Improving Patient Flow with Lean Methodology: A Case Study at the Montreal General Hospital Colorectal Department

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This is to certify that the Thesis prepared,

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Abstract

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Jonathan Rodriguez

Quebec healthcare institutions are facing an increase in patients' request and asked to do more with less, impacting the healthcare staff by working harder and longer shifts. Despite efforts, waiting lists keep growing in number resulting in patients waiting long periods of time for a specific treatment. Lean methodologies, originally developed in the manufacturing industry, offer an alternative to do more with less. Lean focuses efforts on eliminating activities that do not add value from the patient perspective and builds more efficient processes to perform an activity. This thesis proposes the use of Lean methodologies to improve the patient flow throughout the colorectal department at the Montreal General Hospital located in Montreal Quebec. A detail examination of the current processes of the department is analyzed and a proposed system is discussed with the use of value stream mapping and Lean principles. After rigorous data collection and analysis, initial improvements in the capacity of the department will increase in the common flow and colonoscopy loop by 20 patients per week and 60 patients per week respectively. In addition, Lead time will significantly decrease; up to 25% in short procedures, 20% in colonoscopies and 10% in surgeries.

Keywords: Lean Healthcare, Value Stream Mapping, Patient Flow, Care Delivery.

“What we have done for ourselves alone dies with us; what we have done for others and the world remains and is immortal”

Albert Pike

Acknowledgements

I would like to dedicate this Master's thesis to my family. There is no doubt in my mind that without their constant care and support I could not have completed this process.

I am privileged to highlight the inspirational guidance and counsel received from Dr. Kudret Demirli. He has given me the opportunity to understand the importance of Lean Healthcare methodologies and inspire me to continue improving our healthcare delivery.

I would also like to acknowledge the support and assistance given to me by the colorectal department at the Montreal General Hospital and my mentors there. Finally, I would like to thank my wife, Tina, for her support and encouragement. I could not have completed this journey without her comprehension, tolerance, and enthusiasm.

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1 Introduction

Healthcare institutions' success is determined by quality, cost and efficiency of care delivery. Hospitals around the world are concentrating efforts and developing new systems in order to improve patient flow through their premises and lower costs all around. Healthcare delivery institutions are facing an increase in patient population; Therefore, it is very important to develop flexible, efficient and responsive systems to operate at an acceptable service level. Consequently, institutions that do not adopt change will struggle to keep waiting lists at acceptable standards and deliver care at a slower rate. Lean provides a culture of change that enables systems to operate according to current demand and develop self-learning processes to increase efficiency in care delivery at a lower unit cost (Baker, Taylor, & Mitchell, 2009). By adopting a Lean system approach, healthcare institutions will be able to benefit from improving patient care while saving time and resources (Fine, Golden, Hannam, & Morra, 2009). Therefore, Lean healthcare systems are proposed to effectively change Canadian Healthcare delivery.

1.1 Background of Lean Manufacturing

Lean Manufacturing is a model and collection of tools that has the main objective of reduce cost, time and improve quality by eliminating waste (activities that do not add value to the customer experience). This model is more than a set of steps to follow or tools to implement. In 1945, Toyota automobile company set out to improve quality while increasing their productivity at the same time. They were forced to think originally and create flexible systems that allow them to be responsive to the market needs at that time. It was until 1980s that Toyota officially documented the details of their system and it was at this time when Norman Bodek, currently president of PCS press, started to translate the work of Taiichi Ohno and Shingeo Shingo, founders of the Toyota production system (Graban, 2008). In essence, this system shifted the approach of the manufacturing engineer from single machines and their role, to the flow of the product through the system. Toyota concluded that by having the right size machine for the volume needed to process, self-monitoring quality, lining machines in process sequence, quick setups and clear communication between processes, it would be possible to produce products at low cost, high variety, high quality, and rapid throughput times to respond to customer demands (Womack, Jones, & Ross, The Machine That Changed the World, 1991). Table 1 shows the difference between organizations that have implemented a Lean culture versus a Traditional culture.

Traditional Culture	**Lean Culture**
Functional Silos	Interdisciplinary Teams
Managers direct	Managers teach
Blame staff	Blame process
Rewards individuals	Rewards group sharing
Internal focus	Customer focus
Expert driven	Process driven
Volume lowers cost	Removing waste lowers cost
Guard information	Share information
Supplier is enemy	Supplier is ally

Table 1: Traditional Culture versus Lean Culture (Miller, 2005)

1.2 “Waste” in Lean

According to Lean methodology there are three types of activities: value added activities, necessary non-value added activities and unnecessary non-value added activities. Value added activities bring additional value to a procedure or a service; Patients consider these as the activities that change the form, fit or function of a product or service. Necessary non-value added activities are those ones that do not change or add anything to the product or service but they are absolutely necessary in the system, for example, waiting after a short scope procedure to assure there are no complications. Finally, unnecessary non-value added activities are those ones that do not change or add anything to the product or service and can be eliminated without affecting the health and safety of the patient. Both the necessary and unnecessary non-value added activities are considered “waste” in Lean methodology; efforts to reduce or eliminate non-value added activities are the key to improve the system’s flow.

Table 2 represents the 8 types of waste according to Lean Healthcare.

Type of Waste	Definition	Example
Defects	Incorrect delivery of services	Incorrect patient set-up
Overproduction	Providing more, earlier and/or faster services than required.	Material set-ups for one month
Waiting	Idle time	Waiting for physician
Transportation	Moving materials, resources or patients from/to locations	Physician walks from examination room to office
Inventory	Accumulation of materials, resources or patients	Waiting list for a procedure
Motion	Walking, searching or unnecessary motions	Clerk looking for misplaced patient file
Excess Processing	Performing more than necessary to perform effectively	Mailing two copies of patient preparation
Confusion	Performing a service without clear instructions	Incorrect patient file preparation

Table 2: 8 Types of Waste

1.3 Background of Montreal General Hospital

The McGill University Health Centre (MUHC), located in Montreal, comprises of five teaching hospitals united with the Faculty of Medicine of McGill University, and consistently involves clinical and research specialists from around the world to create new knowledge and prepare the next generation of medical professionals.

The Montreal General Hospital (MGH), part of the MUHC, was established due to a rapid climb in population in the early 19th century in Montreal. As the population grew by 5,000 people in 1816, it motivated stakeholders that the previous existing "Hôtel Dieu" and "Hôpital Général de Montréal" were not prepared nor equipped to accommodate this increase change in population. With this in mind, the Montreal General Hospital was founded and as the time passed, it grew in both size and scope. The MGH soon expanded by acquiring nearby buildings and lots until it reached its present size becoming one of the most important hospitals in the province of Quebec (About our hospital, 2009). Figure 1 illustrates the Montreal General Hospital site in 1874 and as of today.

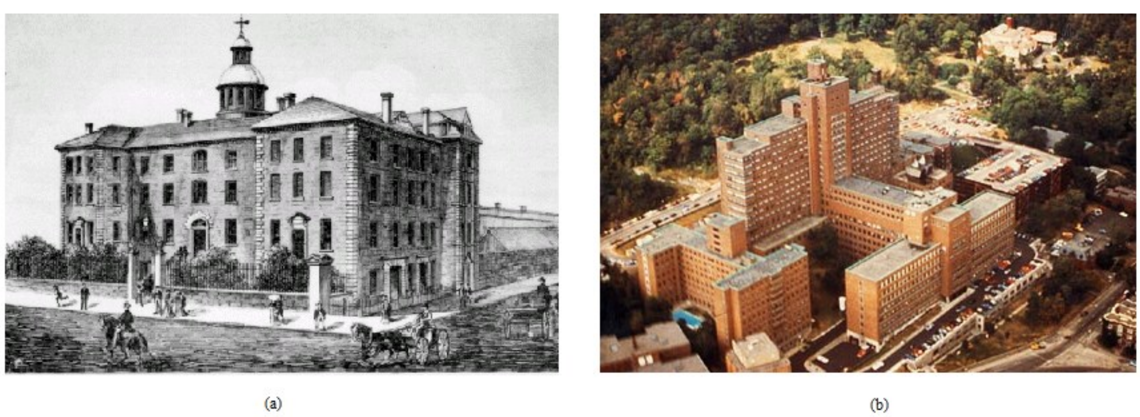


Figure 1: (a) Montreal General Hospital in 1874 (Unknown); (b) Montreal General Hospital today (McGill University, 2011)

Currently, the Montreal General Hospital consists of more than 180 departments and clinics. It consists of 417 beds, 275 resident staff and 925 volunteers. There are approximately 15,000 admissions and 350,000 consultations per year in the emergency and outpatient departments (McGuill University Health Centre, 2012). In addition, a research center was opened on the hospital grounds in 1973 and has been expanding throughout the years.

1.4 Background of Colorectal Department

In April 2011, the head specialist of the colorectal department at the Montreal General Hospital placed a request to evaluate the current conditions of the department. This request was the result of a series of observations and complaints from patients and staff about the long waiting times to accept any type of care. Furthermore, waiting lists were growing despite the efforts to reduce no show patients, book appointments faster and develop better ways to process documentation.

Currently, the department consists of three colorectal specialists, one technician, one assistant technician, two clerks and one medical secretary. In terms of facilities, the department operates in different locations spread over two floors of the hospital. The check-in office, sterilization room and the examination room are located in the same floor but not next to each other (See Figure 2). The colonoscopy room is on another floor isolated from the rest of the department and it is shared two out of five days of the business week with the gastroenterology department.

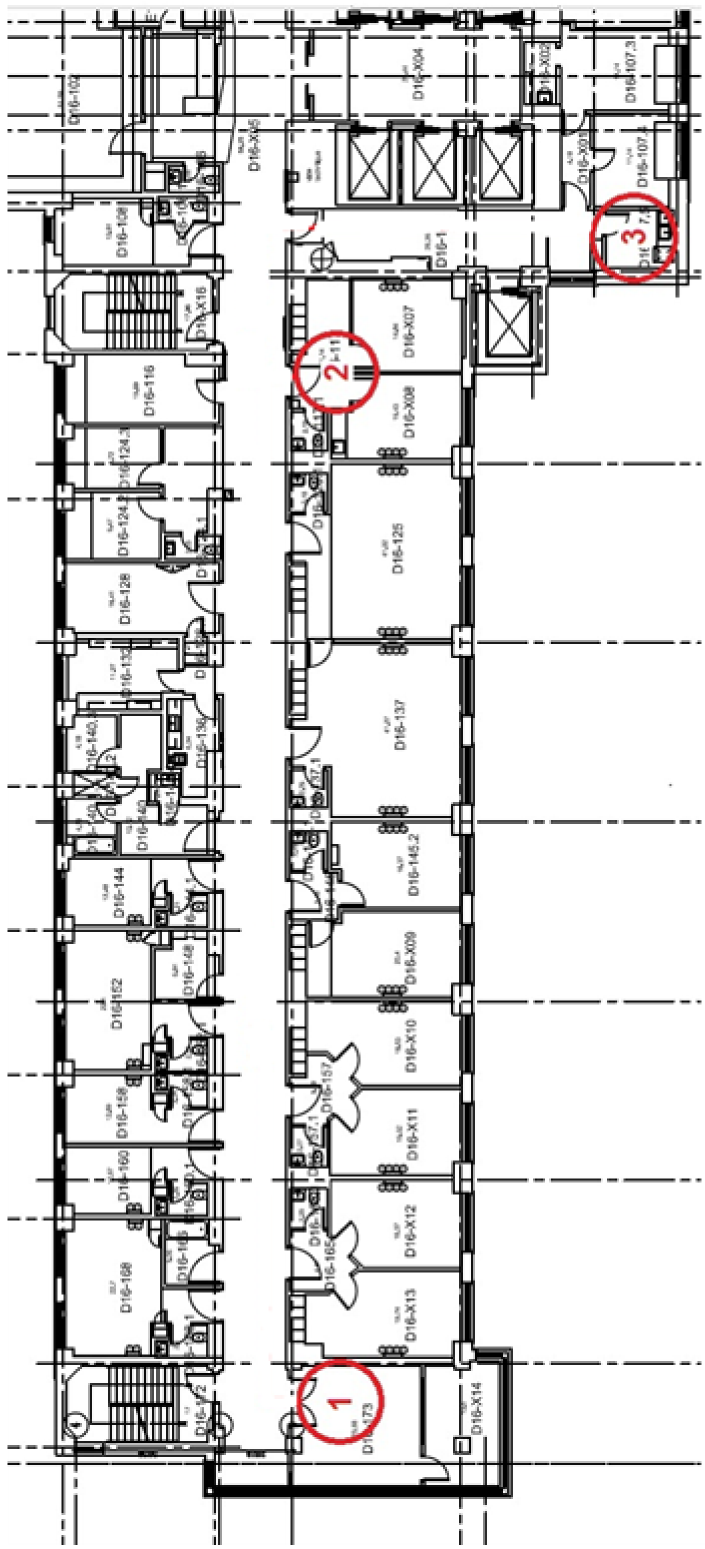


Figure 2: Colorectal Main Floor. (1) Check-in Office; (2) Examination Room; (3) Sterilization Room.

Formerly, the department tried to relocate the premises in a location where every office could be next to each other, however, due to economic difficulties and the priority in other projects this could not be possible. In another attempt to improve current conditions, the department also applied for the allocation of a full time worker to alleviate some of the workload of the clerks, this was not possible due to the lack of budget in the department for the coming years. On the positive side, the department will soon benefit from the acquisition of a fourth colorectal specialist that will absorb a great number of patients placed in the waiting list. However, this translates into an increase of appointments to book, calls to be done and potentially an increase of every administrative task performed in the department. Therefore, the department is facing a big challenge in the near future and the system is currently not prepared to cope with it.

1.5 Why Quebec needs Lean in healthcare

In 2012-13, Quebec's healthcare sector represents 42.5% of the total spending budget (Figure 3), an increase of 3.4% from last year. This should represent the urgency to improve every healthcare system in the province and the priority to do so. For example, by managing more efficiently the amount of patients that go through a department and utilizing fewer resources per patient, we can reduce the unit cost per patient and process more patients per unit time (Kim, Spahlinger, Jeanne, & Billi, 2006). This will potentially benefit the utilization of government's budget allocated to healthcare.

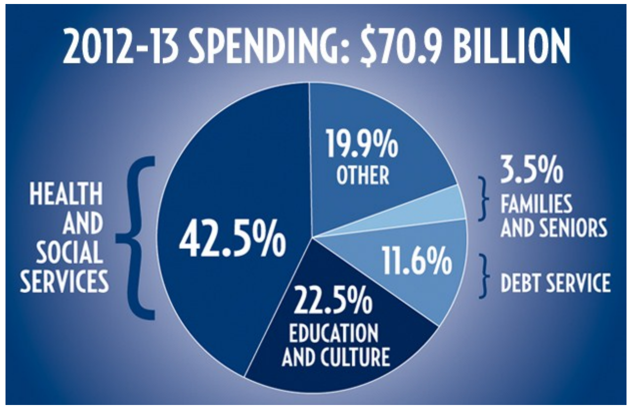


Figure 3: Quebec's budget plan 2012-13 (Institut de la statistique du quebec, 2012)

Cost escalation is not only at a provincial level, the Canadian Institute for Health Information published the national health expenditure trends from 1975 to 2011 (Figure 4) where it shows a positive trend since 1996. Therefore, efforts to increase efficiency is not an option, it is a necessity that will determine the future of healthcare delivery.

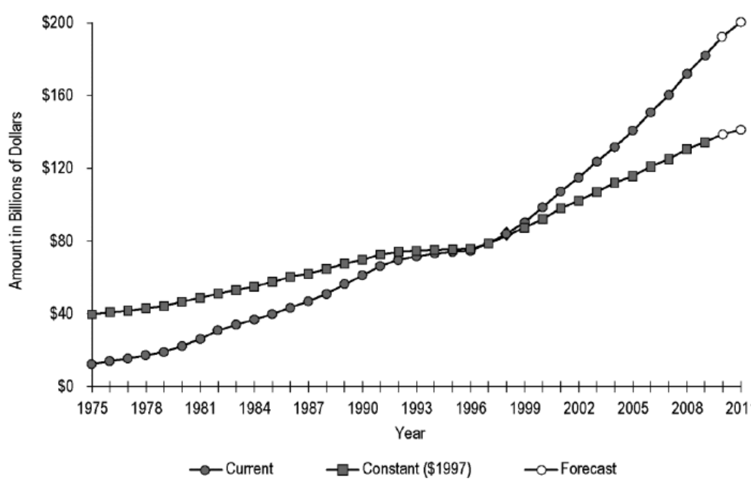


Figure 4: National Health Expenditure Trends, 1975 to 2011 (Canadian Institute for Health Information (CIHI), 2011)

As well, the healthcare industry in Canada is facing another major problem, an increase in patient requests for care. As patient population gets older, the need for healthcare services increases, doing so, the demand for services in hospitals, clinics and other institutions are facing an increase in patient demand (Daniel & William, 1993). Analyzing this further, Figure 5 represents the density of the Canadian population in 2009, 2036 and 2061 in a M1 scenario (medium-growth scenario with historical trend of 1981 to 2008) which suggests that medium aged population will grow at a constant rate in comparison to senior population that will grow in a much more accelerated rate.

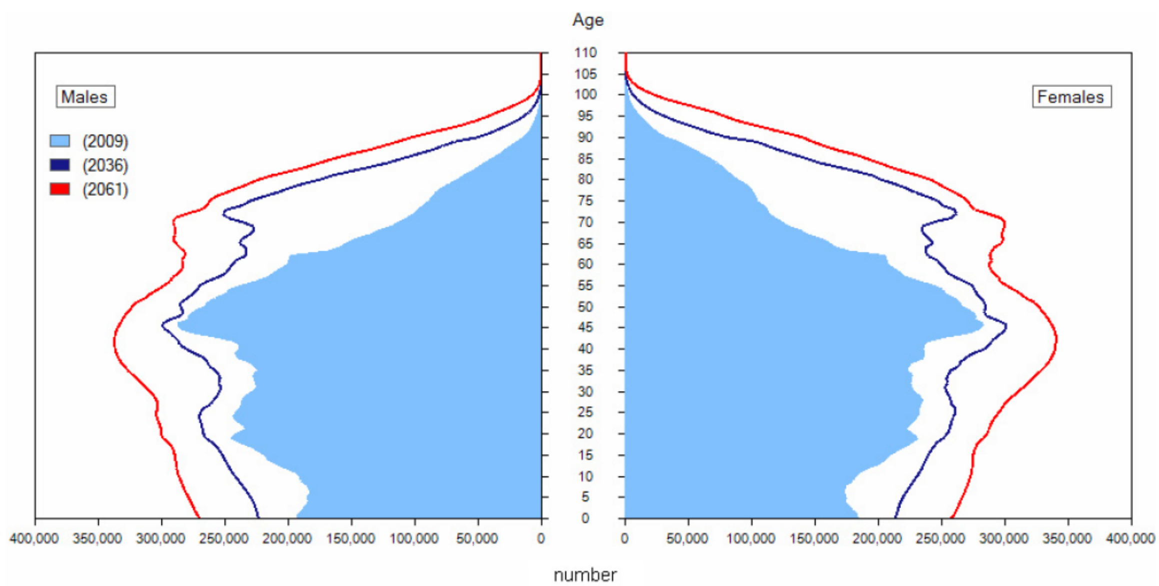


Figure 5: Age pyramids (in number) of the Canadian population, 2009, 2036 and 2061 (scenario M1) (Statistics Canada, 2010)

In addition, Figure 6 exhibits that death distribution of Canadian population will shift towards older population. Therefore, according to statistics Canada, the population will shift towards having more senior population and a longer period of life for them in the near future. Consequently, the healthcare sector will continue to face cost escalation and an increase on demand for the next fifty years and if current systems do not improve their practices they will have longer waiting lists putting at risk Canadian lives. Lean healthcare has the capabilities to create efficient and flexible systems to adapt to this new situation and provide Canadian society with a better healthcare system experience.

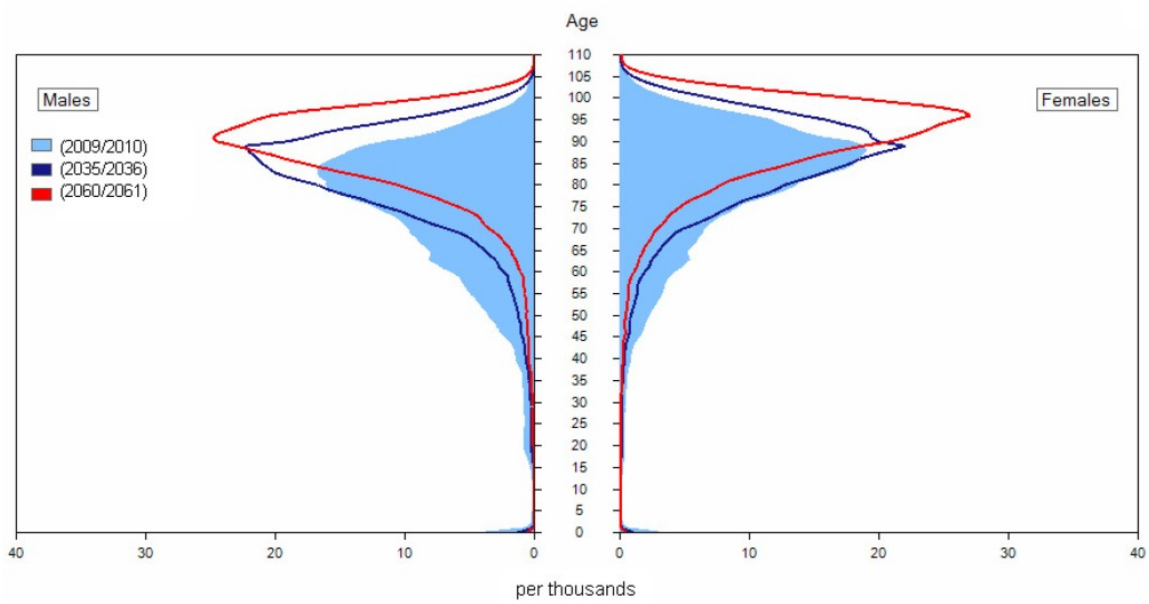


Figure 6: Deaths pyramids (in relative value) of the Canadian population, 2009/2010, 2035/2036 and 2060/2061 (scenario M1) (Statistics Canada, 2010)

Lean healthcare has proven that it can work and can improve the way care is delivered. For example, a chain of pilot projects have been deployed to test the effects of lean at a community medical center in Missoula, Montana. Early results show a reduction of turnaround time for pathology reports from the anatomical pathology lab from five to two days and a reduction of medication order to treatment initiation from 4 hours to 12 minutes (Jimmerson, Weber, & Sobek, 2005). Also, in Pittsburgh, Pennsylvania, a group of hospitals have implemented lean concepts and methodologies to minimize the risk of developing central catheter-related bloodstream infections. Several of these hospitals have been able to cut the incidence of central line infections by 50%-90% through implementation of lean production methods (Spear, 2005). As has been noted, Lean healthcare is capable to improve care delivery and it is applied throughout this research as the principles to follow.

1.6 Objectives

The purpose of this research is to develop an improved colorectal department service operation for the Montreal General Hospital addressing the specific problems and challenges in this particular case. The proposed system focuses efforts on reducing different sources of waste (Section 1.2), increasing capacity, reducing rework, improving staff workloads and reducing the lead time of the services provided by the department. Like Bill Douglas, CFO of Riverside Medical Center, said: “Lean is a quality initiative, isn’t a cost cutting initiative. But the end result is, if you improve your quality, costs will go down”. Therefore, by implementing the proposed system, the unit cost for a specific service can be reduced substantially (Figure 7).

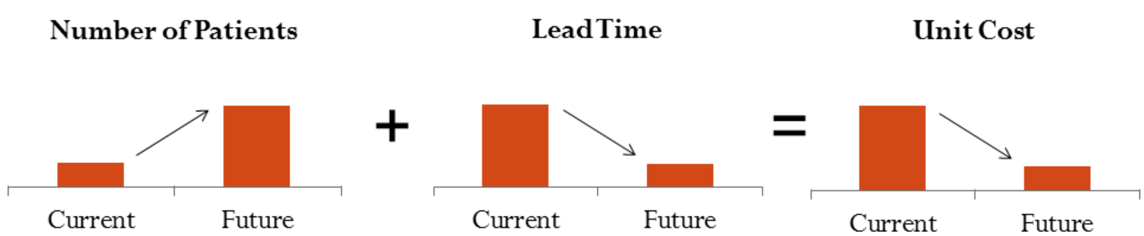


Figure 7: Throughput plus Lead Time impact on Unit Cost

The department is a critical part of a much greater plan for this hospital. If the department adopts this methodology and implements the proposed system, it could impact many other departments to start this journey towards a more efficient delivery of care. Therefore, it is a main objective of this research to influence other departments and motivate them to start their journey to achieve a Lean system.

2 Literature Review

Lean methodology literature is abundant in the engineering field, from manufacturing to healthcare systems. Organizations have implemented this methodology due to the great flexibility of adaptation and the results obtained by large corporations, therefore, attracting others to join in the same journey. However, as with any methodology there are papers suggesting potential disadvantages of this methodology that need to be considered before adopting in any environment.

The supporting literature is a collection of recent published papers that define powerful concepts that aided the analysis and solution generation of this research. Finally, the last section summarizes and links the literature considered to form part of the body of knowledge to carry out the project.

The objective of this chapter is to highlight recent research when implementing these manufacturing concepts in the healthcare industry. In addition, this literature has been referred to compare similarities and differences between previous work done in other institutions and what type of adaptation can be performed to apply certain tools and techniques to improve the quality of this research paper.

2.1 Supporting Literature

Piggott et al. (2011) described the journey taken in Manitoba to achieve excellent emergency cardiac care with Lean principles. The team challenged the misconception that Lean methodology would not address the problems in the emergency department for this specific diagnosis due to the complexity of the condition. However, with the application of workloads analysis, waste elimination efforts and a medical support team on-site, the project achieved an increase of 37.4% completed triaged patients within ten minutes and an increase of 12.1% on patients seen within 60 minutes by a physician. These results were achieved by implementing only a few modules of Lean methodology and currently are working on expanding this project into an institution level approach.

Kim et al. (2006) stated that Lean principles deliver high quality level of care and with the proper adaptation to the healthcare environment; this can provide a more efficient delivery system that will adapt to the present operation requirements to satisfy patient demand. In addition, value stream mapping techniques are referred as the tools to analyse the system's flow of patients in order to increase throughput with the same amount of resources. However, the author makes note that the healthcare industry is formed by a scientific community and more research should be performed in this field before adopting this model at a large scale.

Heenan and Higgins (2009) talk about the importance of getting physician leaders involved in improvement projects. They stated that engaging physicians provide a valuable input when generating improvement scenarios. The key for success of a healthcare project lays on the engagement of the staff, in specific physicians, since the beginning of the project. This theory also proposes the involvement of highly trained staff due to their insights on the processes and their capability to create new scenarios without jeopardizing potential constraints an outsider can neglect.

Mann (2005) refers to Lean as a combination of twenty percent tools implementation and eighty percent changing leaders' practices and behaviors. He states that senior management has the control to enable the success of a project by involving themselves in the project and participating at every step of the process. Not only senior level participation is needed to succeed but more importantly their leadership towards the rest of the staff. The author also states that the longer an organization pursues lean procedures, the higher possibilities to achieve more improvements in the system.

Westwood (2007) discussed the optimization of a system by eliminating sources of waste and increasing customer value added activities. In his paper, he states that executive support is an essential part for success of any lean project. Lean implementation should start from the top, as part of strategic plan, to the bottom. In addition, the author stressed the importance of front line staff involvement in the root cause analysis and implementation plans.

Fine et al. (2005) raised the importance of leading change in lean healthcare projects. The authors developed a roadmap with four stages to succeed while implementing a project of this nature. Those stages basically consist in developing a desired outcome, assessing that the environment where the project is taking place is ready for change, broadening support and sustaining the changes implemented. In addition, they state that lean healthcare is feasible in any type of hospitals, from teaching hospitals to research intensive care institutions. With this in mind, lean healthcare has no boundaries and with the proper methodology implementation can be successful in any environment.

Melton (2005) revealed the common forces supporting and resisting a lean implementation in process industries. She discovered that for every force supporting there was a resisting side opposing change. However, according to the intensity of each force determines the readiness of the environment in change. According to her theory, process industries future success relies in the adoption of flexible and responsive systems. For healthcare, this statement not only determines the success of the hospital in question but the delivery of care throughout a country.

Erenay (2010) recognized the importance of process improvement in the colorectal departments in the healthcare industry. He states that colorectal cancer is the second deadliest and the fourth most common cancer, and the risk can be significantly reduced by periodic colonoscopy procedures. However, her paper focuses on optimizing the screening procedures in order to triage colorectal patients more efficiently. This paper assumes that the screening procedure is the number one priority in order to improve the system, but this has not been proved in the study. Nevertheless, the Markov decision process recommended in Erenay's paper is promising and can be adapted to any other institution.

Kamma (2010), presents in a paper the importance of lean techniques in the healthcare environment. The paper states that there is a lack of implementation documentation and the methodology to analyse a specific department in healthcare with value stream mapping tools. Therefore, there is the need to provide a case study that implements a strong methodology from beginning to end using value stream mapping tools and producing improvement efforts based on Lean principles.

Lummus (2006) performed a value stream mapping case study at a hospital in the Midwest United States to improve patient waiting times. A future state was developed giving priority to patient flow with first in first out transfer points. However, the case study fails to provide the waiting time reductions and the increase in throughput. In addition, the study suggests the importance of educating the staff involved in patient flow and improvement techniques to have a successful implementation.

Brideau (2004) suggests: “In order that caregivers vary intelligently from one patient to another, first the unwanted variation should be removed from the process”. This publication states the importance of patient flow in the healthcare environment and the challenge that represents due to the nature of the work perform in a healthcare facility. Brideau establishes that by improving patient flow and reducing the variation of personal procedures, the system can greatly benefit. He proposes to standardize practices within procedures to reduce processing time variations and be able to better predict and plan according to patient demand.

Winch (2009) discusses the adoption of manufacturing practices, in specific lean principles, into the everyday tasks and processes in hospitals. The author findings show that re-engineering health care delivery with lean concepts has a significant increase in performance, efficiency and quality. However, it is stated that there are potential harms on patient’s safety that researchers have not explored due to the lack of historical data. Lean research in healthcare is considered fairly new and the need for additional case studies and research in this area is needed. Therefore, this thesis contributes to the lack of structured studies performed in the healthcare industry and provides detail information about different stages of the implementation process.

In 2007, the cancer care Ontario society launched the “ColonCancerCheck” program. This initiative was the first of its class in a Canadian province to support five hospitals in the region to improve their colorectal department processes. This program introduces

Lean concepts to evaluate the performance of each of the five hospitals involved. These tools are described in detail and forms are provided to document the milestones, data collection and performance metrics. In contrast, Quebec healthcare associations have not adopted any of these methodologies and efforts for processes improvements have not been published nor rewarded (Ontarion Ministry of Health and Long-Term Care, 2007).

As reviewed, there is an abundant amount of literature that has documented the success of Lean methodology and its tools. However, there is not enough documentation that outlines how to perform value stream analysis and implementation of optimization techniques in the healthcare environment in great detail. For the purposes of this thesis, a collection of different tools and approaches have been adopted. This specific combination of concepts has not yet been implemented in any colorectal department in Canada. These concepts include the involvement of physicians in the project, leading change techniques for success implementation, recognition of the supporting and opposing forces in the implementation environment, identifying sources of waste in a healthcare scenario, A3 methodology and Lean principles. Recognizing the importance of this project could impact the second most deadly type of cancer in North America. Therefore, the methodology provided by this thesis is considered could potentially become a standard to follow in the healthcare industry to carry continuous improvement projects.

3 Methodology

The project was carried according to Lean principles and A3 methodology. Lean principles (Womack & Jones, Lean Thinking: Banish Waste and Create Wealth in your Corporation, 2003) were used to map the course of action to follow and potential areas of improvement. However, the A3 methodology (Baker, Taylor, & Mitchell, 2009) defined the skeleton of this project; the colorectal department staff participated in the completion of the template shown in Appendix D with the researcher guidance and leadership. Both Lean principles and A3 methodology are explained in further detail in the following sections.

3.1 Lean Principles

Lean principles were used throughout the A3 methodology implementation to develop the analysis of the department and create the proposed system. The five principles are: Define value, map value stream, create flow, establish pull, and pursuit perfection (See Figure 8).

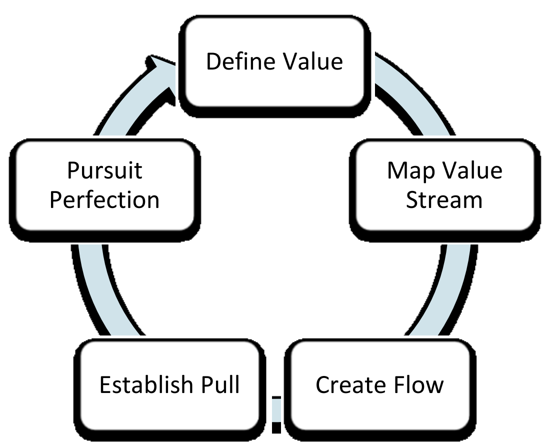


Figure 8: Lean Principles

3.1.1 Define Value

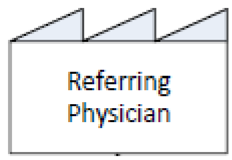
Define Value was utilized to define the activities that meet the patient's needs at a specific time and cost. Value is defined according to the patient's perspective as the activities that add something meaningful to the overall experience delivered by the producer. From the patient's perspective, value is the ultimate reason why they acquire a specific service. For example, a patient that needs a colonoscopy will consider value added activities as the ones that have a direct impact on the colonoscopy process delivery like the Medical Doctor (MD) performing the colonoscopy, the technician operating or assisting the MD in the examination room. However, the patient does not consider the background paperwork needed to book the colonoscopy room as value added activity. Therefore, it is important to define the value in the patient's perspective.

3.1.2 Map the Value Stream

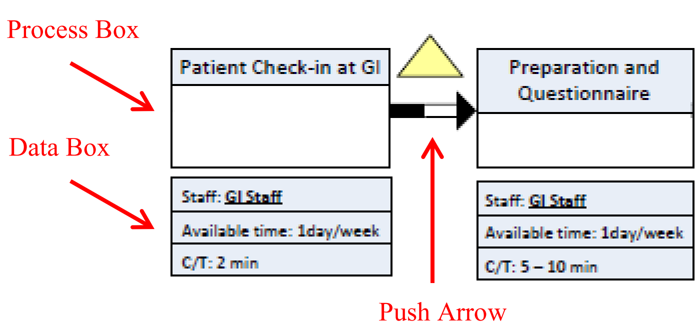
Map the value stream illustrates the current system that the department operates under; this includes information flow, resource utilization, time stamps and other important metrics needed to outline the current procedures. This is a visual representation of the system's operations that will aid the researcher/facilitator to have a clear picture of everything that involves into delivering a service. For the purpose of this research, the approach is departmental; meaning that the value stream map will include every process that involves or impacts the colorectal department. Another approach could be symptomatic; for example, every process involved on the value stream of an influenza patient. It is important to note that mapping the value stream should include staff members and a lean facilitator to achieve best results.

This thesis followed Value Stream Mapping as follows (Rother & Shook, 2003):

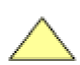
1. Identify the "patient family" to analyze; a "patient family" is a group of a specific type of patients that go through similar processing steps in the value stream.
2. Identify the customer of the value stream; the customer is placed at the top right corner of the value stream map. For example, the customer icon is represented as follows:



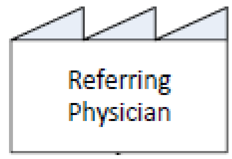
3. Identify every process involved in the processing of the patients in the department. Each process is represented separately if they are not connected with continuous flow in between. In addition, important information, such as cycle time, change over time, staff and available work hours, is recorded for each process in an information box below the process icon. For example:



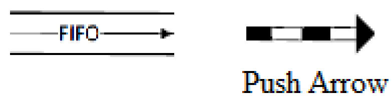
4. Waiting times between each process are identified and quantified. These are represented in the current value state map as yellow triangles.



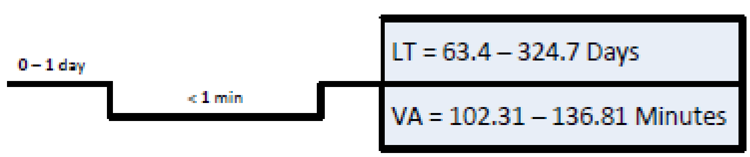
5. The source of demand is identified and placed in the top left corner of the map. This determines where the specific demand of the value stream services comes from. The icon is the same as for the customer, for example:



6. The next step is to add the information and patient flow to the map. The method of communication between each process and the type of patient transfers between processes; for example first in first out, last in last out, push or pull. For example:



7. The last part of the map is the timeline. At the bottom of the map, a timeline is placed containing two types of information, waiting times (represented in a higher step) and lead time for each process (represented in a lower step of the timeline). Note that "LT" is total lead time and "VA" is value added time. For example:



3.1.3 Create Continuous Flow

Create continuous flow focused in the customization of a proposed system where patient flow interruptions were eliminated without jeopardizing the health and safety of patients and considering the restrictions and constraints of the project. Flow is considered a major part of lean principles, in an ideal situation the patient will go through the department's operations without stopping in between, however, in a realistic scenario this cannot be achieved 100%. Several factors affect flow in a value stream: resources available, sharing of resources, facility layout, necessary waiting times due to health and safety and many others. However, whenever continuous flow can be achieved, efforts to attain this scenario should be implemented.

3.1.4 Establish Pull

Establish pull, developed different techniques to have a controlled inventory levels (patient waiting times) on those activities where continuous flow of patients in the system could not be achieved. For example, if the department has only two resources available and there is a demand of three patients, one patient has no choice but to wait until one of the resources is available to process him/her.

In addition, the *pull* principle states that in cases where continuous flow is not achievable, a controlled queue can be developed and the interaction between processes should be controlled by the following process. For example, consider that the resource one and two are one after another and that resource one is faster than resource two, resource one should not start processing a patient until resource two calls for one. This prevents an uncontrollable accumulation of patients between processes.

3.1.5 Pursue Perfection

Pursue perfection is an ongoing activity that reinforces the importance of continuous reiteration of efforts to improve the operations of the department. Hence, these principles are considered the antidote for systems where different sources of waste, or activities that do not add value to the service being provided, prevent the department from operating efficiently (Womack & Jones, Lean Thinking: Banish Waste and Create Wealth in your Corporation, 2003).

3.2 A3 Methodology

The A3 methodology consists of seven different sections: Develop title of the project, Identify the problem, current condition, target condition, root cause analysis, proposed countermeasures, plan and follow-up. In complement, this thesis methodology utilizes the five Lean principles mentioned previously throughout the process.

3.2.1 Title of the Project

Developing the title of the project focuses on the problem and not on the particular solution, for example, "Rework in CT-Scans resulting in longer patient waiting times" instead of "Requests calls produced due to lack of technology system update".

3.2.2 Identify the Problem

Identifying the problem consists of a consolidated effort form the department's staff to identify the true problem currently faced. The key to identify the true problem is to determine the issue that causes other ones. This is a very important phase that points to the direction to follow.

3.2.3 Current Condition

The current condition section is the most important part of this methodology. In this section, a current value stream map of the department was generated including processes, information channels and staff allocation; the process mapping was developed according to best practices in Value Stream Mapping previously discussed in section 3.1.2.

3.2.4 Target Condition

The next section of the A3 methodology, the target condition, includes certain metrics to concentrate and targets to try to achieve after the study is implemented (managerial and floor staff were included in this section of the methodology).

3.2.5 Root Cause Analysis

Next, the root cause analysis section consists of the understanding of the problem that was causing several effects in the system. This result was obtained through a series of one-to-one interviews with the department's staff to successfully complete this stage and the analysis of the current value stream map previously developed and by identifying different sources of waste according to Lean methodology.

3.2.6 Proposed Countermeasures

The next section proposes countermeasures by developing a future value stream map according to lean best practices to improve the system's efficiency and achieve the target condition previously set. To develop the future value stream map, the following steps were followed:

1. Identify and eliminate sources of waste in the current operations. For each loop of the system flow, different sources of waste need to be identified and have their impact measured in the department's performance. These sources of waste fall under the categories previously discussed and provided in Appendix A. Once they are identified, the department needs to propose solutions to eliminate or reduce these waste activities in order to achieve the proposed future value stream map.

2. Create continuous flow where possible. Identify the opportunity to combine and/or eliminate a process box in the system's flow. This will avoid the accumulation of patients in between processes, improve the flow and lower the lead time.
3. Create pull when continuous flow is not possible. If a process box cannot be eliminated or combined with another one, create pull. Pull is when the subsequent process box pulls patients from the previous process box. There are different reasons for continuous flow to be infeasible, the process box represents a task that takes place in a different physical location than the previous one, the resources involved in the processing of a patient are shared, available hours are different in each process, and many other particular reasons that can apply to a specific situation.
4. Calculate takt time (Time per unit to process a patient in order to meet demand). For each loop, takt time is calculated and will determine the "heartbeat" of the system. In an ideal scenario, every process box will have a cycle time of value equal to takt time. To achieve takt time, resources need to be allocated to the correct process box. For example, if there is two clerks available for a process "x" that takes half the value of takt time, we can relocate one resource to process "y" that is performing above takt value and meet takt value with one resource only in process "x".

It is important to note that the future value stream map was developed with the same format as the current value stream map and illustrates the potential system according to lean principles.

3.2.7 Plan and Follow-up

The last section developed a plan with the necessary changes in detail in order to achieve the proposed system. These changes were developed as a result of the previous sections of the A3 methodology in order to optimize efforts and have a greater impact on the performance indicators that benefit the colorectal department the most.

In addition, a set of future follow-ups is suggested to keep improving the current practices and achieve better process performance. It is important to note that Lean transformations are iterative and the cooperation of the staff to develop new solutions and improve current operations is the key to their success. An example of an A3 template is provided in Appendix D.

The following table shows a graphical summary of the methodology followed with A3 and Lean principles together.

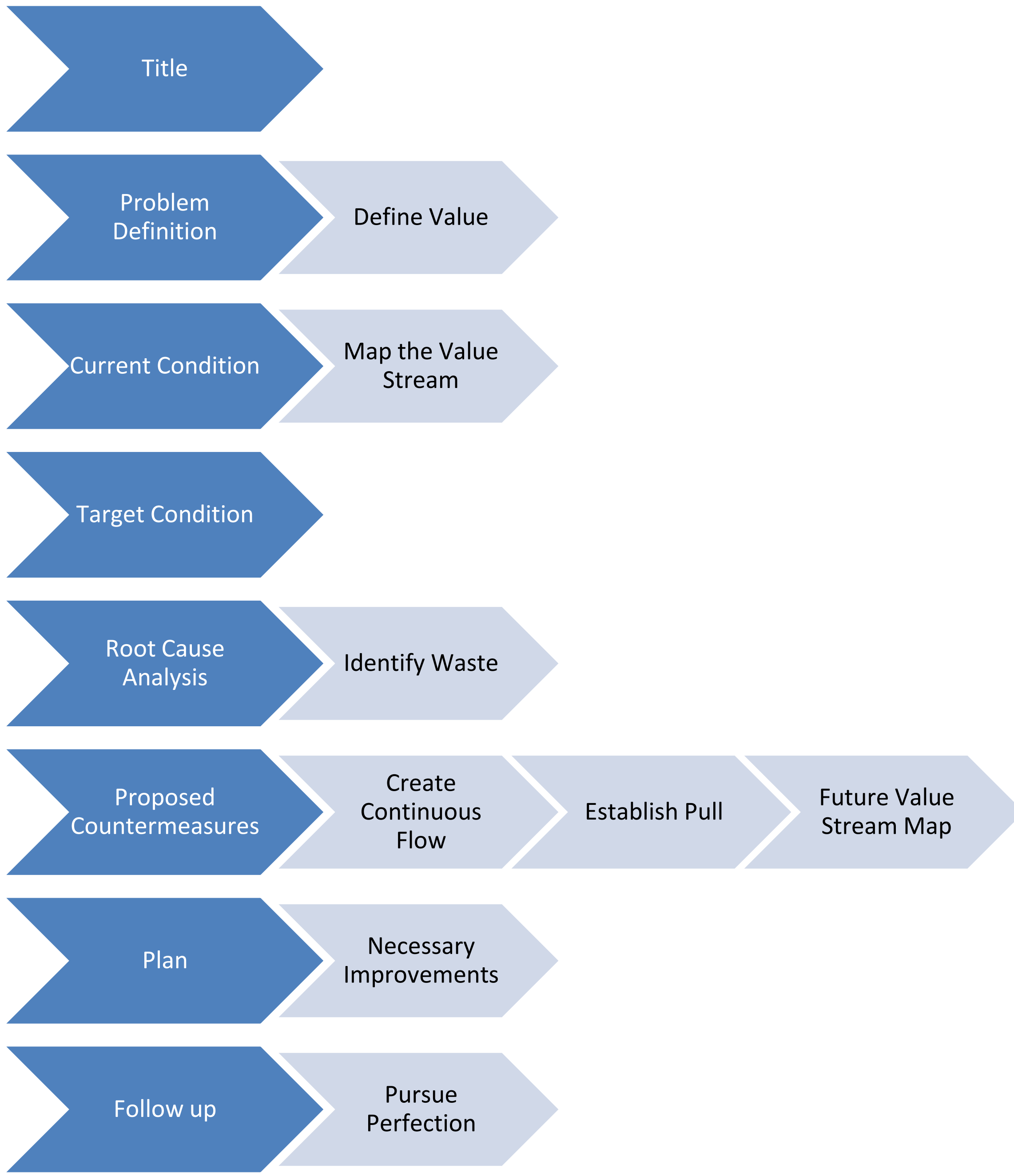


Figure 9: Thesis Methodology Map

4 Case Analysis

The study took place in the Montreal General Hospital at the colorectal department from the time the patient places a request until the patient is discharged from the department with a complete diagnosis and/or the subsequent stage. Furthermore, the department staff consisted of three colorectal specialists, one technician, one assistant technician, two clerks and one medical secretary. This team participated in the process analysis and contributed as an expert consultant in the medical field aspect of this thesis.

The analysis was organized by splitting the department's operations in three sections: short procedures, surgery and colonoscopy patient flow. The first section, short procedure patient flow, consists of those activities related to the short procedures offered in the department, from the time the request is place until the final instructions are given to the referring physician. It is important to note that this is also considered the common flow stream. The second section, surgery patient flow, includes the common flow stream and the flow of the patient from the time a surgery appointment is requested until the patient is released from recuperation ward. The last section, colonoscopy patient flow, includes the common flow stream and the flow of a patient from the time a colonoscopy appointment is needed until the final results are released to the corresponding physician. In addition, a complete current and future state map with all three flows are provided and compared to account for the benefits of the proposed system in KPIs.

In terms of data collection, three sources were utilized; interviews, field data and hospital's databases. Interviews were conducted with every member of the department in both one-to-one and group format. The objective of these interviews was to acquire general knowledge of operation procedures and to consult medical experts to determine limitations and restrictions of the study. Field data was collected live for a period of four consecutive months; this data includes processing times, waiting times, staff workloads and other key performance indicators (KPIs) that will be discussed in the following sections. The last source of data collection were the two hospital's databases; demand history and other booking information were extracted out of these locations. In addition, it is essential to highlight that quantitative information in this thesis was acquired only from field data and hospital's database in order to maintain objectivity and reduce the alteration of behaviour by the subjects being observed (Hawthorne effect).

In this section, the colorectal department system is mapped and analyzed to further understand the complete operations for any service provided to any patient. The scope of the analysis starts at the time any patient places a request for a service, until the final results are delivered to the corresponding physician or the patient needs to follow up in which case it would return to the system. The analysis is separated in five sections, problem definition, current condition, target condition, root cause analysis and potential areas of improvement.

4.1 Problem Definition

The colorectal department is facing several challenges and with a constant increase of request for services, operations have become more complicated. There are patients in the waiting lists for over a year, work in progress has increased to a point where the staff cannot keep up with the organization and frustration is taken over the department's staff. Therefore, a complete analysis of the department's operation was needed and lean analysis was selected as the methodology to follow.

There are several challenges that were considered for this project. First, the system is very complex due to the fact that it is a speciality department. Second, the workforce is not flexible, there is only a certain amount of physicians that can work at this location and the acquisition or transfer of specialists is not an option. Third, colonoscopy equipment and resources are shared with the GI department and they are located in another floor of the hospital. Fourth, the facilities are scattered among the hospital so it creates problem when booking appointments. Fifth, there is a professional zone that has to be respected and specialist's personal procedures cannot be tampered. Last, personnel are not accustomed to change.

In addition, this research considers the following constraints for analysis and recommendations:

- Physical location of the department cannot be modified.
- Patient health and safety is a priority in the healthcare environment. Any recommendation that jeopardizes this will not be considered feasible.
- Cancer patients have priority over others.
- MD professional procedures cannot be modified. Improvements in this area have to come from another MD.
- Department is looking for cost effective solutions.
- Patient and staff personal information cannot be disclosed in this research.
- Key tasks of each staff level cannot be shifted to another member.
- MD professionals are not available for overtime.
- The addition of one MD specialists needs to be considered in countermeasures.

4.2 Current Condition

The colorectal department has been running operations at their best of their capabilities with their current resources. The medical procedures and clerk organization standards are considered one of the best in the province and are currently considered as a template to follow for other healthcare institutions in their respective field. However, there have not been any efforts for a complete system's analysis where the department can learn to improve their care delivery and resource utilization.

According to the A3 methodology and utilization of lean techniques, the current state map was developed (Figure 10) according to the steps described in the methodology section of this thesis. The purpose of this stage is to account for every process of the system, information flow, resources and KPIs. This process involved the whole department staff, representatives of departments that communicate with the colorectal department and the support of managerial staff.

For analysis purposes, the department was divided in four different flow loops: Short procedures or common flow (1), surgery flow (2), colonoscopy flow (3) and calling centre flow (4). In the following subsections, each loop activities are described and KPIs are accounted for each of the processes. However, improvements are proposed considering that the department operates as a system and not every loop in isolation. In addition, the proposed system is compared to the current one and a gap analysis was performed to determine the necessary changes needed to accomplish the proposed solution.

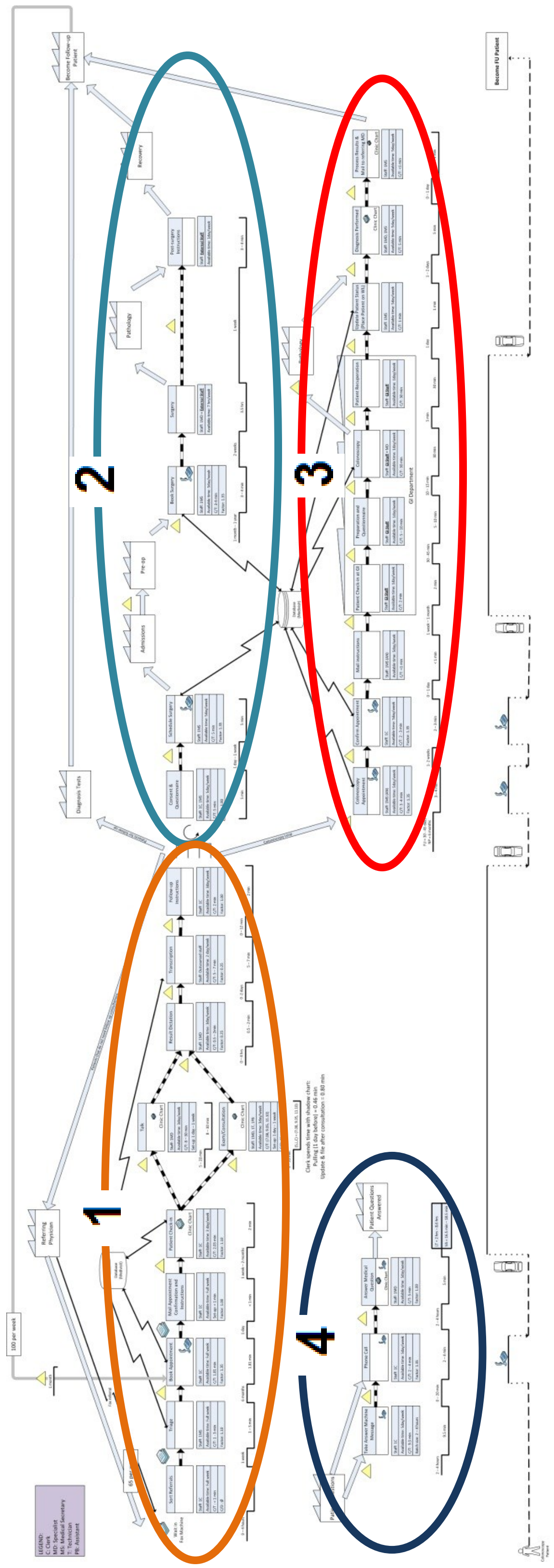


Figure 10: Colorectal Current Value Stream Map

4.2.1 Current Short Procedures Value Stream

The short procedures flow is the common stream for every patient that enters the system, except those whose request is redirected to the corresponding department. A short procedure is an activity performed to the patient that is considered a minor treatment and do not require general anesthesia; for example, rubber band ligatures, colon biopsies and Flexible Sigmoidoscopy (referred to as a short scope).

In this value stream, short procedure patients and colonoscopy or surgery patients have the same processes to go through except in the middle of the stream. Short procedure patients have an examination stage where the MD performs the necessary treatment while the colonoscopy or surgery patients go through a "talk" where a short screening and personal medical history are performed. The common flow CVSM (Current Value Stream Map) is shown in Figure 11.

In order to better understand the system operations, an example is provided for short procedures. To begin, a patient faxes a referral form with his physician notes and requested procedures. Twice a day, one of the clerks reviews the referral form to look if it is a cancer patient, in this case it is a patient that requires a short scope, hence the referral is sent for triage. Once a week the medical secretary triages the referral and determines whether it is an emergency case and the patient can be catalogued regular priority. After six months, the patient receives a call from the colorectal department's clerk to book an appointment within one week to two months, for this example the appointment is booked two weeks in advance. When the clerk books the appointment, he/she prints and mails important information for the patient to follow and prepare for their procedure in a pre-designed package and mails it to the patient's address.

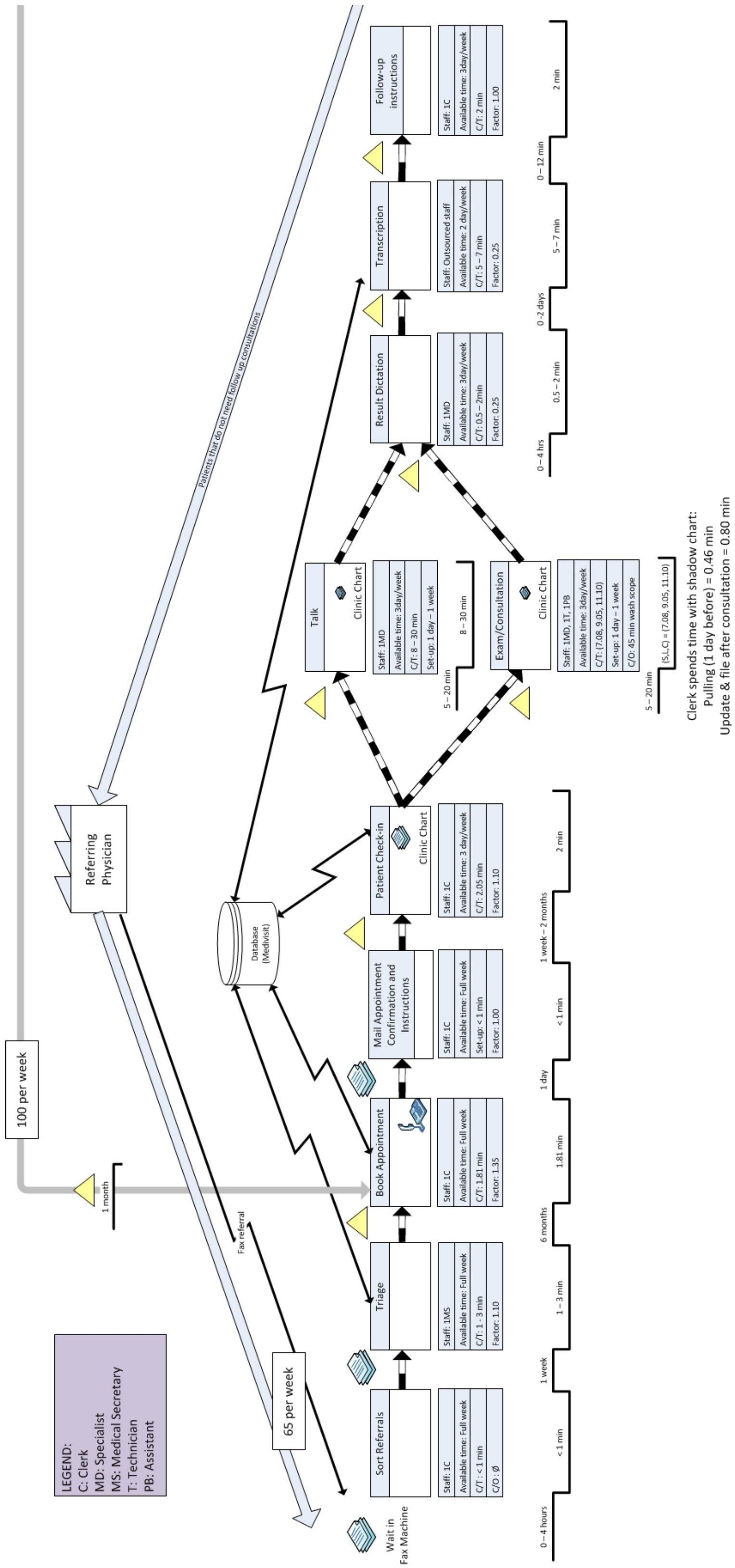
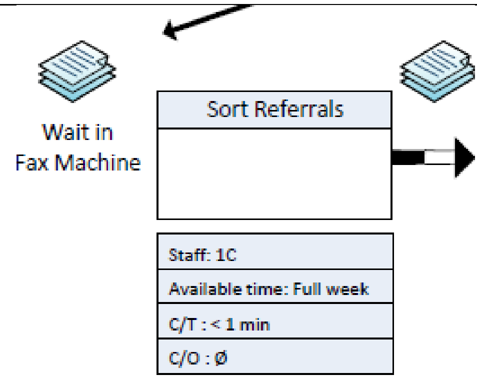
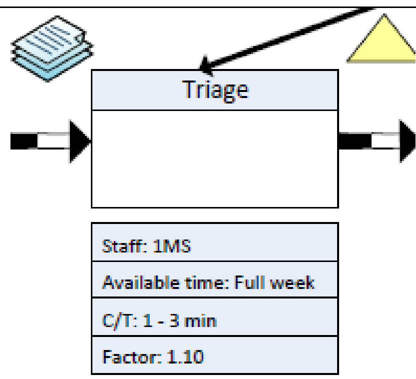
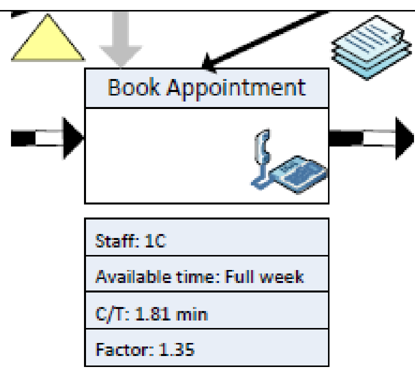
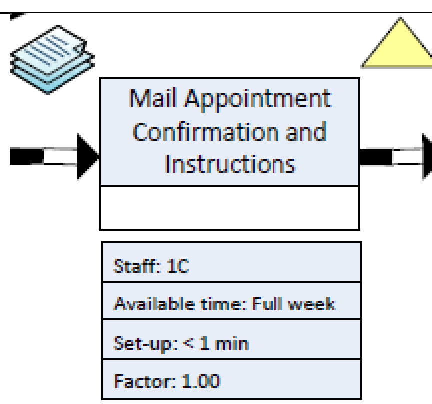
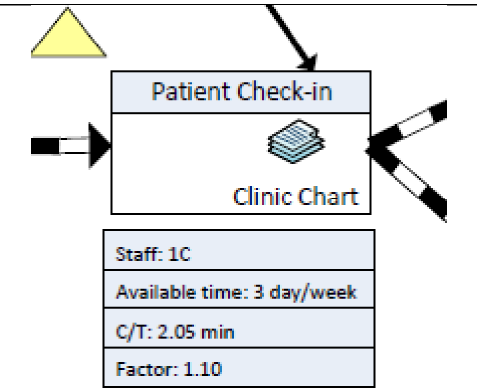
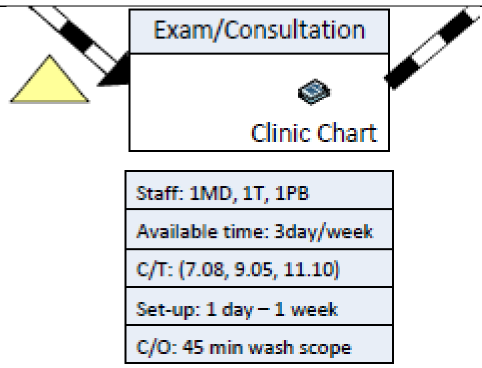
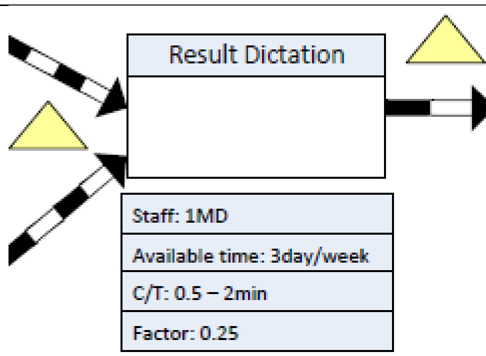
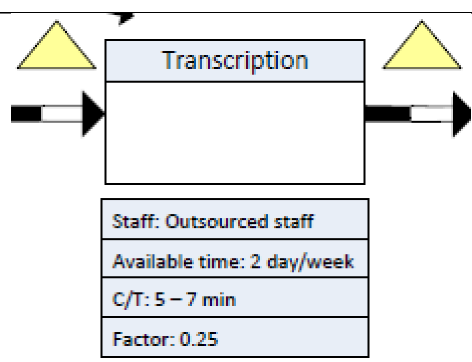


Figure 11: Current Short Procedure Value Stream Section

Two weeks after, the patient check-ins into the department, the clerk confirms patient's personal information, hospital card and updates the hospital and clinic chart. Then, the patient waits in the waiting area between five to twenty minutes until they are called into one of the two examination rooms for setup by the technician. After, the MD briefs the patient about the procedure that he will perform; the technician needs to be present at the time of a short scope to aid the MD according to current procedures. Once the procedure is done, the technician brings the short scope to the sterilization room and loads the machine to start the cleaning; these machines sterilize two short scopes at once so the technician starts the washing cycle every two short scopes. At this point the patient is released from the department and follow-up instructions are given by the clerk. The patient will be contacted if another appointment is needed, in this case he will enter the system again as a follow up. Meanwhile, the MD dictates the results obtained from the procedure and important observations for further review are noted. This dictation is transfer into a pre-design form two times a week and then it is sent to the referring physician of the respective patient. In the end, the goal of the MD is to suggest a protocol to follow and educate the patient to prevent complications or potential reoccurrence of the problem.

A list of each process with resources available, cycle time, change over time and available time to performed each type of activity for any short procedure is described as follow (Each process box is extracted from Figure 12 and it is in the same order):

Process	*Description of activities*
	A referral form is submitted to the department with the referring physician’s signature and specific notes about the case. Clerk sorts through them and extracts emergency cases for fast processing.
	Medical secretary receives the referrals and determines the priority of each one of them according to severity, type and specialist requested by the referring physician.
	A clerk calls the patient to schedule an appointment for their respective request and gives an overview of the steps to come.
	An appointment confirmation form is sent to the patient with specific instructions on the needed preparation at home and documentation needed for their appointment day.

<table>
<tr>
<td>
</td>
<td>Patient's hospital card is stamped in their personal clinical and hospital chart and missing information is given for record keeping. Clinical charts are utilized in this process.</td>
</tr>
<tr>
<td>
</td>
<td>The corresponding treatment is performed and additional information is given for follow ups. Clinical charts are utilized in this process.</td>
</tr>
<tr>
<td>
</td>
<td>Results are dictated using a hand recording device. The dictation includes patient number, observations and course of action given to the patient.</td>
</tr>
<tr>
<td>
</td>
<td>Transcription is performed by listening to the recording with a headset and typing it in a computer. Templates and shortcuts are used to speed up transcription. This is an outsourced staff process.</td>
</tr>
</table>

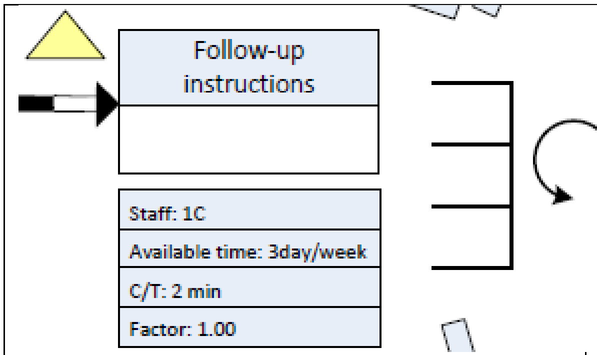
	Follow-up instructions determine if the patient comes back as a follow-up patient or if there is another course of action required to solve the issue in question. If none of the above, the patient is released.

Table 3: Short Procedures Processes Description

4.2.2 Current Surgery Value Stream

Surgery value stream is the flow every patient that requires a procedure in the OR (Operating room), the nature of this value stream is delicate and priority of patients is of extreme importance. In addition, it is important to consider that the OR is considered a department with high demand; therefore, planning and scheduling surgeries are complex processes to follow. For these reasons, the process analysis for this part of the thesis is more restricted that any other value stream.

For this type of patients, the resources needed to perform the surgery are mostly external, however, the MD belongs to the colorectal department and availability of this resource is limited due to the other procedures. It is important to note, surgeries are scheduled months in advance and any change in scheduling is discouraged due to complexity and limited OR time designated to the colorectal department. In addition, patients that need surgery follow an intense preparation procedure and timing is carefully calculated to perform the surgery at the right moment and minimize potential complications as much as possible. Figure 11 represents the CVSM for every surgery patient, from the time they exit the common flow (Figure 10) and enter the surgery loop until they are released.

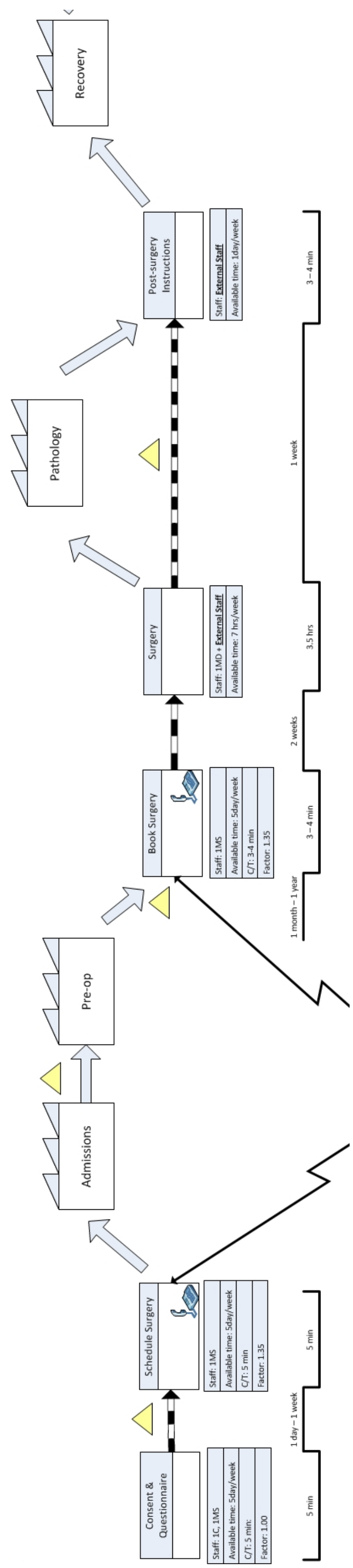
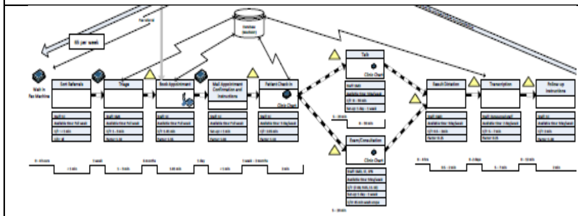
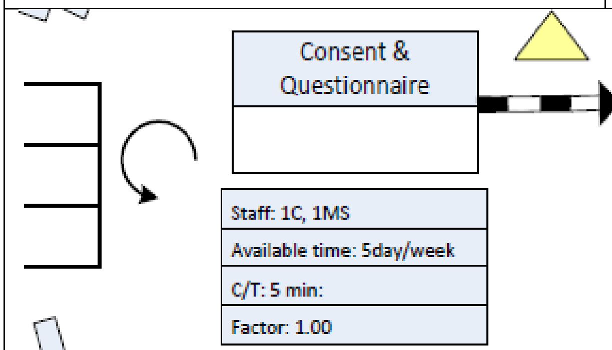
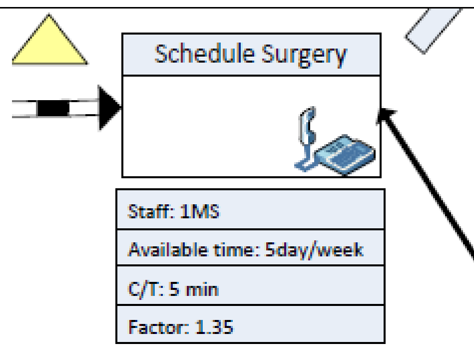
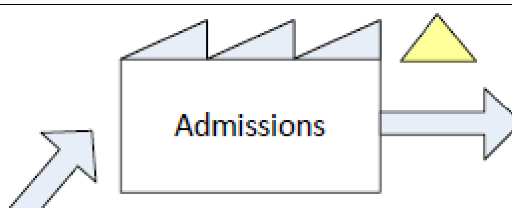
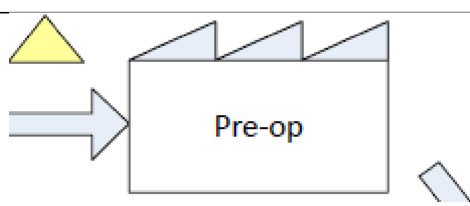
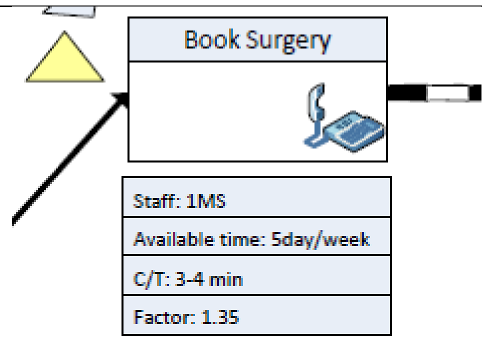
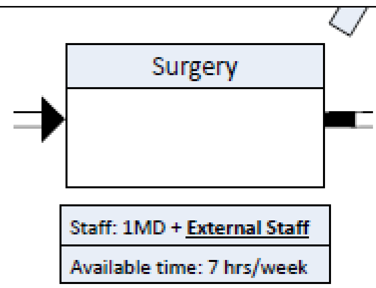
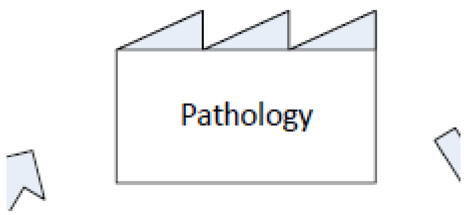
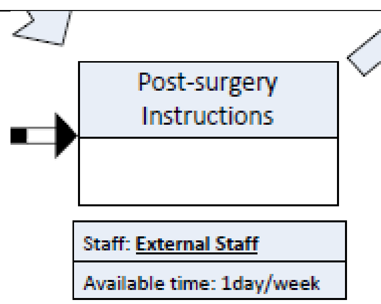
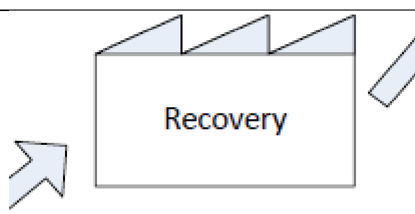


Figure 12: Current Surgery Value Stream Section

In order to better understand the system operations, an example is provided for surgery patients after they exit the common flow. First, the patient gets a consent form and a questionnaire about their personal medical history, the clerk aids with potential questions about filling in the form and if the questions are out of her reach the medical secretary helps the patient clarify any confusion. Once the forms are filled, the medical secretary brings it to the admissions department located in the first floor of the hospital. Third, the medical secretary schedules and coordinates the pre-operation procedures needed for the patient to prepare for their surgery; this could be blood tests, X-rays, CT-scans and many others, which depends on each case. Between scheduling the necessary preparations and booking an appointment, the patient can wait up to a year. Fourth, assuming the patient is eligible for surgery, the medical secretary books an appointment with the patient through the phone two weeks in advance. Fifth, surgery is performed by a colorectal MD surgeon and external resources at the OR. At this point, the MD sends samples to the pathology lab for further testing. Last, the patient receives post-surgery instructions and becomes automatically a follow-up patient to the colorectal department. In the end, the patient will fully recover at home with a special diet and set of medications. If any complications are encountered during their recovery, the patient is admitted back to the hospital to investigate the root of the problem.

A list of the processes with resources available, cycle time, change over time and available time to performed each type of activity for any surgery is described below (Each process box is extracted from Figure 12 and it is in the same order):

Process	*Description of activities*
	Patients go through the common flow described in the short procedures section. However, instead of having an exam process in the middle, they have a "talk".
	Each patient that requires a surgery needs to fill out a consent form and a specific questionnaire about their health. At the end of the day, the medical secretary brings these forms to the admissions dpt.
	The medical secretary calls the patient to schedule the potential surgery date. The patient receives at the same time the information on the steps to follow.
	Admissions department makes the arrangements for the patient to follow before surgery. This is an outside process.
	The patient needs to follow a specific set of tests to determine the potential complications of the surgery and confirm the eligibility for this procedure.

	The medical secretary books a specific day with the patient and the location of the surgery. Final information is given to assure the patient is fully aware of the steps to come.
	Surgery is performed at this stage. External staff is utilized from other departments and the only internal resource used is the MD.
	Samples from the surgery are sent to pathology for analysis. This department is external to the colorectal department.
	The patient is given a program to follow for recuperation and specific instructions to book follow ups in the future.
	The patient recuperates in the hospital installations after the surgery until the MD agrees to release him/her.

	Every patient after the surgery flow becomes a follow-up patient. Each patient is unique and follow-up procedures vary each case.

Table 4: Surgery Processes Description

4.2.3 Current Colonoscopy Value Stream

The colonoscopy exam enables visual inspection of the entire large intestine. Compared to other imaging procedures, colonoscopy's main advantage is that it allows for intervention, it allows to specialist to perform biopsies, remove polyps or cauterize bleeding (Stein & Bonheur, 2012). This technique is widely used in colorectal cancer patients, which constitute the second leading cause of cancer related deaths in Quebec (Sante et Services sociaux Quebec, 2012). Therefore, efforts to improve this system flow are a priority to the hospital and the province.

For the colonoscopy procedures, the GI department provides the staff to support the MD, necessary equipment, supplies, physical location and clerks to check-in and check-out the patient. However, the scheduling for each patient is done at the colorectal department. Currently, MD specialists are working towards improving screening techniques to reduce the amount of patients that are accepted for colonoscopy procedures. By doing this, the waiting lists are expected to decrease and patients will be redirected to the appropriate flow to follow. Figure 13 represents the CVSM for every colonoscopy patient, from the time they exit the common flow (Figure 10) and enter the colonoscopy loop until they are released.

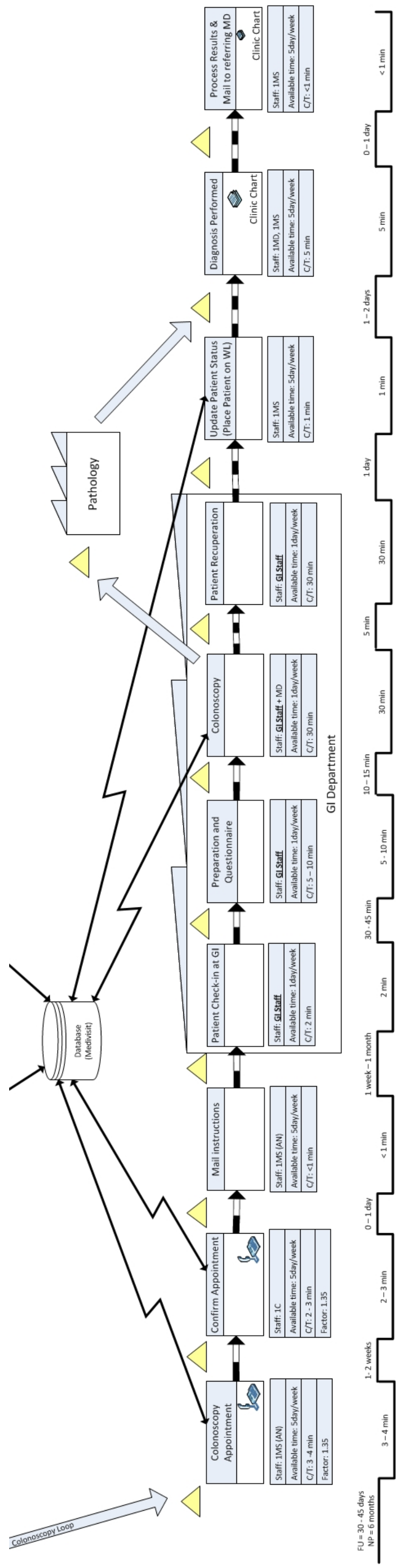
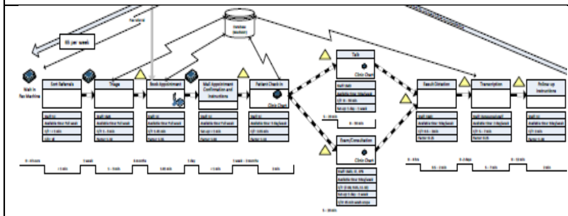
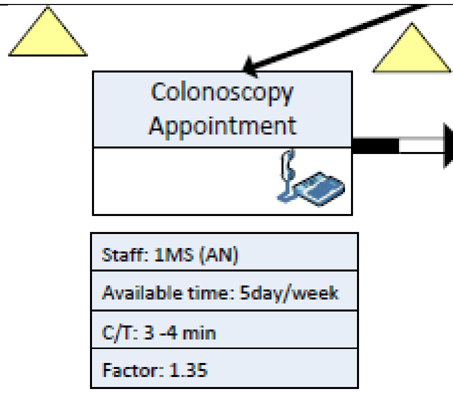
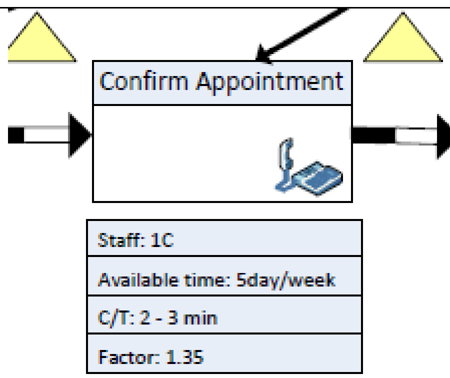
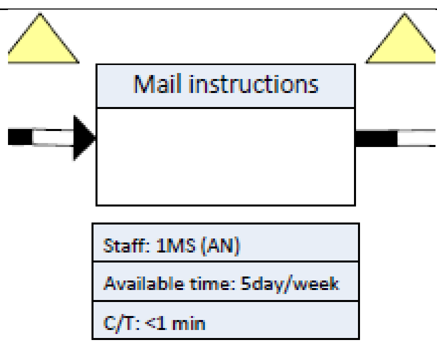
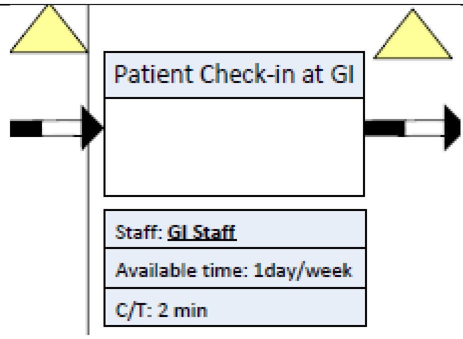
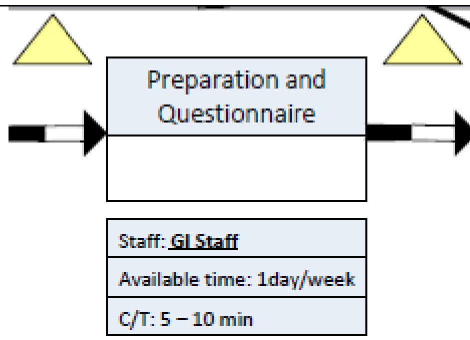
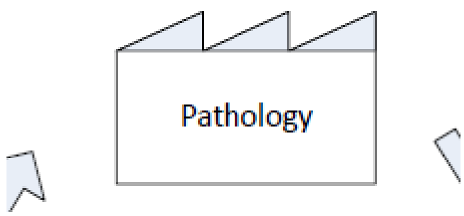
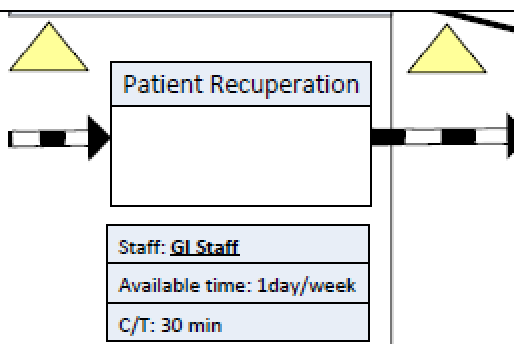
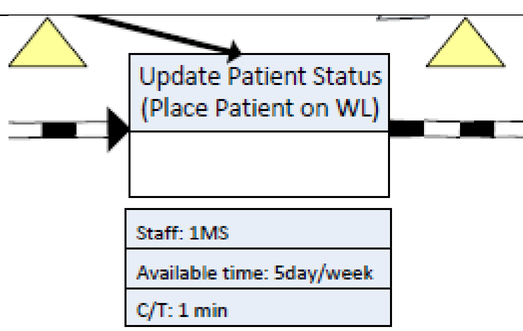


Figure 13: Current Colonoscopy Value Stream Section

As in the previous patient types, an example is provided for colonoscopy patients to clarify the process flow. Initially, the patient goes through the common flow section of the system and waits approximately six months until the medical secretary contacts him/her to book a colonoscopy appointment. Two weeks after, the patient receives another call to confirm the appointment date and time. When the medical secretary confirms the appointment, a package with all the instructions and medications needed for preparation is mailed to the patient by regular mail. Two weeks later, the patient checks-in at the GI department on the day of the colonoscopy. An average waiting time of 40 minutes is needed before a nurse admits the patient into a setup room. Then, the nurse prepares the patient and goes through a series of questions to assure that the patient performed the proper preparation and is eligible to go through a colonoscopy. Once this is complete, the patient is admitted to the colonoscopy room where an MD spends 30 minutes performing the procedure. Afterwards, the patient is sent to a recuperation room in the GI department for an hour, at which point the MD sends a sample from the procedure to pathology for further testing and an initial assessment is printed in the examination room. Finally, the patient is release with the signature of a family member that assumes responsibility for transportation. The colorectal department then updates the file of the patient for follow-up procedures and a final decision on the case is determined and sent to the referring physician to collaborate and approve the protocol to follow.

A list of the processes with resources available, cycle time, change over time and available time to perform each type of activity for any colonoscopy is shown as follow (Each process box is extracted from Figure 13 and it is in the same order):

Process	*Description of activities*
	Patients go through the common flow described in the short procedures section. However, instead of having an exam process in the middle, they have a “talk”.
	The medical secretary calls the patient to book and appointment at a specific date and time. Specific instructions are given verbally to the patient on the steps to follow.
	The clerk calls the patient to confirm date and time of the colonoscopy appointment. Further instructions are given about the location of the exam and specific preparation procedures
	Instructions are mailed to the patient with the necessary products to buy and the preparation methods according to each patient’s case.

	Patient is admitted into the gastroenterology department (GI). One GI clerk is utilized in this process. In this process, every resource is external to the colorectal department.
	The patient goes through a series of questions and preparation for the colonoscopy is performed by a GI nurse. In this process, every resource is external to the colorectal department.
	Samples from the colonoscopy are sent to pathology for analysis. This department is external to the colorectal department.
	Patient recuperates after the colonoscopy in a recuperation area at the GI department. The patient cannot be released until a family member assumes responsibility for transportation to their home.
	The patient is placed in a waiting list by the medical secretary in order to get a follow-up appointment in a specific period of time. Each case has a different timeline.

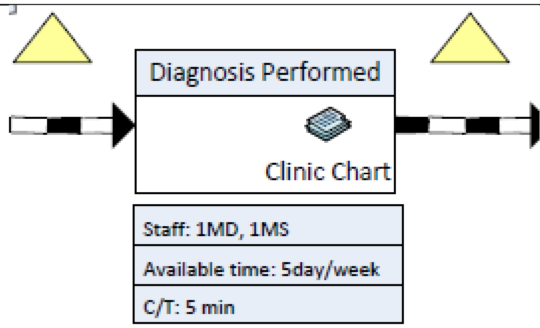
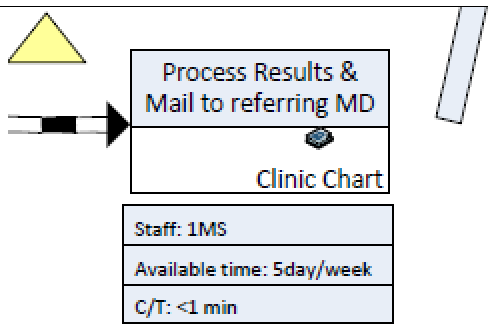
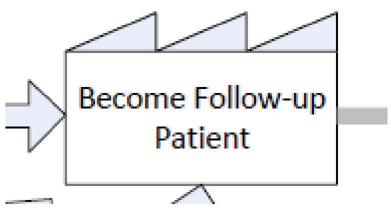
	When pathology results are obtained, the MD performs a diagnosis and course of action to follow. Specific instructions are given to the medical secretary to make the necessary arrangements to deliver the results to the patient or referring physician.
	The medical secretary process the results obtained from the MD and the findings and course of action are mailed to the referring physician for further review. Clinical charts are utilized in this process.
	Every patient after the colonoscopy flow becomes a follow-up patient. Each patient is unique and follow-up procedures vary each the case.

Table 5: Colonoscopy Processes Description

4.2.4 Current Calling Centre Value Stream

This process flow is a representation of any type of calls while a patient is in the system, calls range from “How do I send my referral form?” to “What are the results of my colonoscopy?” Figure 14 represents this flow in the system.

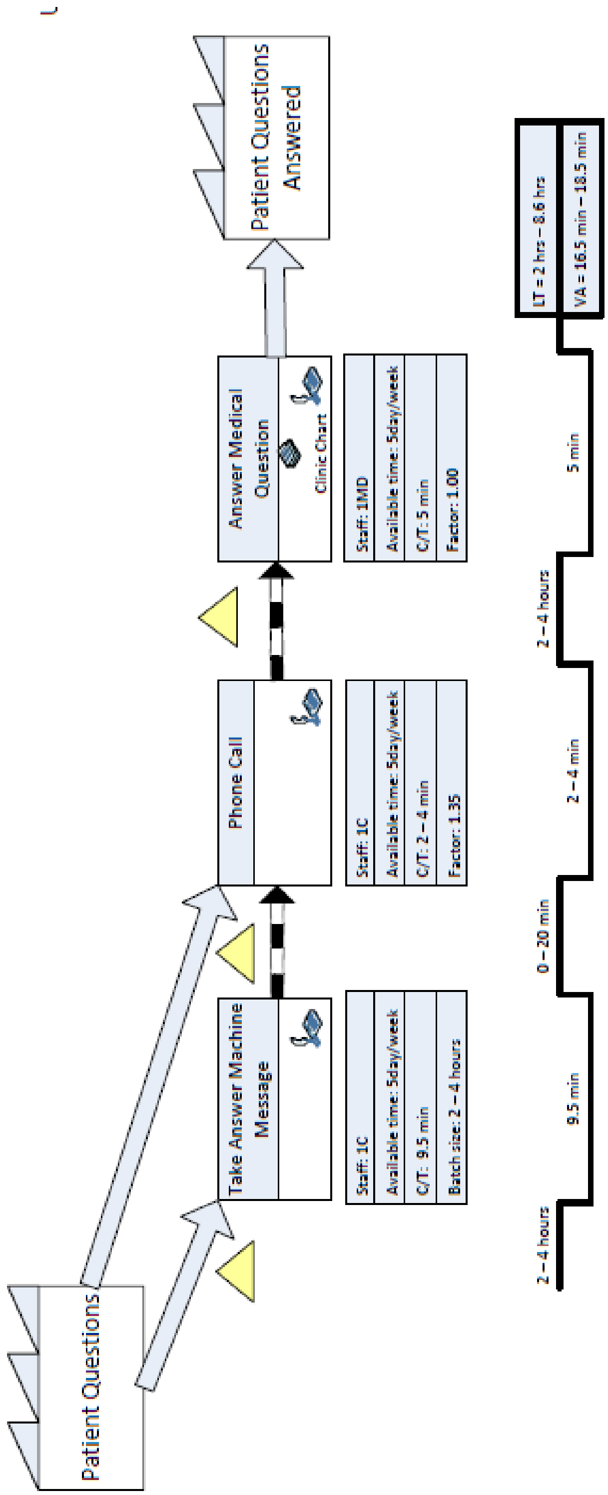
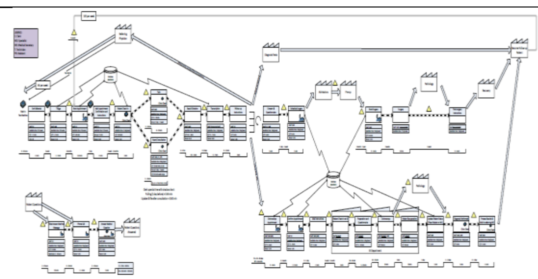
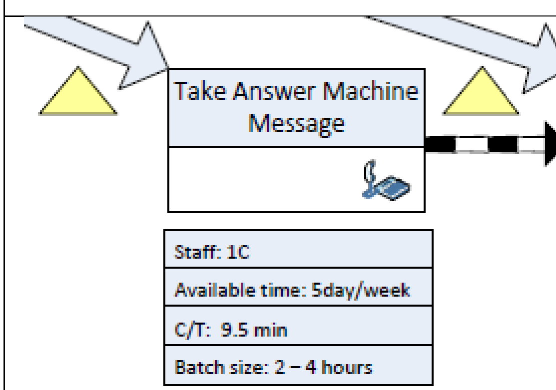


Figure 14: Calling Centre Value Stream Map

A simple example of a patient going through every box of this stream is the following: A patient calls the colorectal department but both phone lines are busy; therefore he leaves a message for the clerk to answer; the clerk checks the answering machine on average twice a day. Afterwards, the clerk listens to the message and determines whether the question asked requires the MD experience to answer. To minimize the utilization of the MD; the clerk submits the question and waits for the answer. Once the clerk receives the answer, he/she proceeds to call the patient and give the appropriate response. Finally, the patient is released from the calling centre loop.

A list of all the process with resources available, cycle time, change over time and available time for performing each type of activity for any call is shown below (Each process box is extracted from Figure 14 and it is in the same order):

Process	*Description of activities*
	Patient calls are received at any stage of the system flow. Due to the nature of the system, quick and accurate responses are needed.
	The patient is required to leave a message in the answering machine outside work hours and when the two phone lines are in use. Personal information and nature of their call is needed.

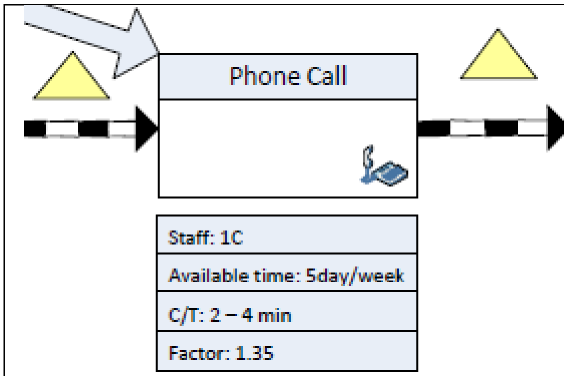
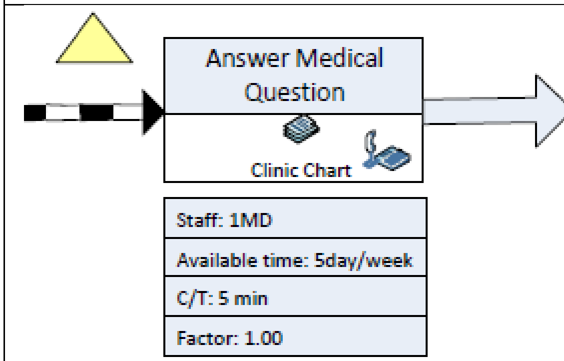
<table>
<tr>
<td>
</td>
<td>The patient is contacted by the clerk. Important questions about their coming procedures, results or referral requirements are the most common types of calls.</td>
</tr>
<tr>
<td>
</td>
<td>In case of a medical question, the clerk pulls the patient’s clinical chart and the MD is consulted to reach a proper answer to give to the patient.</td>
</tr>
</table>

Table 6: Calling Centre Processes Description

4.3 Target Condition

According to the colorectal department needs, the team came to the conclusion that the system should improve their operations. Specifically, lead time will be reduced by 15%, 10 patients per week will be increased, workloads and patient flow will be improved.

4.4 Root Cause Analysis

It can be seen from the previous mapping results that the colorectal department is a complex system and further breakdown of the analysis is required. The following nine major problem areas are identified first (and explained more in detail below):

1) The amount of time a patient spends in the system (Lead Time) is much greater that the amount of time the patient spends time receiving a service (Value Added)

2) The colonoscopy and surgery processing times are much greater that the necessary time to keep up with demand and cause waiting lists to grow
3) There are tasks performed more than one time
4) Scheduling techniques for short scopes do not consider impact on the system
5) There are unnecessary tasks and motions
6) The colorectal department has different physical locations
7) Staff turnover is high
8) There is unnecessary rework at the call centre
9) Culture of “Change” is not in place

Each of these problems is considered a source of waste and was investigated in further detail in order to improve the system; considering the restrictions previously specified.

4.3.1 Lead Time

Patient lead time is much greater that the value added time. Table 7 shows the lead times versus value added activities for each type of patient.

Patient Type	Minimum	Maximum
Short Procedures	21.39 min vs 31.05 days	30.91 min vs 169.07 days
Colonoscopy	102.31 min vs 63.4 days	136.81 min vs 324.7 days
Surgery	248.31 min vs 67.6 days	277.81 min vs 458.9 days

Table 7: Value Added Time versus Lead Time

In order to identify the areas where improvement can reduce the lead time and increase the value added time; further understanding of the processes in the colorectal department is needed. The graph shown in Figure 15 identifies the waiting times between each process in the system for a colonoscopy patient. In this case the two main waiting times are just before booking an appointment for a talk and booking an appointment for a colonoscopy.

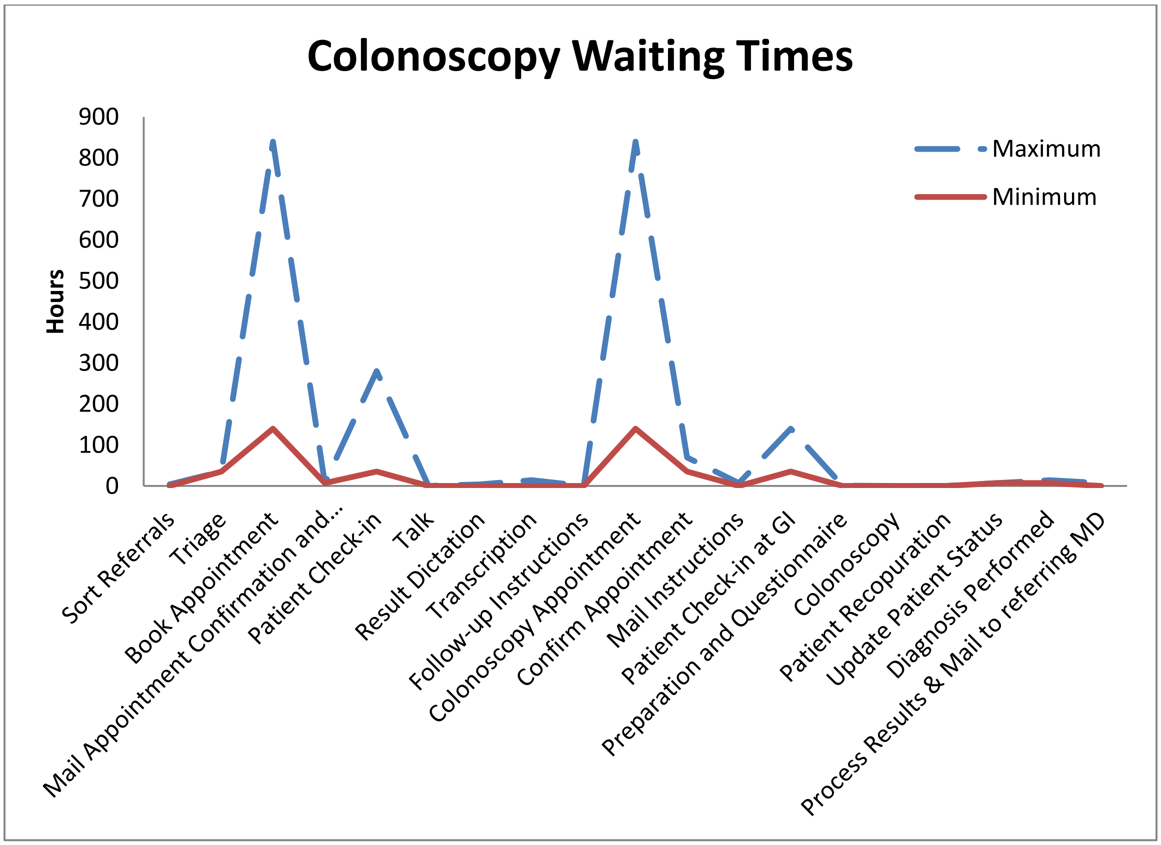


Figure 15: Colonoscopy Waiting Times

With the same logic, the two bigger waiting times for surgery patients are just before booking an appointment (up to 6 months) for a talk and before booking an appointment for a surgery (up to1 year). For short procedures, it is before booking an appointment for an examination (up to6 months) and before checking in at the department (up to 2 months). Last, the calling centre main waiting time is just before returning the call to the patient (Up to 4 hours).

4.3.2 Cycle Times

The processing time to perform a colonoscopy, talk or surgery are long compared to the other processes in the system; Colonoscopies takes 30 minutes each, a talk takes 30 minutes and a surgery takes on average 3.5 hours. This long cycle times impact the system as a whole preventing the continuous flow of patients. For example, Figure 16 shows the processing times of each step for a colonoscopy patient, three types of columns can be identified as bottlenecks in this flow: “talk (at maximum)”, “colonoscopy” and “recuperation”. Note that the recuperation process has several parallel resources for our disposal; therefore, the recuperation processing time will match the colonoscopy time, if colonoscopy time is reduced by 50%, the recuperation cycle time will be 50% lower.

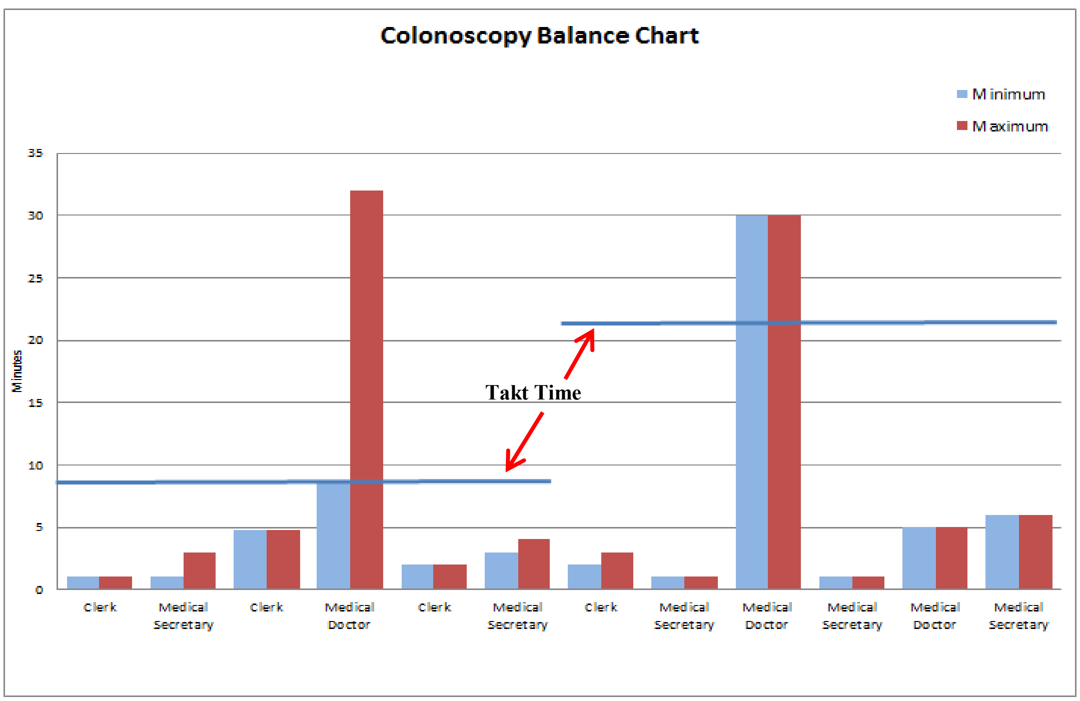


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Figure 16: Colonoscopy Processing Times

4.3.3 Over-Processing

Tasks are performed more than once by different staff. The department has developed standard operation procedures in the past; however, these procedures have not increase the system's overall efficiency as expected. This creates a conflict in activities where two or more people have contact with the patient. For example, when the patient is directed to the examination room for a small procedure, the technician greets the patient and provides an introduction of the procedure to follow. After, the MD enters the examination room to greet the patient and provides a brief description of the procedure to follow. This takes approximately one to two minutes; it may seem a small amount of time but at the end of the day the colorectal department process over 50 patients per day for short procedures only, which translates to 50 minutes of MD time of task repetition.

4.3.4 Scheduling Practices

Scheduling techniques for short scopes are causing delays in the system. The colorectal department operates between 8 a.m. to 4 p.m.; short scopes are scheduled one by one at different times in the day and in most cases more than one short scope appointment follows another one. The technician works from 8 a.m. to 4 p.m. but the technician assistant works only between 9 a.m. until 2p.m. After every short scope patient, the technician needs to bring the scope to the sterilization room for cleaning, which prevents the technician to be available for the MD causing delays in the appointments and having the MD perform setups and cleaning in the examination rooms. Therefore, short scopes scheduled outside technician assistant's work hours cause problems in the system and overload the technician on site.

4.3.5 Unnecessary Motions

Another problem is that there are unnecessary tasks performed in the department. Any task that is not adding value to the patient's experience is considered undesirable and efforts to eliminate it should be a priority to improve the system. For example, the colorectal department updates and manages the hospital charts for every patient at the time of examination; this is set under government regulations and is considered standard practice. However, the department also creates a "clinic chart" for every first time patient in the department and it is updated every time the patient is admitted to the department. For both chart types the updates are manual and both charts are stored in the hospital, one in the archives department and the clinical chart in the colorectal department; for clinic charts older than 5 years, the colorectal department stores them in an outside location where storing and recovering fees are applied by a third party company. The following calculation shows the time spent updating each clinical chart:

(Update time + Pull and Put away time) x Throughput = Total time for maintenance

(0.46 min + 0.80 min) x (50 to 60 patients) = 60 to 75 min/day

The clerk can spend more than one hour per day performing another task instead of updating a record that is already in another location. This time is considered non-value added and should be identified as a point of potential improvement.

It is important to note that the hospital charts contain all the information included in the clinical chart; the value stream maps in this thesis show what processes use the clinic chart with an icon on the process box..

4.3.6 Physical Layout

The colorectal department has different locations and walking times have not been measured. Key staff in the department walks between rooms every day creating a non-value added activity. The medical secretary brings consent forms and questionnaires for surgery patients to the admissions office three times per week; this takes approximately 30 minutes each time making a total of 1.5 hours of wasted time due to walking. In addition, the technician and technician assistant walk several times between three locations: the examination room, sterilization room and check-in office. This activity is considered transportation waste. Figure 17 shows the total walking time in one day for the technician only.

On average, the technician spends 33 minutes of a 7 hour workday walking between locations. For example, the technician walks to the check-in office to obtain the patient file that needs to be stamped by the clerk at the time the patient is admitted to the department. Then, the technician walks to the sterilization room to load and unload short scopes for cleaning. These tasks are lost time for the technician, ideally he/she should be at the examination room at all times. In addition, the technician spends one full day every week doing physical counts of inventory and placing the necessary orders for the following week.

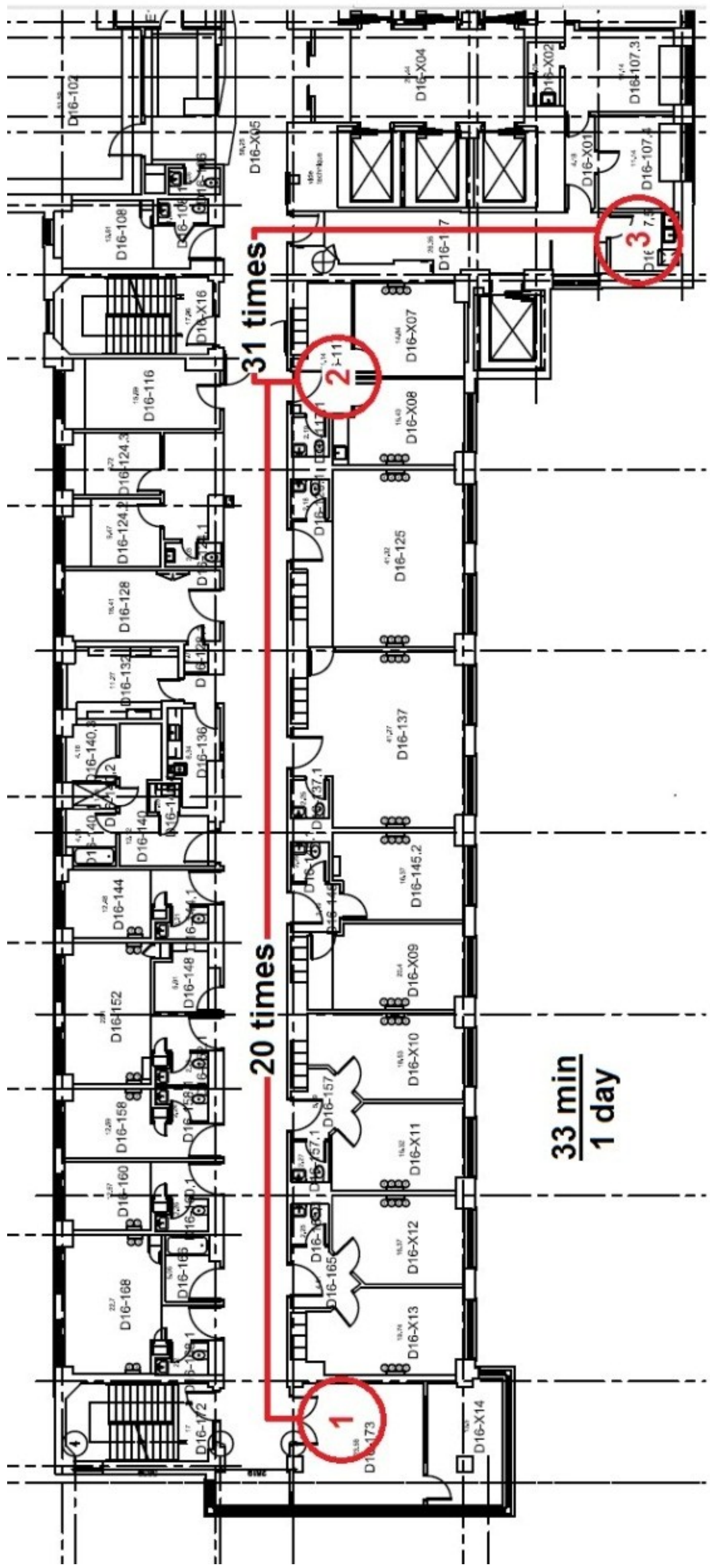

Figure 17: Technician walking patterns per day.

4.3.7 Calling Centre Over-Processing

Another issue, there is unnecessary rework at the call centre. There is on average a 35% rework at the work centre in the form of second calls. This means that the clerk spends time calling patients and 35% of the time, the clerk needs to call back the same patient because of different reasons. In addition, every booking and confirmation of appointments is done by a telephone call, causing the department to allocate a full time clerk to handle the telephone station every day of the week.

4.3.8 High Turnover

In addition to the previous concerns, the staff turnover is high in some positions. Tasks such as the technician walking to every location for materials or equipment, clerks spending time placing second calls to the same patient, updating clinic charts, walking to admissions office to submit specific forms, all these tasks avoid the utilization of staff in value added activities and discourage them to stay in the department. These activities create workloads that are unnecessarily large for each staff member, creating an uncomfortable environment to work in.

4.3.9 Culture of "Change"

The last problem is that the culture of "Change" is not in place. The colorectal department has been functioning according to trial and error efforts from the staff. There has not been any studies performed in this department and change is not a common practice. There are many advantages of having staff with a lot of experience, but there are many disadvantages too. Therefore, the staff is in an idle status in terms of continuous improvements. Implementation of this methodology will be challenging if the culture of change is not adopted.

4.4 Potential Areas of Improvement

Having considered the underlying problems, in the colorectal department, potential areas of improvement need to be identified. Lean methodologies were used to identify areas of improvement; this avoids the common misconception of concentrating efforts in the wrong process and focus in reducing the lead time. The goal is to improve the system's efficiency as identified by lead time and not the single process efficiency. Figure 18 shows the difference between each type of efficiency; on the top left corner a canoe has been optimized in a way to advance the further distance with the least amount of effort while in the bottom right corner the canoe system optimized the rowing of one person, causing the canoe as a whole to deviate from their purpose.

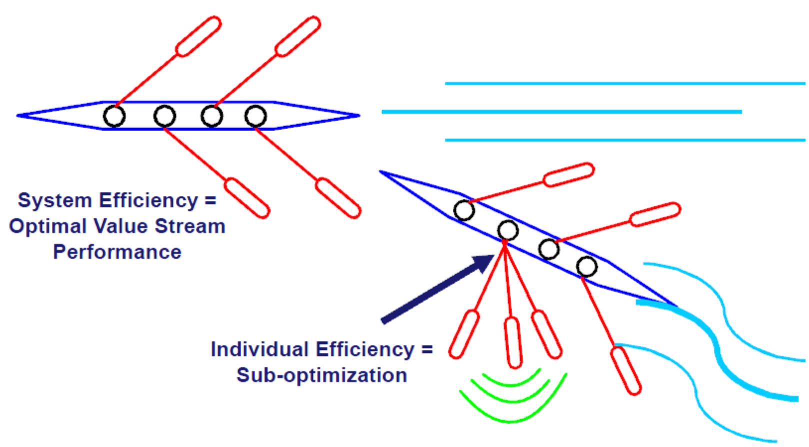

Figure 18: System Efficiency versus Individual Efficiency (Martin, 2009)

5 Proposed System

After creating a clear picture of the colorectal department current operations and outlining the main problems, the next sections will describe the necessary changes needed to improve the flow of patients in the system according to lean principles in the proposed countermeasure phase of A3 methodology (Figure 9). It is important to note, the medical staff was considered during the generation of improvements and the constraints previously described are still being respected.

The proposed system focuses efforts on reducing different sources of waste (Section 1.2), increasing capacity, reducing rework, improving staff workloads and reducing the lead time of the services provided by the department.

5.1 Proposed Countermeasures

The colorectal department has room for improvement at every flow loop and focusing in improving the right processes is the key to impact the entire system. As in chapter four, the department is divided into four different flow loops (Figure 19): (1) Short procedures or common flow, (2) surgery flow, (3) colonoscopy flow and (4) calling centre flow. In the following subsections, recommendations and changes needed to improve the system are described for each loop and a future value stream map is provided for each one to facilitate visualization of the proposed system.

The proposed operations are described for each subsection in the following order: problems in this flow loop, changes to adopt continuous flow and/or pull, challenges to be considered for future research and proposed future value stream map.

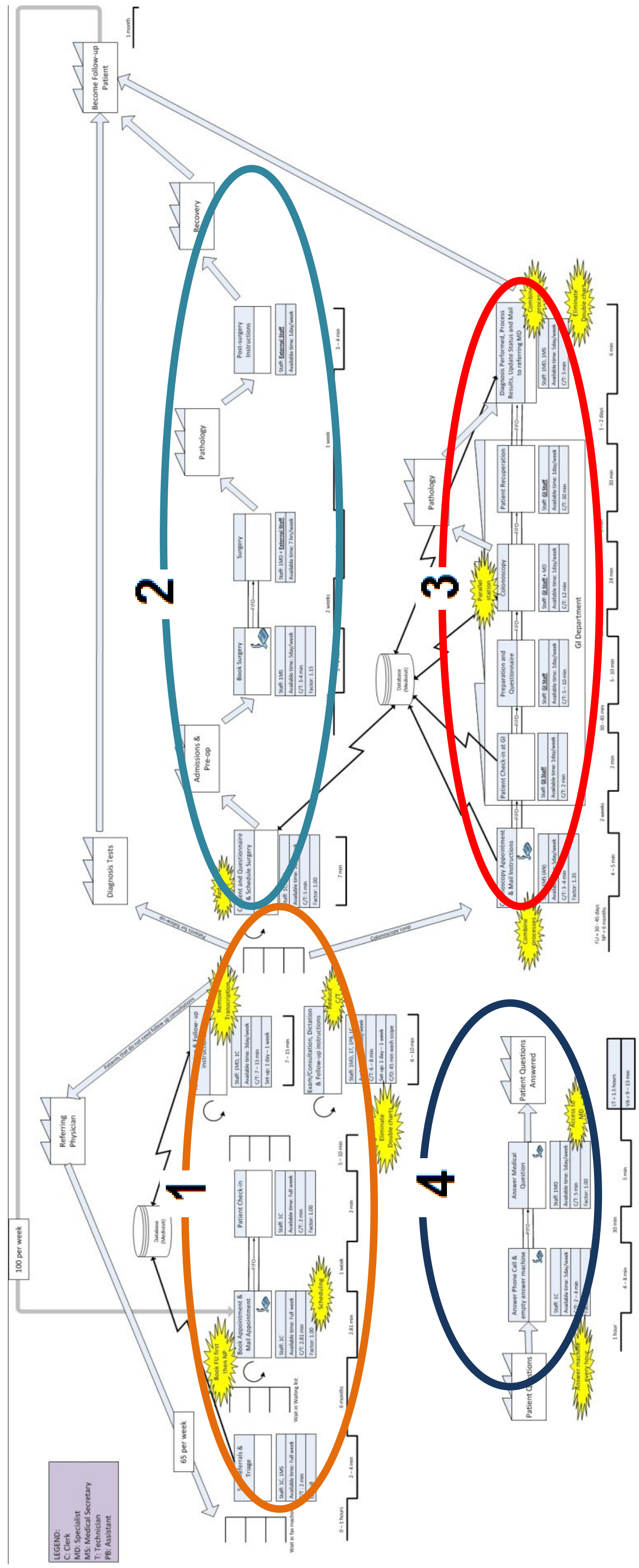

Figure 19: Proposed Colorectal Value Stream Map

5.1.1 Proposed Short Procedures Value Stream

For the colorectal department, this section of their flow is one of the most important. Every patient that is admitted has to go through this section regardless, therefore, it is important to be effective and efficient.

Four main problems are present in this section of the system. First, the processing time of the talk and examination processes are above takt time, the time required to maintain a continuous flow. Table 8 and Chart 1 shows takt time and Balance Chart respectively:

Request per week	Available Time (min)	Takt at 95% (min)
165	1260	8.04

Table 8: Short Procedures Takt Time Calculation

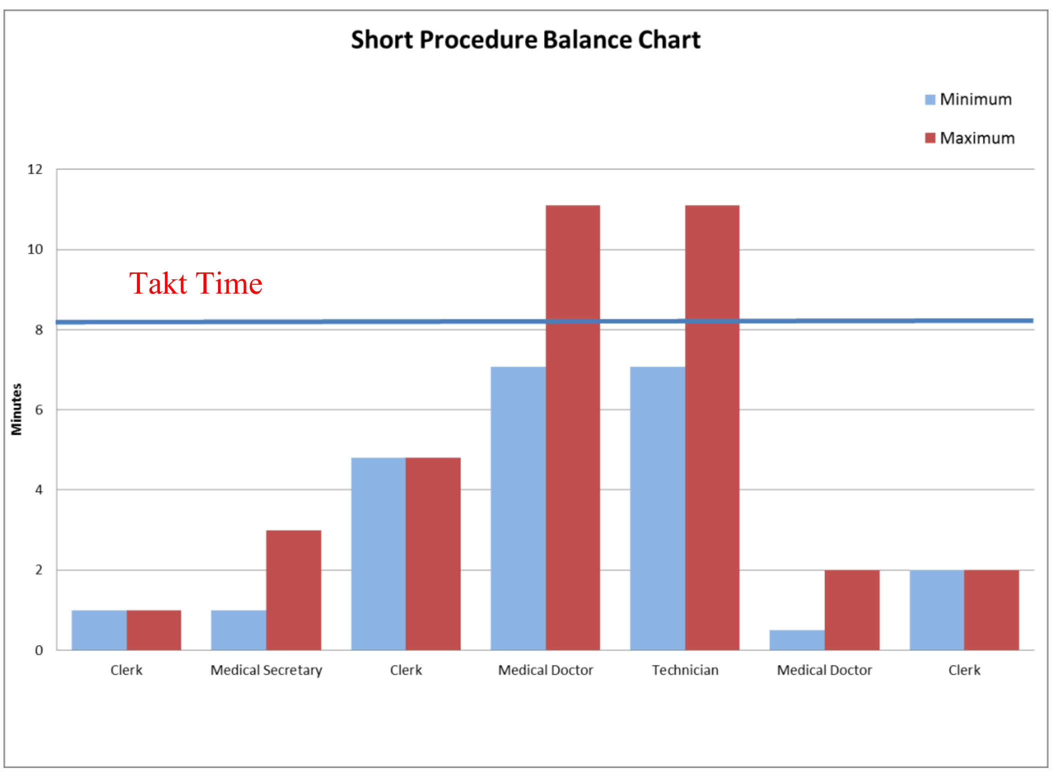

Chart 1: Short Procedure Balance Chart

The other three problems affecting this part of the system are: tasks are performed twice during the procedure process, scheduling techniques for short scopes do not consider impact on the system and walking time of the technician is above desired. These problems have been explained in detail in the analysis section.

Knowing the problems of the department allows concentrating efforts in the important processes and determining what activities are necessary and unnecessary. Figure 20 represents the proposed system for short procedures. There are six necessary changes to achieve this proposed system: Book follow-up and first-time patients as a mix, change short scopes scheduling techniques, eliminate double charting, remove transcription process, eliminate weekly inventory physical count and reduce cycle time in the short procedure and exam processes. Details are provided below.

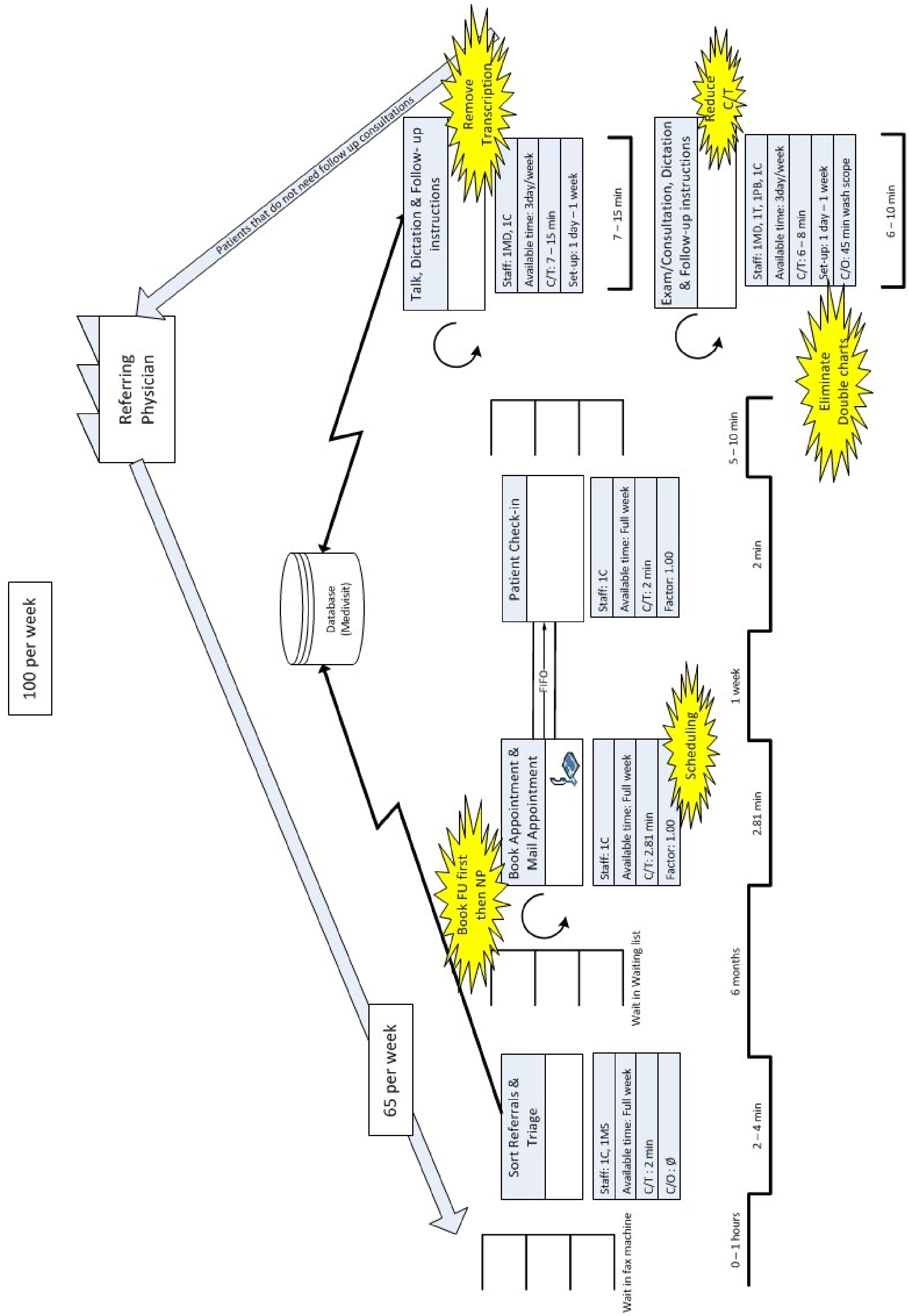

Figure 20: Proposed Short Procedures Value Stream

First, follow-up patients have been booked in different days than first-time patients. This causes an inconsistency in the system in a day-to-day basis. Follow-up patients generally take less time to process because there is previous history in the department and the MD knows the case already. In contrast, first-time patients take longer amount of time in each process because the lack of history and the MD knows less about their condition. Currently, the department receives 100 follow-up patient requests for every 65 first-time patient requests per week. Therefore, the department should schedule a ratio of 2:1 follow-ups to first-time patients. This will not only level operations in a day to day basis but it will create a continuous flow within the day's operations.

Second, short scopes should be scheduled within 9am to 2 pm, while the technician assistant is at work, to allow the technician to be available for the MD at all times. In addition, short scopes should not be carried to the sterilization room one by one; instead the technician assistant will collect two short scopes at the time in a predetermined container and bring them as a set. This is done to reduce the amount of trips to the sterilization room by half. This can be accomplished due to the sterilization machines configuration of washing two scopes at the time, therefore, eliminating the need to make a trip every short scope patient. This change will reduce the technician walking time by 2.5 kilometers or 38 minutes per day.

Third, the department needs to eliminate double charting. The information contained in the departments chart is all included in the hospital chart, which is the official one. By eliminating this extra procedure, the clerks will recover 60-75 minutes per day, making them available to concentrate in key tasks. In addition, by eliminating department's charts, the need to store 5 year old charts in an outside location will be no longer needed and the department can recuperate a portion of their yearly budget.

Fourth, the transcription process should be eliminated. Currently, it requires two full work days to an external staff to complete this task. For internal purposes, this task is unnecessary and can be eliminated with the creation of a standard forms that contain this information. For external purposes, a voice recorded diagnosis or a standard form can be sent to the referring physician. There is no need to allocate resources to transcribe the diagnosis, this task has been eliminated in several other hospitals and it is possible to implement in this department.

Fifth, physical inventory count should be eliminated to free up the technician resource. Currently, the technician does a physical count every Friday and prepares for the following week. Instead, it is recommended that the department adopts a visual tool to alert the technician when to order a specific product. This is a cost efficient solution and the adaptation stage for the technician is very fast. An example of this tool is found in Figure 21.

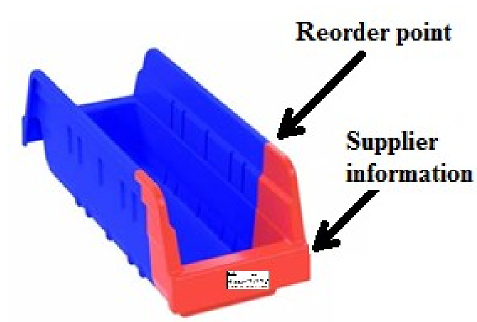

Figure 21: Visual Inventory Control Tool (Global Equipment Company Inc., 2012)

This type of tool will eliminate one day of technician time and allow him/her to concentrate on tasks that are value added.

The last necessary change is to reduce the short procedure cycle time. In order to maintain a continuous flow through the process, the cycle time of the procedure process needs to be 8.04 minutes, as shown in Table 8. The head MD in the department is the fastest of the three, he will provide mentoring to the other MDs to be more efficient and reduce their processing time. In addition, the technician will acquire two minutes of the processing time by introducing and setting up the patient in the room. Therefore, the MD will concentrate their time in performing the procedure and improve in their processing times with the help of the most experienced one. By doing these two changes the future processing time will be between 5 and 10 minutes.

In the future, the department should concentrate efforts in creating safer and more efficient procedures to reduce the cycle time at the consultation process. Furthermore, the department should upgrade from paper based records to digital; this will free resources and the staff can concentrate on improving their value added time and delivery of care to the patient.

If these proposed changes are achieved, Lead Time reductions could potentially range between 19.36% - 25.94%.

5.1.2 Proposed Surgery Value Stream

This section of the system's flow is one of the most delicate to work with. A patient that requires a surgery is considered highly important and patient's safety is a main concern.

There are many preparation procedures and communication between departments is constant for this type of patients.

There are two main problems are present in this section of the system. The first problem is unnecessary motions performed by the staff; this has been described in detail in chapter four of this thesis. The second problem is that the processing time of the surgery process is above takt time. Table 9 demonstrates the required takt time and Chart 2 shows takt time and Balance Chart respectively:

Request per week	Available Time (hrs)	Takt at 95% (hrs)
7	21	3.15

Table 9: Surgery Takt Time Calculation

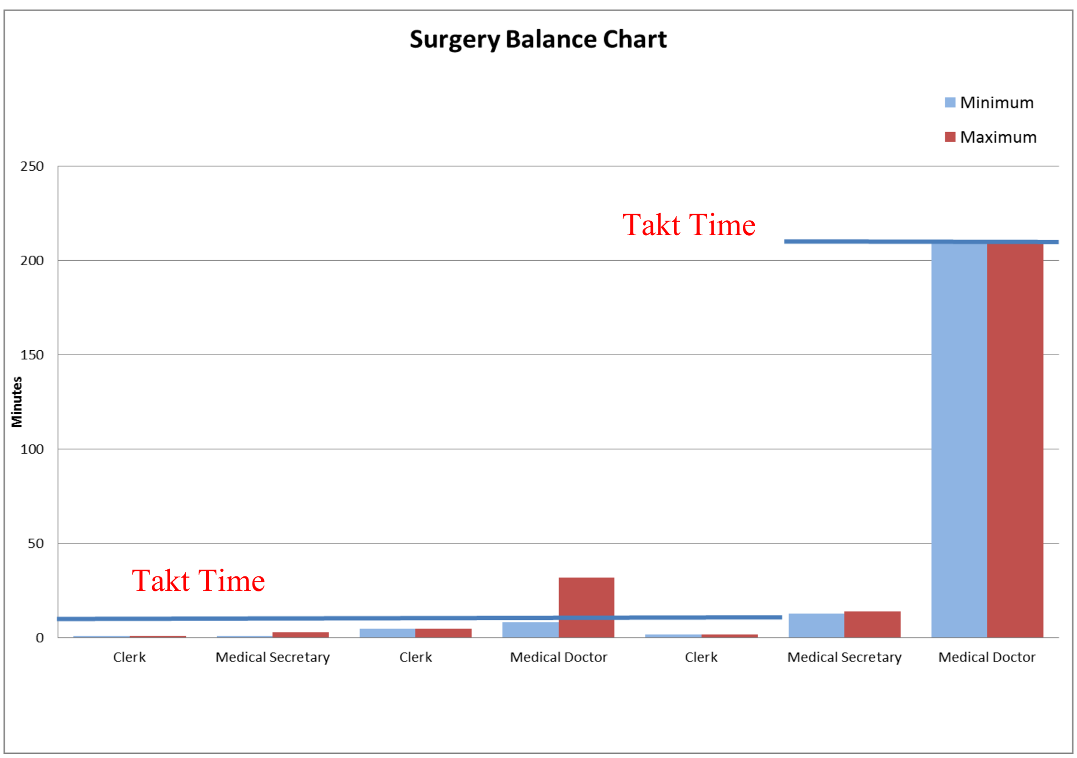

Chart 2: Surgery Balance Chart

As part of the project constraints, medical procedures cannot be changed in a way that would risk the health and safety of a patient, therefore, the surgery processing time will stay the same in the proposed system (Figure 22). However, the supporting tasks around this procedure can be improved. There are two main changes that are required to achieve the proposed system.

First, the medical secretary should not bring the consent form and questionnaire to the admission department. This activity is reducing the availability of the medical secretary by 1.5 hours per week. It is important to note that the medical secretary is considered extremely important due to the knowledge to respond to medical questions. He/she can alleviate the questions backlog directed to an MD. Therefore, it is of great importance to free as much as possible of his/her activities. In order to avoid the medical secretary to go to admission, a new procedure has been developed to drop the consent forms and questionnaires to admissions. Currently, the hospital has mail clerks (their function is to deliver mail to each department) which can be utilized for delivering the consent form and questionnaires to admissions. However, this information is considered to be confidential and the misplacement of such documents can have dangerous consequences.

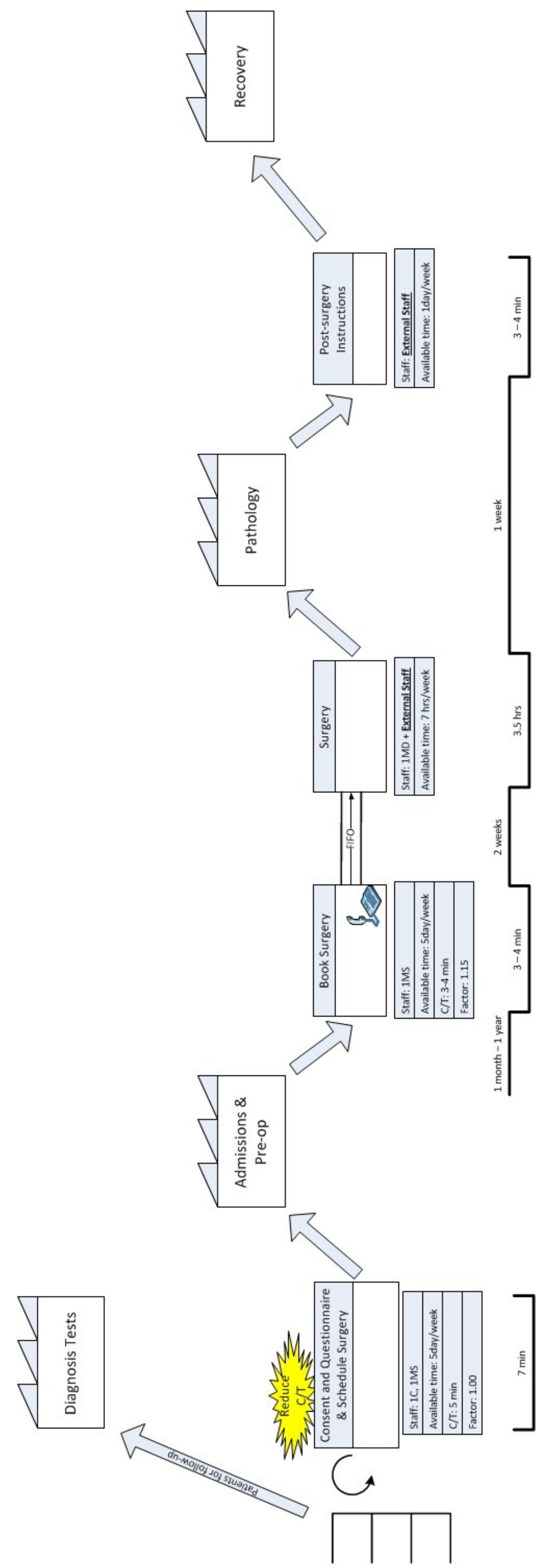

Figure 22: Proposed Surgery Value Stream Map

To account for this restriction, a color coded enveloped will be used for each group of patient's documents, this package will then be placed in a specific section of the mail cart to avoid confusion and will be delivered only to the admissions department. The following Figure represents the recommended mail cart configuration.

Figure 23: Hospital's mail cart configuration (GovGroup, 2011)

This configuration will save 1.5 hours of medical secretary time in the colorectal department and if it is adopted by the hospital, it can save valuable time in every department. This solution is cost effective and can be adopted immediately.

Second, the surgery will be scheduled at the time the consent form and questionnaire is finished. This will avoid having to call the patient to schedule a surgery; they will be notified when they drop their papers at the colorectal department. It is important to note that this task does not select a specific date and time for a surgery, it only places the patient in the system and proceeds to schedule preparation procedures in advance.

Future research is needed to reduce surgery processing time and allow patients to flow continuously throughout the department.

If these proposed changes are achieved, Lead Time reductions could potentially range between 10.39% - 10.71%

5.1.3 Proposed Colonoscopy Value Stream

This section of the colorectal department's flow is very complex. There is a certain amount of patient requests that can be forecasted, but most of the patient requests that go to this department are complex cases.

There are three main problems that are present in this section of the system. The processing time of the colonoscopy process is above takt time; Table 10 and Chart 3 demonstrate the required takt time and Balance Chart respectively:

Request per week	Available Time (min)	Takt at 95% (min)
58	1260	22.67

Table 10: Colonoscopy Takt Time Calculation

The other two problems are: Unnecessary tasks and motions by the colorectal staff and there are tasks that are performed more than once by different personnel. These problems have been described in detail in the analysis chapter of this thesis.

After the problems are identified and analyzed, the next step is to concentrate efforts in eliminating tasks that are unnecessary and create a more efficient flow in the system. Figure 24 represents the proposed system for colonoscopy loop. There are four elemental changes needed to achieve this proposed system: eliminate double charts, eliminate processes, combine processes and reduce cycle time during colonoscopy process. First, the elimination of double charts benefits has been previously discussed in the proposed common flow section.

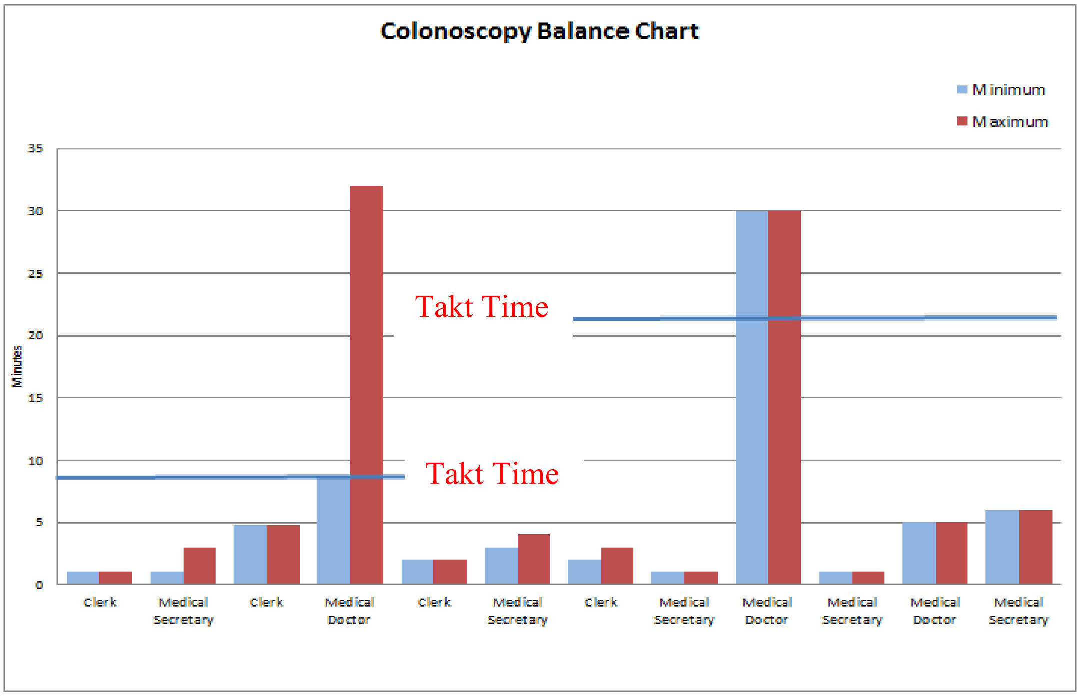

Chart 3: Colonoscopy Balance Chart

Eliminating and combining processes is a technique that is performed one in relation to the other. Currently, the department calls the patient to book the appointment, confirms the appointment two weeks later and then mails the instructions up to one month prior to their colonoscopy. In the proposed system, the confirmation of the appointment is eliminated; instead, the colonoscopy appointment is booked and confirmed in the same step one month prior to the date of the appointment, in this manner the instructions can be mailed right after the appointment is booked. Also, the department is currently updating the patient's status, two days after the diagnosis is performed by the MD and then a day later the results are processed and mailed to the referring physician. In this situation,

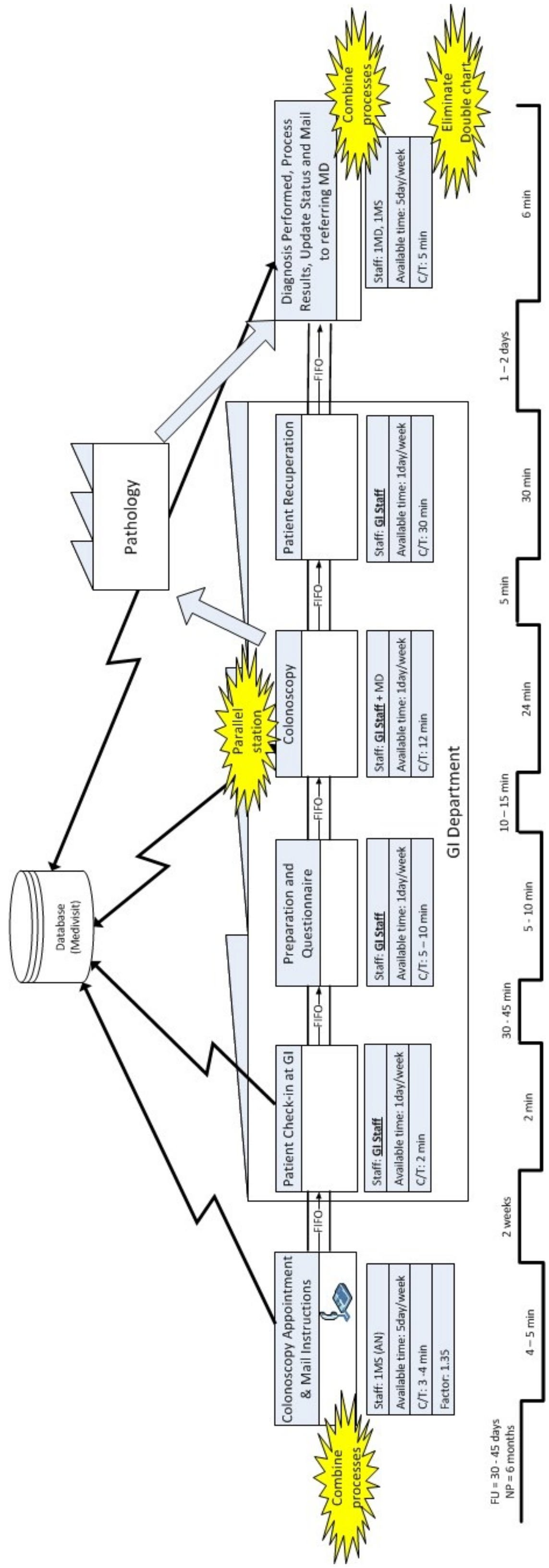

Figure 24: Proposed Colonoscopy Value Stream Map

these three processes can be combined by updating the patient status after the diagnosis is performed and at the same time the results can be processed and mailed at the same time.

The last change, the colonoscopy cycle time needs to be reduced. As stated in the constraints, an additional MD will be added to the colorectal team and it will be placed where it has the best impact for the department, that place is in the colonoscopy process. Currently, the waiting lists for colonoscopies keep increasing and with an aging population they will continue to increase. Therefore, the additional MD will perform colonoscopies in a parallel process with the other three MDs. This will reduce the cycle time from 24 to 12 minutes as shown in the proposed colonoscopy value stream map (Figure 24).

With the addition of the new MD resource and the reduction of cycle time, the department's capacity will be increased by 60 patients per week. The following calculation demonstrates the increase in throughput:

Current System

(420 min)/ (30 min per patient) ≈ 14patients * 1 resources * 3 days = 42 patients/week

Proposed System

(420 min)/ (24 min per patient) ≈ 17patients * 2 resources * 3 days = 102 patients/week

Future research is needed in this section to improve the communication between departments where paper records are still being used instead of digital ones. Any improvement in this process will impact the whole system positively.

If these proposed changes are achieved, Lead Time reductions could potentially range between 11.17% - 20.68% and patient throughput will increase by 60 patients.

5.1.4 Proposed Calling Centre Value Stream

This part of the value stream has not a direct impact on the system. However, improvements in the calling centre produce available resources to execute key activities in the value stream.

There are currently two problems in the calling centre: backlog of calls in the answering machine and an increase of messages to be returned by the MD. The backlog of calls in the answering machine is produced by checking the messages only twice a day. This was an issue due to large clerk workloads; however, in the proposed system the clerk has time to check the answering machine every hour. Not only patients will receive a faster answer but they will not place a second or third message in the answer machine about the same issue. As for the waiting messages to be answered by the MD, they are answered twice in the morning and twice in the afternoon. However, this seizes the MD resource for a longer period of time each time. In the proposed system, the MD will check the messages in smaller batches, every 30 minutes, in this manner the MD only requires a few minutes to answer the questions and provide the patient with a faster response.

Figure 25 represents the proposed system for the calling centre with the recommended improvements in place. Notice that there is a “FIFO”, first in first out, queue to avoid some callers to wait longer than others. Also, this helps to avoid forgetting to answer a message that is older than others.

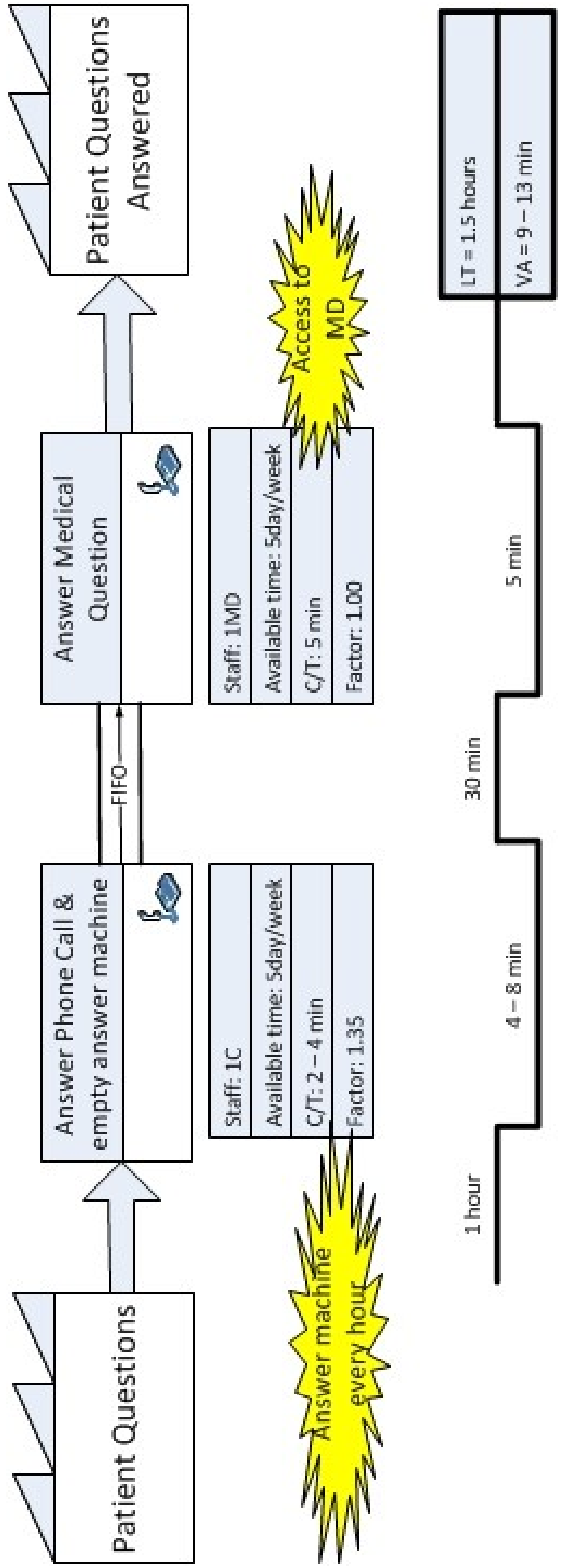

Figure 25: Proposed Calling Centre Value Stream Map

6 Summary, Conclusions and Future Research

This chapter provides a summary of importance of implementing the proposed system with a corresponding conclusion on the results previously discussed. In addition, future research areas are recommended to further improve the system and deliver better care.

6.1 Summary

The proposed methodology is promising in healthcare and should be adopted by the industry. In this research, the main objective was to increase the capacity of the department and decrease the lead time.

The main factor limiting the overall capacity in the department was found to be the number of MD resources in the colonoscopy process; this is the bottleneck of the system's flow. As discussed in section 5.1.3, proposed colonoscopy value stream, the current colonoscopy processing time is almost ten more minutes above takt time. Therefore, by allocating the new MD resource into this process, the takt time will be increased by 22 minutes making the colonoscopy processing time lower than the required new takt time.

With the new MD resource in the colonoscopy process, the system's flow will be smoother and the waiting list can be reduced by performing under takt time. It is important to note that this proposed change will have the most impact in the system flow; without this improvement, other efforts will have a low impact on the overall Lead time reduction.

Therefore, in order to achieve the maximum results the following changes need to be implemented: Book follow-up and first-time patients as a mix, change short scopes scheduling techniques, eliminate double charting, remove the transcription process, eliminate weekly inventory physical count, reduce cycle time in the short procedure and exam processes, eliminate double charts, eliminate unnecessary processes, combine processes when possible, reduce colonoscopy cycle time, medical secretary should not bring the consent form and questionnaire to the admission department, surgery will be scheduled at the time the consent form and questionnaire is finished, the MD will get phone messages every 30 min and the clerk will check the answer machine every hour and have the new MD resource work in parallel in the colonoscopy process.

If the proposed system is properly implemented and the changes previously stated are adopted, the capacity of the department will increase in the common flow and colonoscopy loop by 20 patients per week and 60 patients per week respectively. In addition the Lead time will significantly decrease; the comparison is shown in Table 11. This Table shows the minimum and maximum value of the current versus the proposed system for each section of the value stream. In addition, the last column shows the comparison result as a percentage of reduction for each row.

	Section	Current System (days)	Proposed System (days)	Reduction
Min	**Short Procedures**	31.1	25.0	19.36%
	Colonoscopy	63.4	56.3	11.17%
	Surgery	67.6	60.6	10.39%

	Short Procedures	169.1	125.2	25.94%
Max	**Colonoscopy**	324.7	257.6	20.68%
	Surgery	458.9	409.8	10.71%

Table 11: Lead Time comparison

The combination of both, increase of patients processed per week and lead time reduction, will impact the unit cost per patient in the department. With the proper implementation and under the right leadership, the colorectal department at the Montreal General Hospital can become a standard to follow and a leader for other institutions.

In addition, the proposed system tackled each problem identified in the Root Cause Analysis section of this thesis. Lead time has been reduced (Table 11), the colonoscopy and surgery processing times are reduced to match takt time in each loop, tasks are no longer performed twice, scheduling techniques have been adjusted to match the department needs and relief workload from the technician, unnecessary tasks and motions have been reduced and in most cases eliminated, call centre rework has been reduced and culture of change is in place.

6.2 Conclusions

Healthcare institutions around the world are facing the similar underlying problems like the ones shown in this thesis, and therefore it is important to concentrate efforts to reduce activities that do not add value to the patient and to manage key resources efficiently. Lean healthcare provides the methodology to identify different sources of waste, areas of improvement and tools to improve current practices, providing the healthcare industry with the opportunity to improve operations in the care delivery and impacting patient's experience.

This thesis not only provides a clear case where lean principles can be applied, but it is a reference tool for any other departments and/or institutions that wish to apply A3 and lean methodology to improve system's operations. In addition, this research provides a unique methodology with clear descriptions each step of the process, becoming a valuable thesis.

The Colorectal department has acquired the necessary tools to continue to improve their operations and reduce further their amount of waste. The increase in capacity provides the department with the opportunity to reduce the waiting list and set an example for other departments to concentrate efforts and do the same. Standard procedures will be set in place by the MDs and together the cycle times in the examination procedures will be reduced, giving am opportunity to increase their throughput.

The colorectal department at the Montreal General Hospital is pursuing to implement these tools and concepts; it requires full collaboration of managerial staff as well as floor staff. The proposed system should be implemented in different iterations and a culture of change is the best tool to continue improving the system. The improvements of this implementation can change the manner healthcare services are delivered in Canada and help improve the quality of life for many individuals.

Lastly, the contribution this thesis provides to the healthcare is of great magnitude. The proposed methodology combines Lean and A3 concepts to adapt these non-healthcare concepts into a guide to achieve effectiveness and efficiency in the delivery of care. In coming years, the Canadian population will continue to grow in average age and the need for better healthcare systems will continue to increase rapidly. This proposed solution is a great tool to commit into an improvement project and strive for perfection. By motivating the staff and adapting to a culture of change, the healthcare community can achieve great success. Therefore, by adopting these concepts, we could have a flexible, responsive and efficient healthcare system that it is very much needed.

6.3 Future Research Directions

Potential research topics to further improve the healthcare operations with lean methodology are:

- Digital hospital charts instead of paper based. What are the benefits of transferring all records into a database? What are the operational benefits of digital charts? What is the most effective plan to achieve this transition without affecting operations of healthcare institutions?
- Optimization of colonoscopy and surgery procedures. How can these procedures be more efficient without lowering the quality of care? What tasks should key resources be performing and what tasks should be transferred to others? How can these procedures be standardized to reduce the variability on processing time between practitioners? What is the percent utilization of specialized equipment?
- Analysis of personnel roles in healthcare. How can the healthcare institutions determine the appropriate number of nurses per physicians? What type of activities should be performed by key resources? Is there a need for flexible resources to perform different levels of tasks? What is the proper sizing of a

department personnel according to the type of care, throughput and complexity of the delivery?

- Standardization of medical procedures such as colonoscopies, surgeries and small procedures in ambulatory services. How can the medical society standardize efficient practices to reduce the variability in processing times? What are the areas in healthcare institutions that will benefit the most of this type of improvements?
- Screening of patients eligible for surgery versus other procedures. What is the efficiency of the current procedures for surgery screening? What are the key factors to triage the importance of the surgery on a patient? What type of screening techniques should be implemented and how can they be applied in a standard manner?

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Appendix A: Lean sources of waste

1. Defects
2. Overproduction
3. Waiting
4. Transportation
5. Inventory
6. Motion
7. Excess Processing
8. Confusion

(Graban, 2008)

Appendix B: Processing time observation sheet template

Time Observation Sheet

Process:

Date:

Task	Task Decription	1	2	3	4	5	6	7	8	9	10	Best Time	Avg. Time	Notes
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														
	Observed Cycle time													

Appendix C: Technician versus Assistant walking distance template

Distance Walked

Date:

	Staff #1		Staff #2	
Time	To Cleaning room	To check-in office	To Cleaning room	To check-in office
8:00				
9:00				
10:00				
11:00				
12:00				
13:00				
14:00				
15:00				
16:00				
17:00				
Total				

Appendix D: A3 Template