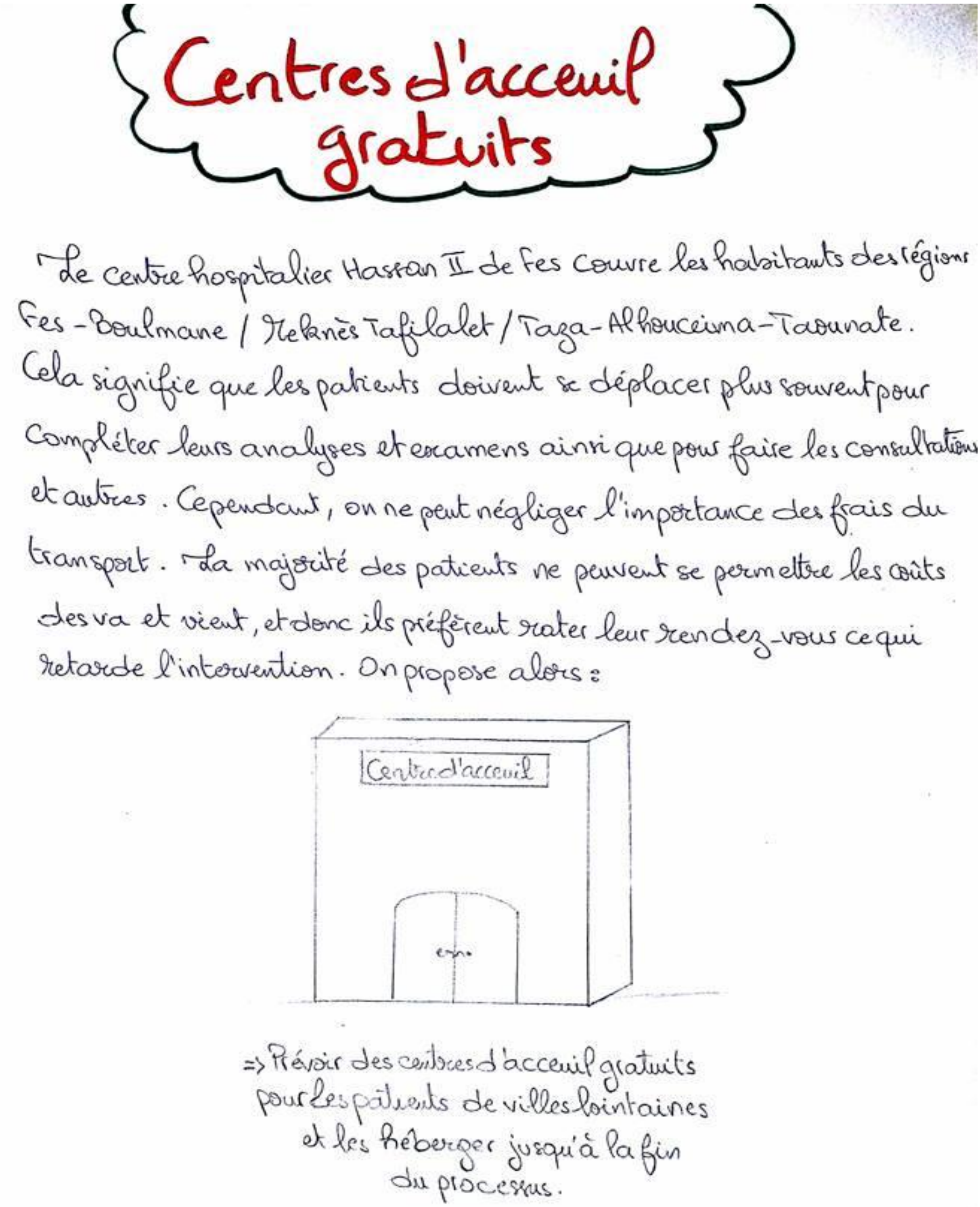



***Figure 57: Free reception centers***

## *Conclusion:*

Design thinking is a method that allowed us to broaden our vision and work on a new concept. It served us well to complete the work done in the Lean Six Sigma phase.

# Conclusion:

La santé est l'élément le plus précieux pour l'être humain, et assurer une qualité des soins est une responsabilité de toutes les parties prenantes du système de santé. Ce secteur dans pays émergents rencontre beaucoup de problèmes, notamment l'encombrement des listes d'attentes des hôpitaux, ce qui influence systématiquement sur la qualité du traitement des patients.

Des méthodes comme Lean Six Sigma et Design thinking ont montré leur efficacité pour améliorer aussi bien le temps du traitement des patients, et la robustesse du processus.

Dans ce travail, on a utilisé ces deux méthodes, et on a eu beaucoup de résultats motivants, pour continuer à les implanter dans le secteur de santé au Maroc. Parmi les résultats on cite:

- Moyenne du temps total du processus : 97,30 => 59,59 jours.
- Ecart type : 135,3 => 92 ,89.
- PPM : 258 064 => 150 537.
- Convergence des solutions obtenues par les deux méthodes.

# Perspectives :

- Continuer à implanter Lean Six Sigma et Design Thinking jusqu'à l'adoption de ces deux philosophies comme des méthodes de travail.
- Formation personnel et staff médical.
- Développer un concept général du secteur de santé au Maroc en se basant sur Lean Six Sigma et Design thinking.

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## *Appendix 1*
## *Table: Measures*

| Patient number | Patient code | Diagnosis | Date of histological diagnosis | Date of Ct scan (TDM TAP) | Multidisciplinary/ surgery meeting (RCP/ Staff) | Date of surgery. |
|---|---|---|---|---|---|---|
| 11 | 1361114116 | Tumor of the stomach | 09/03/2016 | 03/03/2016 | 29/03/2016 | 14/04/2016 |
| 12 | 138714136 | Rectal tumor | 30/03/2016 | 31/03/2016 | 28/04/2016 | 03/05/2016 |
| 13 | 78111267 | Colonic tumor | 18/05/2015 | 05/06/2015 | 07/07/2015 | 08/07/2015 |
| 14 | 13561168 | Adk du bas retum | 12/05/2016 | 05/05/2016 | 17/05/2016 | 23/05/2016 |
| 15 | 13798512 | Coecal tumor | 14/04/2016 | 09/05/2016 | 10/05/2016 | 11/05/2016 |
| 16 | 1381411129 | Tumor of the colonic angle | 10/02/2016 | 15/02/2016 | 12/05/2016 | 16/05/2016 |
| 17 | 135514108 | Tumor of the lower rectum. | 20/01/2016 | 05/02/2016 | 09/02/2016 | 25/05/2016 |
| 18 | 12968510 | ADK colic | 20/05/2016 | 19/05/2016 | 24/05/2016 | 02/06/2016 |
| 19 | 1378985 | Colonic tumor | 06/05/2016 | 24/05/2016 | 17/05/2016 | 30/05/2016 |
| 20 | 109810135 | Gastric tumor | 18/05/2016 | 28/05/2016 | 07/06/2016 | 08/06/2016 |
| 21 | 139109138 | Colon tumor | 07/05/2016 | 09/05/2016 | 02/06/2016 | 07/06/2016 |
| 22 | 131061078 | Tumor of the esophagus | 30/05/2016 | 30/05/2016 | 07/06/2016 | 28/06/2016 |
| 23 | 10912986 | Sigmoid tumor | 07/06/2016 | 07/06/2016 | 21/06/2016 | 21/07/2016 |
| 24 | 68109107 | Stromal Tumor | 27/07/2016 | 28/12/2016 | 19/07/2016 | 01/03/2017 |
| 25 | 137101377 | Tumor of the cardia. | 10/08/2016 | 17/03/2017 | 23/08/2016 | 07/07/2017 |
| 26 | 138851110 | Gallbladder tumor. | 02/06/2016 | 05/07/2016 | 02/08/2016 | 16/08/2016 |
| 27 | 8681176 | Sigmoid tumor | 02/08/2016 | 09/08/2016 | 09/08/2016 | 22/08/2016 |
| 28 | 1214138146 | Sigmoid tumor | 11/07/2016 | 22/08/2016 | 18/08/2016 | 29/08/2016 |
| 29 | 12861275 | Tumor of the pancreas. | 17/05/2016 | 17/08/2016 | 06/09/2016 | 18/10/2016 |
| 30 | 109117107 | Tm cardinoide iléale | 28/07/2016 | 15/09/2016 | 02/08/2016 | 20/09/2016 |
| 31 | 13139141311 | Gastric tumor | 20/10/2016 | 04/11/2016 | 08/11/2016 | 28/11/2016 |
| 32 | 12661489 | Tumor of the stomach | 25/10/2016 | 27/10/2016 | 17/11/2016 | 23/11/2016 |
| 33 | 14512141113 | Gallbladder tumor. | 21/12/2016 | 14/12/2016 | 20/12/2016 | 29/12/2016 |
| 34 | 9128141314 | Rectal tumor | 23/02/2015 | 29/10/2015 | 10/03/2015<br>05/05/2015 | 04/11/2015 |
| 35 | 1071112109 | Rectal tumor | 23/01/2017 | 04/01/2017 | 03/01/2017 | 04/02/2017 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 36 | 13135667 | Tumor of the lower rectum. | 09/09/2016 | 16/09/2016 | 05/01/2017 | 10/01/2017 |
| 37 | 1461014910 | Colon tumor | 19/10/2016 | 08/11/2016 | 08/11/2016 | 05/01/2017 |
| 38 | 146119119 | Tm réctale | 28/12/2016 | 06/01/2017 | 12/01/2017 | 18/01/2017 |
| 39 | 1313814118 | Sigmoid rectum tumor. | 20/09/2016 | 18/01/2017 | 19/01/2017 | 23/01/2017 |
| 40 | 128971411 | Stromal Tumor | 01/07/2015 | 09/12/2016 | 24/01/2017 | 13/03/2017 |
| 41 | 14710141213 | Tumor of the head of the pancreas. | 08/02/2017 | 01/02/2017 | 14/02/2017<br>07/02/2017 | 09/03/2017 |
| 42 | 1451213109 | Gastric tumor | 09/12/2016 | 09/12/2016 | 07/02/2017 | 15/02/2017 |
| 43 | 14713797 | Gallbladder tumor. | 09/02/2017 | 06/02/2017 | 07/02/2017 | 24/02/2017 |
| 44 | 14710141213 | Tumor of the head of the pancreas. | 08/02/2017 | 01/02/2017 | 14/02/2017 | 09/03/2017 |
| 45 | 14911569 | Sigmoid tumor | 21/02/2017 | 24/02/2017 | 21/03/2017 | 06/04/2017 |
| 46 | 14109958 | Gastric tumor | 22/03/2017 | 24/03/2017 | 06/04/2017 | 11/04/2017 |
| 47 | 1411148106 | Gastric tumor | 19/04/2017 | 11/04/2017 | 09/05/2017 | 17/05/2017 |
| 48 | 107119811 | Gastric tumor | 09/05/2017 | 15/05/2017 | 22/05/2017 | 29/05/2017 |
| 49 | 131411121014 | Gallbladder tumor. | 08/01/2016 | 16/12/2016 | 30/05/2017 | 31/05/2017 |
| 50 | 1412118710 | Tumor of the head of the pancreas. | 14/06/2017 | 02/06/2017 | 06/06/2017 | 19/06/2017 |
| 51 | 1412118147 | Gastric tumor | 16/05/2017 | 25/05/2017 | 30/05/2017 | 31/05/2017 |
| 52 | 141214121114 | Gallbladder tumor. | 16/06/2017 | 17/05/2017 | 20/06/2017 | 21/06/2017 |
| 53 | 1413117126 | Gallbladder tumor. | 05/09/2017 | 24/07/2017 | 18/07/2017 | 13/09/2017 |
| 54 | 6121210813 | Rectal tumor | 12/07/2016 | 27/05/2016 | 19/07/2016<br>06/09/2016 | 26/07/2017 |
| 55 | 99911514 | Hepatogastric tumor | 25/09/2017 | 19/09/2017 | 03/10/2017 | 08/11/2017 |
| 56 | 147981414 | Stromal Tumor | 28/06/2017 | 04/05/2017 | 27/10/2017 | 16/11/2017 |
| 57 | 85121367 | Rectal tumor | 20/11/2014 | 03/11/2014 | 27/01/2015 | 04/02/2015 |
| 58 | 109116712 | Rectal tumor | 24/07/2014 | 11/02/2014 | 02/02/2015 | 11/02/2015 |
| 59 | 119771210 | ADK of the lower rectum. | 01/10/2014 | 12/09/2014 | 22/09/2014 | 09/02/2015 |
| 60 | 11131011710 | Colonic tumor | 16/02/2015 | 23/01/2015 | 12/02/2015 | 19/02/2015 |
| 61 | 111368119 | Left colonic tumor | 25/12/2014 | 19/12/2014 | 12/02/2015 | 27/02/2015 |
| 62 | 11131111108 | Sigmoid tumor | 13/02/2015 | 01/02/2015 | 19/02/2015 | 24/02/2015 |
| 63 | 111314131412 | Sigmoid tumor | 16/01/2015 | 21/01/2015 | 26/01/2015 | 23/02/2015 |
| 64 | 1051211105 | Tumor of the lower rectum. | 17/01/2014 | 17/09/2015 | 06/10/2015 | 04/04/2016 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 65 | 118612119 | Sigmoid tumor | 26/09/2014 | 25/02/2015 | 10/03/2015 | 17/03/2015 |
| 66 | 1251012115 | Gallbladder ADK. | 13/03/2015 | 02/04/2015 | 02/04/2015 | 06/04/2015 |
| 67 | 1113714513 | Adk of the lower rectum. | 10/04/2015 | 14/04/2015 | 16/04/2015 | 20/04/2015 |
| 68 | 126814910 | Colon tumor | 06/04/2015 | 24/04/2015 | 23/04/2015 | 29/04/2015 |
| 69 | 126612713 | Tumor of the transverse colon | 21/04/2015 | 20/04/2015 | 05/05/2015 | 29/05/2015 |
| 70 | 95131479 | Stromal Tumor | 14/05/2015 | 19/05/2015 | 11/05/2015 | 16/06/2015 |
| 71 | 111311665 | Tumor of the right colon. | 06/05/2015 | 08/05/2015 | 12/05/2015 | 19/06/2015 |
| 72 | 6891155 | Adk rectal | 23/04/2015 | 28/04/2015 | 07/05/2015 | 01/07/2015 |
| 73 | 12814779 | Gastric tumor | 07/05/2015 | 19/06/2015 | 22/06/2015 | 06/07/2015 |
| 74 | 129111168 | ADK gastric | 27/07/2015 | 29/07/2015 | 06/08/2015 | 11/08/2015 |
| 75 | 1281414139 | Gallbladder tumor. | 09/09/2014 | 02/07/2015 | 05/08/2015 | 08/09/2015 |
| 76 | 1210128614 | Gastric tumor | 28/08/2015 | 28/08/2015 | 03/09/2015 | 04/09/2015 |
| 77 | 129651011 | colonic tumor | 11/08/2015 | 27/08/2015 | 15/09/2015 | 16/09/2015 |
| 78 | 12111181011 | Rectal tumor | 28/09/2015 | 23/09/2015 | 24/09/2015 | 30/09/2015 |
| 79 | 1113812147 | Gastric tumor | 23/05/2015 | 30/09/2015 | 27/10/2015 | 03/11/2015 |
| 80 | 121111131011 | Gastric tumor | 29/09/2015 | 02/10/2015 | 06/10/2015 | 10/12/2015 |
| 81 | 651081179 | Sigmoid tumor | 12/01/2018 | 15/01/2018 | 16/01/2018 | 24/01/2018 |
| 82 | 1251011810 | Tumor of the lower rectum. | 18/11/2017 | 08/12/2017 | 19/12/2017 | 02/02/2018 |
| 83 | 147614125 | Sigmoid tumor | 30/01/2017 | 27/01/2017 | 13/06/2017 | 20/06/2017 |
| 84 | 65765611 | Rectal Tumor | 23/09/2017 | 10/10/2017 | 17/10/2017 | 13/02/2018 |
| 85 | 659991213 | Tumor of the head of the pancreas. | 15/12/2018 | 15/12/2017 | 19/12/2017 | 22/01/2018 |
| 86 | 6511106136 | Sigmoid tumor | 02/02/2018 | 21/12/2017 | 23/01/2018 | 14/02/2018 |
| 87 | 1051261114 | Rectal Tumor | 21/12/2017 | 17/01/2018 | 22/02/2018 | 28/02/2018 |
| 88 | 651114101212 | Tumor of the head of the pancreas. | 10/01/2018 | 31/01/2018 | 13/02/2018 | 30/03/2018 |
| 89 | 6510145128 | Tumor of the pancreas. | 06/03/2018 | 12/03/2018 | 30/01/2018 13/02/2018 | 13/03/2018 |
| 90 | 6512751111 | Gastric tumor | 15/01/2018 | 02/03/2018 | 27/02/2018 | 19/03/2018 |
| 91 | 65127111413 | Sigmoid tumor | 07/03/2018 | 07/03/2018 | 13/03/2018 | 22/03/2018 |
| 92 | 141261066 | Tumor of the pancreas. | 20/06/2017 | 16/05/2017 | 14/06/2017 | 05/07/2017 |
| 93 | 65711121111 | Gastric tumor | 05/09/2017 | 28/08/2017 | 20/03/2018 | 26/03/2018 |

# *Appendix 2*
# *Table: State of Art*

| No | Name of the article | Author, year | Objectives | Methodology | Focus of research | Finding | Suggestions/ Future researches/ challenges |
|---|---|---|---|---|---|---|---|
| 1 | Process Improvement in a Cancer Outpatient Chemotherapy Unit using Lean Healthcare | **S.M Coelho, C.F Pinto, R.D Calado and M.B Silva. 2013.** | The aim is to increase the efficiency of operations and improve the quality of care, by removing wastes and managing queues at a public oncology clinic. | - Production leveling "Heijunka";<br>- Lean production :<br>⇨ Value stream map;<br>⇨ PDCA cycle (Plan-Do-Check-Act) ;<br>⇨ Pareto Analysis;<br>⇨ Cause-Effect Diagrams;<br>⇨ Affinity Diagrams;<br>⇨ Five Whys;<br>⇨ Spaghetti Diagram (Pinto 2010). | Healthcare | The main problem in this service of ***Hospital Regional do Vale do Paraíba*** is overcrowding.<br><br>The treatment schedule is fragmented in three parts, these agendas are changing several times during the same day. This variation is due to disease characteristics and nonscheduled prescriptions.<br><br>As a result they obtained Total time gain: ***516 hours*** per year! | Our facility is located within a hospital and has limited expansion capacity. |
| 2 | Use of Lean and Six Sigma Methodo- | **P.F Lawrence, MD, 2011** | Optimize the surgical process time and | - Lean Six sigma. | Healthcare | There are many barriers found, | There are limitations to this study related to |

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| | logy to Improve Operating Room Efficiency | | increase value from each step of the process. And to initiate a global assessment of patient flow from the surgical consult through postopera-tive recovery. | - Value stream mapping;<br>- Process Improve-ments. | | such as Unplanned surgical volume variation / OR non-operative time/ redundant patient information.<br><br>Patient wait times at the surgical admissions desk of longer than 10 minutes were decreased after implementa-tion of SPI (42% versus 12%)<br><br>On-time arrival to the preoperative area was significantly improved (81% versus 52%)<br><br>Parallel processing significantly improved overall turnover times (TS, 40 minutes versus 30 minutes; GYN, 35 | the organizational and infrastructure capabilities of our institution. There is a substantial OR capacity with 88 ORs available for daily use and >20 additional outpatient OR/procedural areas available. The majority of the surgeons operate on an every other day schedule, which also provides the patient the option of having next-day surgery. Next-day surgery increases variability in the system and a more dynamic scheduling system. |

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| | | | | | | minutes versus 20 minutes; Gen/CRS, 34 minutes versus 23 minutes;)<br><br>Generally speaking, Efforts to reduce non-operative time between subsequent cases for a given OR were successful across all specialties. | |
| 3 | Lean Principles optimize on-time vascular surgery operating room | **C J. Warner, MD, MS, D B. Walsh, A J. Horvath, BA , T R. Walsh, RN, D P. Herrick, BA, S J. Prentiss, MEng, and R J. Powell. 2013** | The objective of this study is to identify the cause of delayed vascular surgery OR first case starts and optimize the use of OR time. | - DMAIC methodology;<br>- Value stream maps and process flow diagrams;<br>- Pareto and control charts ; | Healthcare | The study shows few non-value-added activities, including redundant documentation that needs to be removed & presentations that have to be streamlined.<br><br>Missing surgeon documentation was a primary cause of delay in patient processing and clearance for | The utility of improving on-time OR first case starts to decrease costs is debated in the literature.<br><br>They used opportunity costs instead of activity-based costing. True activity-based costing would have been incurred at the end of the day when ORs ran late and difficult to specifically |

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| | | | | | | transportation to the OR.<br><br>Late arrival of the surgery resident in the preoperative holding unit, was the primary cause of delayed completion of the operative consent and history and physical update. | attribute to changes in morning start times.<br><br>This study was performed in an academic medical center; thus, the results may not be generalizable to nonteaching hospitals.<br><br>With process improvement, there is potential for the Hawthorne effect, or participants modifying their behavior in response to their knowledge of being studied. |
| 4 | Reducing patient waiting time in a pathology department using the Six Sigma methodology | **E.V. Gijo, Jiju A. and J. Hernandez, J. Scaria. 2012** | The aim is to reduce waiting time in a super-specialty hospital attached to a large electrical manufacturing company based ***in India***.<br><br>It includes Reducing ER cycle time, | Six sigma (DMAIC);<br><br>SIPOC (supplier-input-process-output-customer) mapping;<br><br>Project Charter;<br><br>p-value;<br><br>Box-Cox transformation; | Healthc-are | A number of non-value added activities were identified within the process and actions were initiated to eliminate different forms of waste using the principles | Results were achieved by implementing only simple solutions, without any investment or cost impact for the company.<br><br>Training the lab technicians and nurses and help them understand |

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| | | | increasing timely completion of medical records, increasing bed availability, improving patient flow, enhancing patient safety, increasing capacity of the theatres, reducing medication errors and so on and so forth. | Process analysis;<br><br>cause and effect diagram;<br><br>Micro level flowchart;<br><br>GEMBA investigation<br><br>t-test;<br><br>f-test;<br><br>Box plot;<br><br>Dot plot. | | of Lean thinking.<br><br>As a result, the average waiting time reduced from 24 minutes to 11 minutes (i.e. over ***50 %*** reduction), the standard deviation reduced from 17.5 minutes to 10.04 minutes(over ***40 %*** reduction). | the Six Sigma methodology was a real challenge since they were only trained in topics related to medicine, hygiene, housekeeping, community services…<br><br>The scope of this study was limited to sample collection in the pathology department.<br><br>Since it is the first time a Six Sigma project was undertaken in a hospital, the team was unenthusiastic to join the Six Sigma movement. |

***Table 17: State of art***

# Appendix 3
# Empathy Map

Here are the Empathy map details presented by parts:

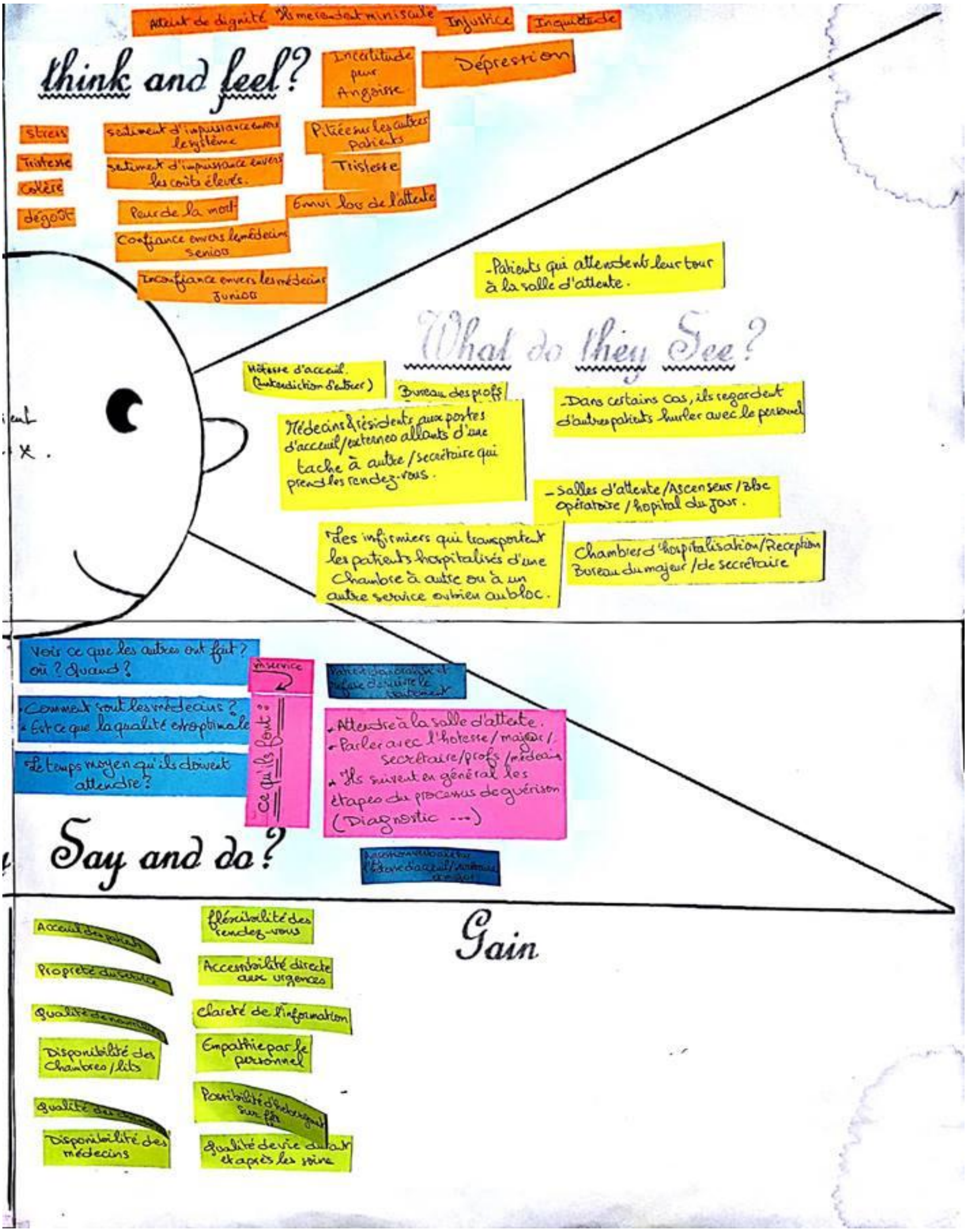


*Figure 58: Part 1-empathy map*

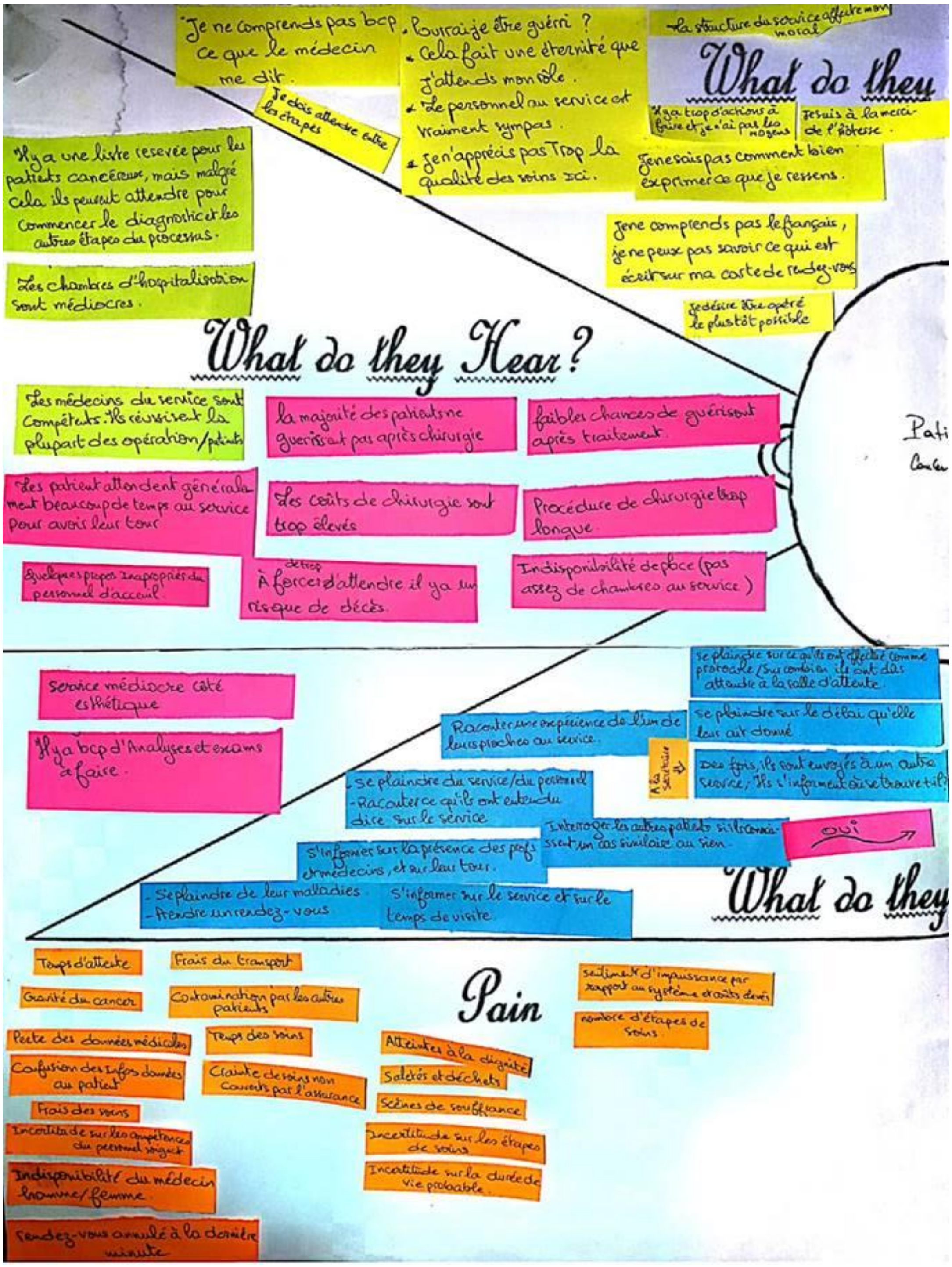


*__Figure 59: Part 2 -Empathy map__*

# Appendix 4
# Value map

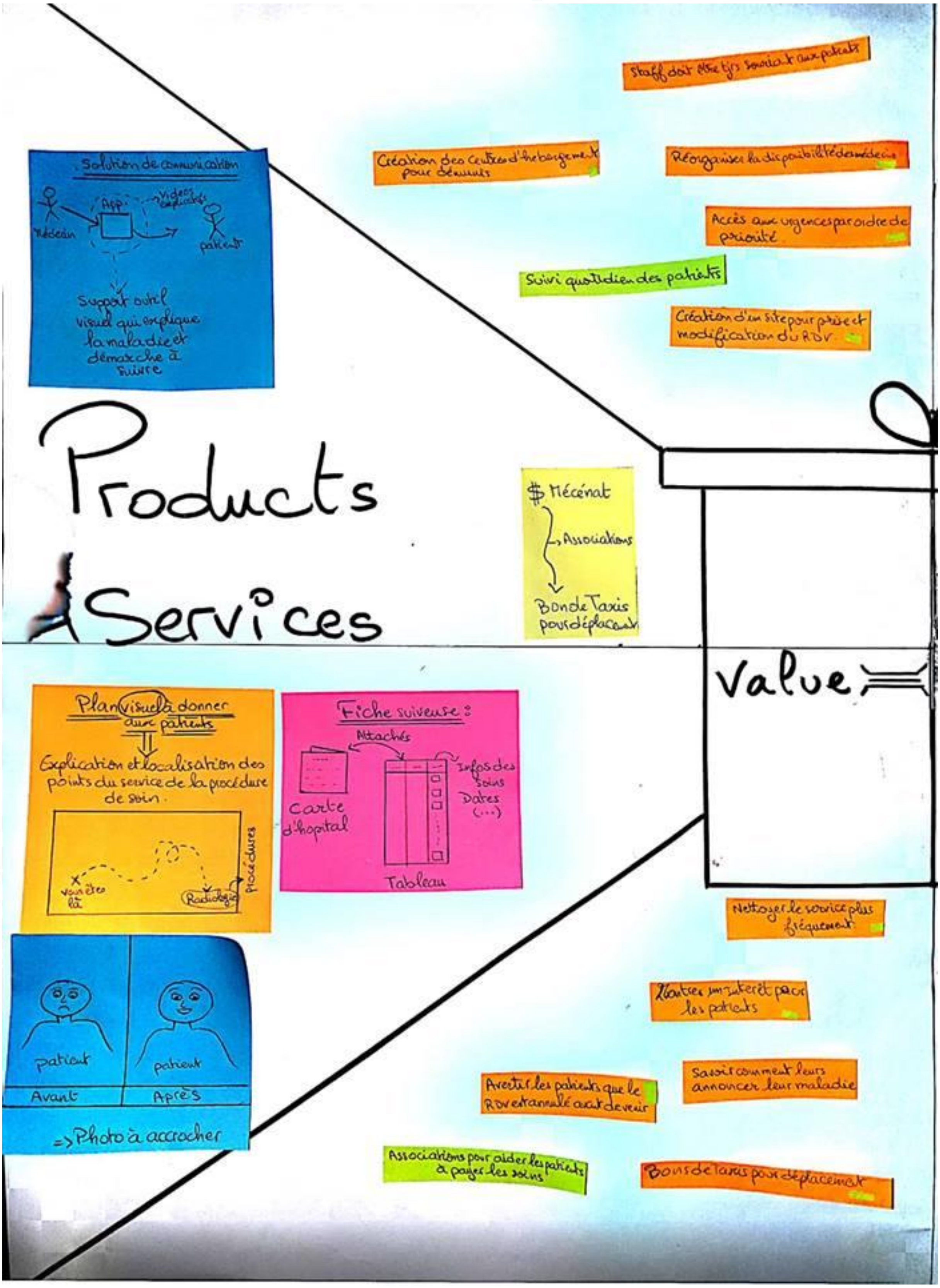


***Figure 60: Value map- part 1***

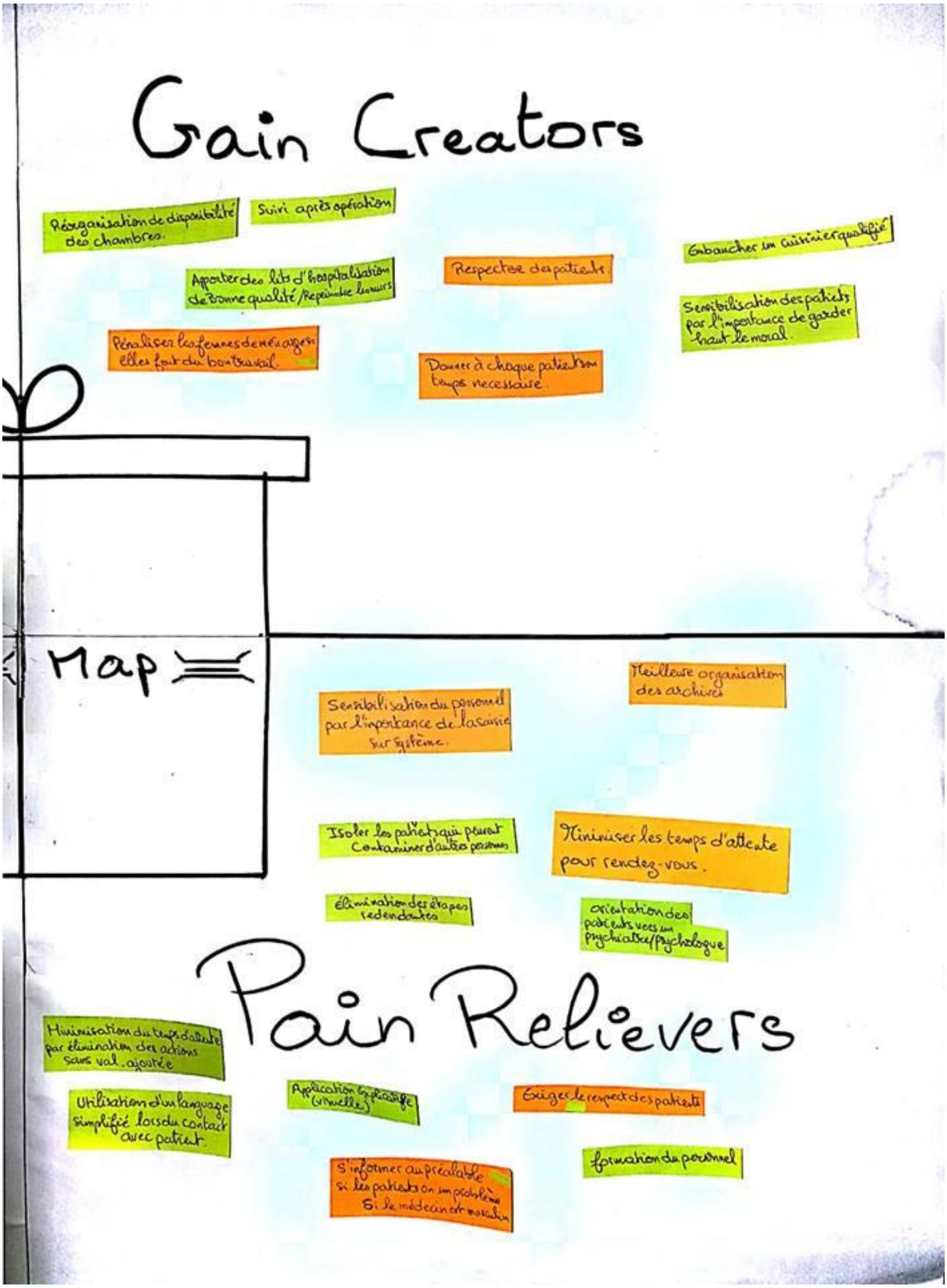


*Figure 61: value map- part 2*

# Appendix 5
# Table: normal law

$P\{z \geq Z_\alpha\}$ ou $P\{z \leq -Z_\alpha\}$

| $Z_\alpha$ | x.x0 | x.x1 | x.x2 | x.x3 | x.x4 | x.x5 | x.x6 | x.x7 | x.x8 | x.x9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | .5000 | .4960 | .4920 | .4880 | .4840 | .4801 | .4761 | .4721 | .4681 | .4641 |
| 0.1 | .4602 | .4562 | .4522 | .4483 | .4443 | .4404 | .4364 | .4325 | .4286 | .4247 |
| 0.2 | .4207 | .4168 | .4129 | .4090 | .4052 | .4013 | .3974 | .3936 | .3897 | .3859 |
| 0.3 | .3821 | .3783 | .3745 | .3707 | .3669 | .3632 | .3594 | .3557 | .3520 | .3483 |
| 0.4 | .3446 | .3409 | .3372 | .3336 | .3300 | .3264 | .3228 | .3192 | .3156 | .3121 |
| 0.5 | .3085 | .3050 | .3015 | .2981 | .2946 | .2912 | .2877 | .2843 | .2810 | .2776 |
| 0.6 | .2743 | .2709 | .2676 | .2643 | .2611 | .2578 | .2546 | .2514 | .2483 | .2451 |
| 0.7 | .2420 | .2389 | .2358 | .2327 | .2297 | .2266 | .2236 | .2206 | .2177 | .2148 |
| 0.8 | .2119 | .2090 | .2061 | .2033 | .2005 | .1977 | .1949 | .1922 | .1894 | .1867 |
| 0.9 | .1841 | .1814 | .1788 | .1762 | .1736 | .1711 | .1685 | .1660 | .1635 | .1611 |
| 1.0 | .1587 | .1562 | .1539 | .1515 | .1492 | .1469 | .1446 | .1423 | .1401 | .1379 |
| 1.1 | .1357 | .1335 | .1314 | .1292 | .1271 | .1251 | .1230 | .1210 | .1190 | .1170 |
| 1.2 | .1151 | .1131 | .1112 | .1093 | .1075 | .1056 | .1038 | .1020 | .1003 | .0985 |
| 1.3 | .0968 | .0951 | .0934 | .0918 | .0901 | .0885 | .0869 | .0853 | .0838 | .0823 |
| 1.4 | .0808 | .0793 | .0778 | .0764 | .0749 | .0735 | .0721 | .0708 | .0694 | .0681 |
| 1.5 | .0668 | .0655 | .0643 | .0630 | .0618 | .0606 | .0594 | .0582 | .0571 | .0559 |
| 1.6 | .0548 | .0537 | .0526 | .0516 | .0505 | .0495 | .0485 | .0475 | .0465 | .0455 |
| 1.7 | .0446 | .0436 | .0427 | .0418 | .0409 | .0401 | .0392 | .0384 | .0375 | .0367 |
| 1.8 | .0359 | .0351 | .0344 | .0336 | .0329 | .0322 | .0314 | .0307 | .0301 | .0294 |
| 1.9 | .0287 | .0281 | .0274 | .0268 | .0262 | .0256 | .0250 | .0244 | .0239 | .0233 |

***Figure 62: Table of the normal law***