Improving program efficiency and patient experience

Ambulatory Cardiology Program

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Management summary

Context
Mount Sinai Hospital (MSH) in Toronto, Ontario, Canada, is a mid-size teaching hospital. Because of the existing financial climate across the province of Ontario and changes in funding models introduced by the Ministry of Health and Long Term Care, it essential for MSH to critically examine the effectiveness and efficiency of all cardiology services provided to its patients. The processes in the ambulatory cardiology program were perceived as not effective and not efficient. This research reviews the services of the ambulatory cardiology program.

Research opportunity
There was a need to perform a review of the ambulatory cardiology program due to a drop in patient demand with an increase in staff, high cancellation and no-show rates, low block utilization and uneven daily schedules. Furthermore, delays were experiences in inpatients being booked, outpatients being booked and referring doctors getting results. We provide insights in the existing processes of an ECG investigation and an ECHO investigation and make recommendations for improvement.

Methodology
The DMAIC cycle is used as our method. The methods of analysis starts with a systematic literature study of determining effectiveness and efficiency with the use of lean management in a health care environment. Based on the literature search we map the current processes using observational studies including time studies. We analyze the current process on workload, disturbances and demand, after which we investigate how to improve the processes. We describe implementation theories for redesigning processes in a health care environment, resulting in recommendations both for the short term as well as the long term.

Results
Results of the observational studies show a number of 15 handoffs within the ECG process and a number of 16 handoffs within the ECHO process. In both processes value is only added when an ECG technician or sonographer does the real test and a cardiologist reads the ECG/ECHO. The time efficiencies for the investigations as a percentage of the total time are:

	ECG	ECHO
Outpatient	13%	31%
Inpatient	20%	28%
With fellow	NA	19%

Table 1: Time efficiency per investigation

The block utilization in the ECHO schedule is around 70%, with a no show rate for outpatient ECHOs of 10% and a cancellation rate for outpatient ECHOs of 12%. The percentage of cancelled clinics is 32% and 28% of all outpatients getting an ECHO has to wait for more than 25 days to get the ECHO.

In order to improve the efficiency and effectiveness of the ECG and ECHO processes, the following general recommendations for future states are made, separated in the short term, long term, an ideal situation and recommendations for the ECHO schedule. The number of handoffs in the future states are also included.

Short term	**Long term**	**Ideal situation**	**ECHO schedule**
- Combined ambulatory cardiology reception; - Complete requisitions are mandatory; - Reminders by telephone; - Modifying registration screen in PM Launch; - Assigned blocks for inpatients and non-clinic outpatients; - Clinic blocks redesign; - Heart Failure Clinic books own patient electronically; - Sonographers fax preliminary report; - Streamlined billing.	- Self booking for MSH clinics; - Start with online requisitions; - Automatic confirmations and reminders via Customer Appointment Manager (CAM); - Access to CAM for sonographers/technicians; - Demographics are automatically loaded in ECHO/ECG machine; - Digital preliminary ECHO reports/ECGs to the clinics; - Auto-faxing.	- Online booking for all patients; - Self-service check in kiosk; - No MSH card; - Cerner scheduling and worklist; - Patient notification system.	- 17 outpatient ECHOs per day; - All inpatients done on the same day; - Two outpatient and one inpatient room; - Three sonographers every day; - Fellows perform mostly inpatient ECHOs; - Different shift times for sonographers; - Clinic blocks redesign; - Rules regarding cancellation of clinics.
Handoffs - ECG: 10 ECHO: 13	*Handoffs* - ECG: 5 ECHO: 8	*Handoffs* - ECG: 2 ECHO: 2	NA

Table 2: General recommendations for future states and the number of handoffs

Conclusions and outlook

Implementing the recommendations will lead to the following time efficiency for the investigations:

	ECG			**ECHO**		
	Short	*Long*	*Ideal*	*Short*	*Long*	*Ideal*
Outpatient	13%	18%	22%	32%	38%	41%
Inpatient	25%	29%	29%	30%	33%	36%
With fellow	NA	NA	NA	19%	23%	24%

Table 3: Time efficiency per investigation after implementing the recommendations

The recommendations from this research can be used as guidelines and ideas to improve the ambulatory cardiology program. It should be taken into account that the number of observations is limited and the research is conducted during the summer. Further research could be done in the other processes in the ambulatory cardiology program, at referring doctors and in the billing process. It is now up to the program itself to take the next steps.

Management samenvatting

In Dutch

Context

Mount Sinai Hospital (MSH) in Toronto, Ontario, Canada, is een middelgroot academisch ziekenhuis. Vanwege de huidige financiële situatie in de provincie Ontario en de veranderingen in het financieringsmodel van het Ministerie van Gezondheid en Langdurige Zorg, is het voor het MSH essentieel om kritisch naar de effectiviteit en efficiëntie van de cardiologieafdeling te kijken. De processen van de poliklinische cardiologie afdeling worden beschouwd als niet effectief en niet efficiënt. Dit onderzoek analyseert deze processen.

Aanleiding en doel van het onderzoek

Meerdere redenen creëerden de behoefte om de poliklinische cardiologie afdeling te analyseren: het teruglopen van het aantal patiënten met een toename in de hoeveelheid personeel, een hoog percentage aan patiënten dat hun afspraak annuleert of niet op komt dagen, een lage bezetting van de beschikbare momenten waarop ECHO's kunnen plaatsvinden en ongelijkmatig verdeelde dagelijkse roosters. Daarnaast speelden ook vertraging in het boeken van zowel klinische als poliklinische patiënten een rol, evenals het verschaffen van resultaten aan doorverwijzende doctoren. We geven inzicht in de bestaande processen van het krijgen van een ECG en het krijgen van een ECHO, en doen aanbevelingen hoe die processen verbeterd kunnen worden.

Aanpak

Dit onderzoek wordt gedaan op basis van de DMAIC cyclus. De analyse begint met een systematisch literatuurstudie naar het bepalen van effectiviteit en efficiëntie door middel van lean management in de gezondheidszorg. Op basis van deze literatuurstudie brengen we de huidige processen in kaart met behulp van observatie en tijdstudies. We analyseren de huidige processen op het gebied van werkdruk, storingen en vraag, waarna we onderzoeken hoe we de processen kunnen verbeteren. We beschrijven daarnaast implementatie theorieën voor het herinrichten van processen in de gezondheidszorg, met als resultaat aanbevelingen voor zowel de korte als lange termijn.

Resultaten

Observatie toont aan dat er 15 handoffs plaatsvinden in het ECG proces en 16 handoffs in het ECHO proces. In beide processen wordt er enkel waarde toegevoegd wanneer een ECG verpleegkundige of echoscopist de daadwerkelijke test uitvoert en een cardioloog de ECG of ECHO leest. De efficiëntie van de testen als percentage van de totale tijd zijn als volgt:

	ECG	**ECHO**
Poliklinische patiënten	13%	31%
Klinische patiënten	20%	28%
Met arts in opleiding	NA	19%

Tabel 4: Tijdsefficiëntie per test

De bezettingsgraad van het ECHO schema is ongeveer 70%, met een percentage van het aantal poliklinische patiënten dat niet op komt dagen van 10% en een percentage van het aantal poliklinische patiënten dat de ECHO afspraak afzegt van 12%. Het percentage van klinieken dat niet doorgaat is 32% en 28% van alle poliklinische ECHO patiënten wacht meer dan 25 dagen voordat het haar ECHO krijgt.

Om de efficiëntie en effectiviteit van de ECG en ECHO processen te verbeteren, worden de volgende algemene aanbevelingen gedaan voor de korte termijn, lange termijn, de ideale situatie en het ECHO schema. Het aantal handoffs is ook in de tabel opgenomen.

Korte termijn	**Lange termijn**	**Ideale situatie**	**ECHO schema**
- Gecombineerde poliklinische cardiologie receptie; - Enkel complete aanvragen worden in behandeling genomen; - Telefonische herinneringen; - Registratie scherm in PM Launch aanpassen; - Toegewezen momenten voor klinische en externe poliklinische patiënten; - Heart Failure Clinic boekt eigen patiënten elektronisch; - Echoscopisten faxen het voorlopige rapport; - Gestroomlijnde facturering.	- MSH klinieken boeken zelf; - Start met online aanvragen; - Automatische bevestigingen en herinneringen via Customer Appointment Manager (CAM); - Toegang tot CAM voor echoscopisten en ECG verpleegkundigen; - Patiëntgegevens worden automatisch in de ECHO/ECG machines geladen; - Digitale voorlopige ECHO rapporten/ECG's naar de klinieken; - Automatisch faxen.	- Online boeken van alle patiënten; - Zelf-service check-in kiosk; - Geen MSH kaart meer; - Cerner planning en *worklist*; - Patiënt notificatie systeem;	- 17 poliklinische ECHO's per dag; - Alle klinische patiënten op dezelfde dag uitvoeren; - Twee poliklinische en een klinische behandelkamers; - Elke dag drie echoscopisten; - Artsen in opleiding voeren meestal klinische ECHO's uit; - Verschillende tijdschema's voor echoscopisten; - Kliniek indeling herontwerpen; - Regels met betrekking tot de annulering van klinieken.
Handoffs - ECG: 10 ECHO: 13	*Handoffs* - ECG: 5 ECHO: 8	*Handoffs* - ECG: 2 ECHO: 2	NA

Tabel 5: Algemene aanbevelingen voor verschillende termijnen in de toekomst en het aantal handoffs

Conclusies en verder onderzoek

Het implementeren van de aanbevelingen zal leiden tot de volgende tijdsefficiëntie:

	ECG			**ECHO**		
	Kort	*Lang*	*Ideaal*	*Kort*	*Lang*	*Ideaal*
Poliklinische patiënten	13%	18%	22%	32%	38%	41%
Klinische patiënten	25%	29%	29%	30%	33%	36%
Met arts in opleiding	NA	NA	NA	19%	23%	24%

Tabel 6: Tijdsefficiëntie per test na het implementeren van de aanbevelingen

De aanbevelingen uit dit onderzoek kunnen als richtlijnen en ideeën worden gebruikt om de poliklinische cardiologie afdeling te verbeteren. Er moet rekening mee worden gehouden dat het aantal waarnemingen beperkt is en het onderzoek is uitgevoerd in de zomer. Verder onderzoek kan worden gedaan in andere processen op de poliklinische cardiologie afdeling, bij doorverwijzende artsen en in het factureringsproces. Het is nu aan het programma zelf om de volgende stappen te nemen.

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Michiel Barends

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1 | Introduction

Mount Sinai Hospital (MSH) in Toronto, Ontario, Canada, is continually challenged to provide more efficient and effective services to patients while maintaining or improving care and outcomes. Because of the existing financial climate across the province of Ontario and changes in funding models introduced by the Ministry of Health and Long Term Care (MOHLTC), it essential for MSH to critically examine the effectiveness and efficiency of all cardiology services provided to its patients.

For our research project we will review the services of the ambulatory cardiology program. We will provide insights of the existing processes within the program and make recommendations for improvement.

This introductory chapter describes the context of our research. In section 1.1 both the history of Mount Sinai Hospital and its environment and the ambulatory cardiology program are described in detail. Section 1.2 describes the problem definition and section 1.3 defines the research objective and approach.

1.1 | Research context

1.1.1 | Mount Sinai Hospital

The history of the hospital goes back to 1923, when The Hebrew Maternity and Convalescent Hospital started operating. Since then, the hospital has moved several times and has grown from a 30 bed hospital to a 442 bed hospital. Not only has the hospital location and the size changed, but the name also changed to Mount Sinai Hospital. The hospital is considered a mid-size teaching hospital, affiliated with the University of Toronto. It is located at 600 University Avenue in downtown Toronto (Mount Sinai Hospital, 2013a).

In table 7 some statistics of MSH are shown (Mount Sinai Hospital, 2013c).

Hospital staffing	**Amount**
Staff members	4,607
Trainees	1,738
Volunteers	1,003
Activity	
Ambulatory care visits	742,009
Admissions	26,983
Surgical procedures	16,692
Emergency department visits	56,080
Births	6,624

Table 7: MSH statistics

The mission of MSH is as follows:
"Discover and deliver the best patient care, research and education with the heart and values true to our heritage."

To become the best hospital in Canada a new vision has been created, called Vision 2017. The CEO of MSH has identified two reasons for developing this new vision (Chief Executive Officer MSH, 2014). The first reason is the competitive environment MSH operates in. To illustrate this environment: within a radius of 1.4 kilometres from MSH, six other hospitals exist, of which three are direct neighbours of MSH (see figure 1). The second reason is the introduction of a new MOHLTC funding model. Instead of receiving funds from a global funding model, the hospital will receive funding from a Quality Based Funding Model. Joseph Mapa, President and CEO of MSH, described this as a tremendous push to create a new vision. According to him "healthcare is changing, so we have to grasp the change instead of following it".

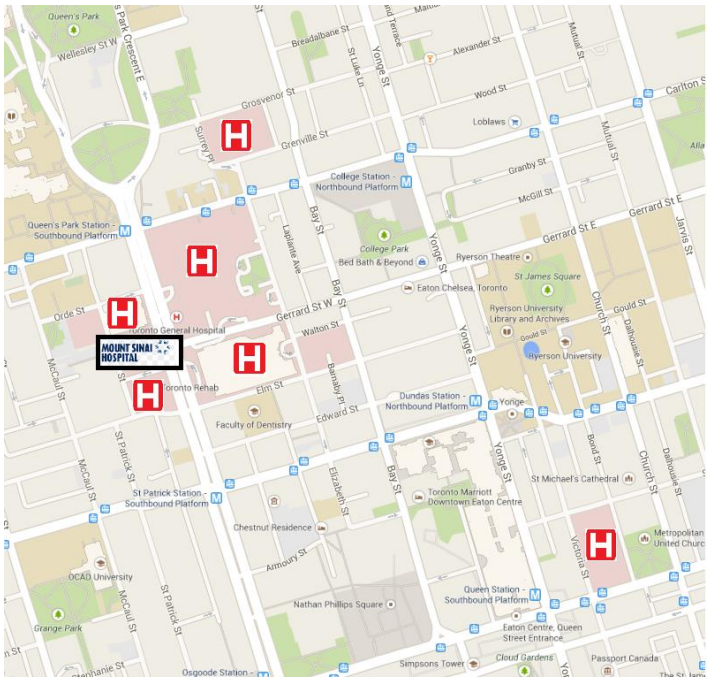


Figure 1: The environment of MSH (Google maps, 2014)

Vision 2017 must ensure that "Mount Sinai Hospital will be Canada's highest quality academic health science centre, providing the best medicine and best patient experience", stated by Joseph Mapa. The new vision focusses on four strategic priorities (Mount Sinai Hospital, 2013b):

- Differentiate our flagship clinical programs;
- Grow our organization through strategic partnerships;
- Drive high performance across our organization;
- Advance philanthropic leadership.

Vision 2017 will have influence on every part of MSH. MSH exists out of six different centres of excellence (Mount Sinai Hospital, 2013d):

1. Frances Bloomberg Centre for Women's and Infants' Health
2. Christopher Sharp Centre for Surgical Oncology
3. The Daryl A. Katz Centre for Urgent and Critical Care
4. The Centre for Inflammatory Bowel Disease
5. Centre for Musculoskeletal Disease
6. The Lunenfeld-Tanenbaum Research Institute

This research focuses on the ambulatory cardiology program within the Daryl A. Katz Centre for Urgent and Critical Care.

1.1.2 | Ambulatory cardiology program

The division of Cardiology at MSH provide services to patients for a wide range of cardiac conditions. The department provides consultation service to the Emergency Department, Intensive Care Unit, along with medical and surgical specialities at MSH. Cardiology also works closely with the high-risk obstetrics service and disease in pregnancy service, and provides consultation service for patients in Princess Margaret Hospital.

The division of Cardiology is located on the 16th floor of MSH. The floor is divided into a north side and a south side. The cardiology inpatient (see appendix I for an explanations of definitions) unit (Cardiac Care Unit; CCU) is located on the north side while the ambulatory cardiology program, which consists of the electrocardiogram (ECG) and echocardiogram (ECHO) departments, is located on the south side.

Various investigations for both inpatients and ambulatory patients are provided by the ECG and ECHO departments, these can be found in the list of definitions appendix I.

1.2 | Problem statement

Changes in funding models introduced by the MOHLTC make it essential for MSH to critically examine the effectiveness and efficiency of all cardiology services MSH provides to its patients.

The management of the ambulatory cardiology program indicates there is a need for insight in the processes of current ECG and ECHO departments. The demand for the investigations has dropped in the past year, while staffing hours has increased. Management believes that designing more effective, efficient and patient centred processes would lead to a rise in the referrals to the department. These process changes also decrease overall costs which would support the changes how the program will be funded in the future.

In order to examine the opportunities for improving the processes in the ECG and ECHO departments, we need to know the exact steps currently being performed. When these steps are clearly understood, we can then determine the value added steps and make recommendations for eliminating waste and adding customer value. We have developed the following problem statement:

Problem statement

"The current processes in the ECG and ECHO departments are perceived as not effective and not efficient. There is a need for insight into the exact steps taken in the processes in both departments."

1.3 | Research objective and approach

Because of the numerous processes that exists within the ambulatory cardiology program, we will focus on the processes concerned with receiving an Electrocardiogram (ECG) and a trans-thoracic ECHO (ECHO). Within these processes the research focuses on the process from the moment a patient is referred to the ambulatory cardiology program at MSH until the time the investigation is complete for the patient. The research includes the booking of patients for an investigation and the scheduling of staff. We have developed the following research objective:

Research objective

"To review the existing processes associated with both an ECG investigation and a trans-thoracic ECHO investigation, to determine whether and how the processes can be improved in terms of effectiveness and efficiency, while improving the quality and patient experience."

To reach the objective, the research follows the following steps. Every step is based on a question that needs to be answered.

1. *What is the workflow and performance of the ambulatory cardiology program at MSH?*

   In chapter 2 we start with a systematic literature study of determining effectiveness and efficiency with the use of lean management in a health care environment. We search for instruments which we can use for determining and improving effectiveness and efficiency in hospitals. Also, we search for literature about improving effectiveness and efficiency in the broad Management Science literature. These concepts mostly originated and have been applied in manufacturing, but may give rise to ideas which we may be able to use in the healthcare sector.

   Based on the literature search we map the current processes of both an ECG investigation and a trans-thoracic ECHO investigation in chapter 3. In paragraph 3.1 we discuss the current financial model of health care in Ontario and the changes that will be made in this model. We define the current workflow in paragraph 3.2, the current ECHO schedule in 3.3 and the customer value in 3.4. After identifying the processes to get an ECG and ECHO in chapter 3, we measure the performance of these processes in chapter 4. Paragraph 4.1 shows the number of investigations done during the week, paragraph 4.2 shows the results of direct (time) observation and paragraph 4.3 shows the number of handoffs within the processes.

2. *What is the workload and demand of the ambulatory cardiology program at MSH, and what are the disturbances?*

   In chapter 5 we analyze the current process on workload, disturbances and demand. We analyze the demand within the program in paragraph 5.1, the waiting times in paragraph 5.2 and describe the method of staffing in paragraph 5.3. We discuss the problems extracted from defining, measuring and analyzing the ambulatory cardiology program at MSH in paragraph 5.4.

3. *How can we improve the processes of providing an ECG and an ECHO at MSH?*

   We develop ways to improve the processes for an ECG and ECHO in the ambulatory cardiology program, based on the knowledge gathered in literature, together with ideas from MSH and common sense. We start with describing the ideal situation in paragraph 6.1.

4. *Which alternatives exist on the short and the long term for redesigning the processes of providing an ECG and an ECHO at MSH?*

   In paragraph 6.2 and 6.3 we formulate different alternatives for redesigning the processes at MSH so that the processes will be more effective and more efficient both for the short term and the long term. We describe a combined reception area in paragraph 6.4 and an improved ECHO schedule in paragraph 6.5.

5. *How should the alternatives for redesigning the processes be implemented?*

   In paragraph 7.1 we study implementation theories for redesigning processes in a health care environment. Based on the literature we investigate how the alternatives for redesigning the processes at MSH should be implemented in paragraph 7.2. This is the foundation for testing different (parts of the) alternatives in the ambulatory cardiology program at MSH. In paragraph 7.3 we describe the effects of implementing different alternatives on the processes of providing an ECG and an ECHO at MSH.

6. *Which recommendations can be made to improve the efficiency and effectiveness of the ambulatory cardiology program at MSH?*

   Based on the knowledge gathered in the six chapters, we develop recommendations for improving the processes concerned with booking and providing an ECG and an ECHO at MSH, both in terms of effectiveness and efficiency. We develop those recommendations for the short term and the long term and describe them in chapter 8. The chapter also includes the conclusion and discussion of the research.

2 | Literature

In chapter 2 we perform a systematic literature study of determining effectiveness and efficiency with the use of lean management in a health care environment. Paragraph 2.1 describes lean thinking in general, after which the DMAIC cycle is explained in paragraph 2.2. Every step of the DMAIC cycle is extensively explained in paragraph 2.3 until 2.6, including different tools and techniques related to these steps.

2.1 | Lean thinking

'Lean thinking' or 'Lean operations' means eliminating waste in order to develop a faster and more dependable process, combined with a higher quality of products and services, and lower costs (Slack et al., 2010). The use of lean thinking was first introduced by the automotive manufacturer Toyota Corporation, followed by the automotive, manufacturing and service industry. Eventually, lean thinking was also introduced in health care (Liker, 2004).

Womack and Jones (1996) describe five principles of lean thinking, which can be applied to any industry:

1. Provide the value customers actually desire
2. Identify the value stream and eliminate waste
3. Line up the remaining steps to create continuous flow
4. Pull production based on customers consumption
5. Start over in a pursuit of perfection 'the happy situation of perfect value provided with zero waste'

In lean thinking 'value' is defined as "*the capability to deliver exactly the product or service a customer wants with minimal time between the moment the customer asks for that product or service and the actual delivery at an appropriate price*" (Joosten et al., 2009).

Within lean thinking, different techniques exist to create value, such as value stream mapping and 5S (Rooney, 2005), Just-in-Time (Slack et al., 2010) and Six Sigma (Montgomery et al., 2008). According to Slack (2010), the most significant part of lean thinking is its focus on the elimination of waste. Waste can be seen as any activity that adds cost but does not add value. In table 8 eight types of waste can be distinguished.

Overproduction	Producing too much too early when the internal or external customer no longer has a need.
Waiting	Having to wait for services, people, information or supplies.
Transportation	The movement of people, material, supplies, data further than necessary.
Extra (Over) Processing	Producing things or completing a task that is unnecessary, that are duplicates or due to rework or inspection.
Inventory	Excess materials and supplies or things waiting in queue when there is no demand.
Motion	Unnecessary human or machine motion that does not add

	value, takes time and increases cycle time.
Defects	Wrong/inaccurate information or anything that does not meet internal or external requirements.
Underutilized Human Potential	The lack of an organizations ability to capitalize on the creative thinking and talent of its employees.

Table 8: Eight types of waste

2.1.1 | Key concepts in lean thinking

When introducing lean thinking in an organization, three key concepts should be taken into account: leadership, culture and process (Womack et al., 2005).

Leadership – The leaders at the very top of the organisation must lead the introduction of lean thinking. For an organization to be successful implementing lean strategies, it should be introduced and supported by top leaders, not only by middle managers or frontline workers, using a whole-system approach.

Culture – The set of values and beliefs that cause people to behave in certain ways forms an organization's culture. This culture is key when introducing lean thinking: a lean culture should provide the context or environment in which lean tools and techniques are implemented. That is why leaders should create a vision which enables people to make the right choices within a lean organization. One way to accomplish this is by evaluating the organizational structure, eliminating hierarchical layers and forming operational teams based on services.

Process – A distinction can be made between primary processes and internal processes. Primary processes serve the external customer, while internal processes serve the internal customer (staff) in support of the primary process. Both processes are necessary to create value. Value should be defined by the primary customer and be created by the process of the organization. As Womack et al. (2005) state: "*In a perfect process, every step is valuable (creates value for the customer), capable (produces a good result every time), available (produces the desired output, not just the desired quality, every time), adequate (does not cause delay), flexible, and linked by continuous flow. Failure in any of these dimensions produces some type of waste.*"

2.1.2 | Lean thinking in health care

In all industries, working efficiently is important to maintain healthy organisations. The term "efficient" is used to describe a system which is "achieving maximum productivity with minimum wasted effort or expense" (Oxford Dictionaries, 2014a). In health care, where expenditures appear to be ever-rising in the past decades, operating efficiently is particularly important. Applying lean thinking in health care will guide health care organizations to operate more efficiently.

However, managing systems of health care is notoriously difficult (Glouberman et al., 1996). Before changing the management to a lean thinking environment, we have to understand why managing health care systems is difficult. One explanation is that health care systems are one of the most complex systems known to contemporary society. Hospitals, in particular, are considered as extraordinarily

complicated organizations. Glouberman (1996) explains this fact by considering four different worlds within hospitals: community (the world of trustees), control (the world of managers), cure (the world of doctors) and care (the world of nurses). These four worlds are a consequence from four different ways management is practiced:

1. *Down* – directly into the clinical operations
2. *Up* – toward those who control and/or fund the institution
3. *In* – to units and people under clear control of the institution
4. *Out* – to those involved with the institution but technical independent of its formal authority

The fact that the different worlds (community, control, cure and care) remain disconnected to each other, makes it difficult to manage hospitals. Part of lean thinking is bringing those worlds together.

According to Bercaw (2012) the main opportunity for lean thinking in health care is information quality. Bercaw states: "Many work hours are consumed and many patient delays arise from the need to find, check, and/or verify information. This constant hunting, checking, and clarifying may require full-time workers. While an individual clarification may appear minor, the waste from accumulated efforts is monumental."

Value is an important aspect within lean thinking. In health care, value is often defined by the patient (Kim et al., 2006). Young and McClean (2008) propose value to be considered in three different ways in health care: clinical, operational and experiential.

- *Clinical* – achieving the best outcome for the patient
- *Operational* – primarily the cost effectiveness of a service
- *Experiential* – relating to the quality of the health care experience for patients, and their carers

Understanding value from a patient's perspective will lead to better addressing patient expectations and preferences, as well as improved clinical outcomes (Hydes et al., 2012). Though, Dickson et al. (2007) states measuring value in health care is extremely difficult. First of all because of the patient who is typically unaware of the price of the service. Second, because the patient cannot fully quantify the quality of the service. Third, because it can be extremely difficult to measure the expense that goes into the service. Despite these difficulties Dickson emphasizes that objective indicators of value are critical when assessing the effect of lean thinking. Another critical aspect to successfully implementing lean thinking according to Dickson, is placing flow ahead of efficiency: first flow, then synchronization, then efficiency.

2.2 | Lean Six Sigma: DMAIC

Next to Lean, Six Sigma is another approach for improving operations in an organization. Six Sigma focuses on reducing variability in key quality characteristics around specified target values to the level at which failure is extremely unlikely (Montgomery et al., 2008). Combining Lean Thinking with Six Sigma results in Lean Six Sigma (LSS), a process improvement method. LSS uses the DMAIC procedure,

including five steps to improve processes: define, measure, analyze, improve and control (Montgomery et al., 2008 and Neufeld et al., 2013).

Step 1: *Define* – In this step the business improvement opportunity is identified, together with the critical customer requirements. In order to do that the processes within the organization are understood by mapping the business flow.

Step 2: *Measure* – In this step the performance of the organization is measured by determining what to measure in order to satisfy customer's needs first and then gathering the data.

Step 3: *Analyze* – In this step the data gathered in step two is analyzed to find variations in the process and determine potential causes of the defects, quality problems, customer issues, cycle time and throughput problems, or waste and inefficiency.

Step 4: *Improve* – In this step the alternatives are developed to improve the process, so that variations can be eliminated. The alternatives are quantified and evaluated to verify and gain approval for the final improvement.

Step 5: *Control* – In this step customer requirements are met by controlling process variations. A strategy is developed to monitor and control the improved process. Step five results in an ongoing process management plan.

To perform each of the described steps of DMAIC, different tools and techniques exist. We describe different useful tools and techniques per step in the following.

2.3 | Define

In this paragraph we describe value stream mapping, the technique of distinguishing value added and non-value added activity and the technique to determine customer value.

In order to identify the business improvement opportunity it is useful to use a SIPOC diagram. A SIPOC diagram defines project boundaries and scope by showing the supplier(s), input, process, output and customer(s) (George et al., 2005).

Value stream mapping

According to Rother and Shook (2009) within value stream mapping you map all the actions (both value-creating and non-value creating) currently required to bring a product or service through the main flow essential to deliver a product or service. The initial steps are as follows:

1. Current state drawing by gathering information on the floor
2. Future state drawing to close gaps in flow and waste from the current state
3. Work plan & implementation leading to continuous improvement at the value stream level

The value stream map should include all major process steps and activities, along with suppliers and customers. Queue lengths, waiting times and work-in-process levels should be identified (Montgomery et al., 2008), together with starts and stops in the process, connections and hand-offs (Bercaw, 2012).

Value added and non-value added activity

To eliminate waste we have to reduce non-value added activity. In order to reduce non-value added activity we have to distinguish value added and non-value added steps. Every activity that occurs in an organization falls into one of these two categories (Bercaw, 2012). Value added activities contribute directly to satisfying the needs of the customer. Another definition of a value-added activity is any action for which a customer is willing to pay.

Non-value added activities are the exact opposite of value added activities. Such activities can be defined as operations that do not add any value to the process and should be removed completely. A non-value added activity may also be defined as an activity for which a customer is not willing to pay. A special type of non-value added activities are activities which are necessary but add no value. These activities are required by law or business practice and therefore cannot be removed.

As stated above, in health care the definition of value is slightly different from the definition of value in other industries. A value added activity directly meets the need of customers (Bercaw, 2012). In order to determine whether an activity adds value or not, it has to be clear who the customers are and what their needs are.

Customer value

In order to figure out what customers care about and set priorities and goals consistent with customer needs, we have to determine customer value. We used customer observation, the results of customer surveys done by the department itself and the results from a three days value stream event (see chapter 3). The data gathered by these tools were used to develop critical-to-quality requirements (George et al., 2005).

2.4 | Measure

In this paragraph we describe different methods that can be used to measure the performance of the processes. We will describe the direct (time) observations and the handoff process mapping.

Direct (time) observation

This tool is used to identify waste by observing the processes directly (Bercaw, 2012). To do this we need to go to the workplace and see the actual waste and make use of time studies. The first step of a time study is recording the task times. Then these tasks need to be standardized, to create a more productive and safer way of working. Finally, the average time for each task is calculated, so we can set a time standard for each task. To measure the task time a Time Observation sheet can be used. On this sheet all the different steps are listed and the time each step takes for at least ten observations. The average of the sum of the time each step takes is the total time for one cycle.

Handoff process map

A circle diagram can be used to visualize the information flow within a process. a circle diagram can be used as a tool to visualize all those transportations. Some examples of information flows are via email, faxes and telephone, but also face to face (Bercaw, 2012).

To visualize all the information flows first draw a large circle. List all the different roles/resources that exchange information within the process around the circle. Every time there is an exchange in information among the roles/resources a line is drawn between the two. Once all of the information flow lines have been drawn, the lines are counted. The number of lines equals the number of information hand-offs. A process with numerous handoffs usually means there is redundancies in information and has the potential to cause or lead to errors in the transfer/sharing of information. By reducing the number of hand-offs the quality of information can be increased and the timeline can be shortened (Bercaw, 2012).

2.5 | Analyze

In this paragraph we describe two different methods for analysing the data gained by the measure step. We will describe the Ishikawa diagram and a metric that can be used to determine the efficiency of the process.

Metric of time efficiency

This tool can help to determine how much time and effort is spent on a specific process. One of the metrics that can be used is the Process Cycle Efficiency (Bicheno, 2004). The rate shows how much of the total time spent in a process is really value adding for the costumer, in this case the patient. The rate can be determined according to the following metric:

$$Process\ Cycle\ Efficiency = \frac{Value\ Added\ Time}{Process\ Cycle\ Time}$$

Ishikawa diagram

There are many tools that can help with identifying potential causes for problems. To identify possible root causes for problems, an Ishikawa (cause-and-effect) diagram can be used. All the possible causes are sorted in different groups, for example Equipment, People, Procedure and Policy (Neufeld et al., 2013) and are placed in a fishbone diagram with the problem at the head of the fishbone.

2.5 | Improve

Improving processes start with creating flow. In health care, patients should flow through the system. This implies that creating flow is not the same as lining up sequential activities in a continuous manner. Flow can be defined as “completing the value added tasks in continuous flow at the rate of customer demand in a standardized way” (Bercaw, 2012). In order to create flow we first have to eliminate waste and second have to perform the value added activities in a standard way to achieve consistent outcomes. However, sometimes it is not possible to create a continuous flow of all steps: that is where the concept of pull is introduced. In its simplest form pull is a signal to do work. This means work would

only be performed when a true need from the customer is present. Bercaw describes certain attributes for the signal which will satisfy the principle of pull:

1. Only one way to trigger exists
2. Only one way to respond exists
3. The processes within the systems are seamless and synchronized and involve no gaps, overproduction, asking, searching or clarifying.

So to improve the processes we start with creating flow. To do that, we have to make the future-state value adding process flow by eliminating the identified waste and implement customer-pull. This should result in increased quality, productivity and flexibility, which can also be obtained by transferring responsibility, problem solving and decision making to employees (Bowen, 1998). According to Capelli and Rogovsky (1994), four characteristics of lean thinking work practices exist to transfer responsibility:

- Employee empowerment and participation in decision making
- Group participation, or teamwork
- Job rotation and cross training
- Supportive personnel practices including profit sharing, pay-for-skill programmes, skills training and socialization programmes

During a value stream event valuable information for improving the process can be obtained from employees. During such an event the employees map their current process and think of ways to improve this process into a future state. Since those employees are part of the process, the ideas generated tend to be small and very specific (Dickson et al., 2009).

Part of the improve step in DMAIC is also re-measuring the data obtained in the measure and analyze step. This is done by testing the improved processes in real life through Plan-Do-Study-Act (PDSA) cycles in which small tests of change are carried out. We first design small tests of change (plan), then implement the tests on a small scale (do), measure the performance compared with the current state and evaluate how it could be better (study) and introduce the changes to adjust the process (act), while determining whether the changed process is sustainable (Womack et al., 2005).

Takt boards

One specific technique used for improving a process and reaching continuous improvement is the use of a takt board. Takt boards monitor the output of a process so that the employees, who are part of the process monitored by a takt board, are able to judge if the output is meeting the demand. According to George et al. (2005) takt boards should provide at least three key pieces of information: the work being done, the desired speed and the actual completion rate. The board consists of a *Plan* and an *Actual* column. In the *Plan* column the amount of units per hour based on takt time are shown. In the *Actual* column the actual amount of units per hour are recorded. By recording the actual output and comparing it with the planned output we can determine where the process is delayed and why the process is delayed. This makes waste visible and helps getting the work back on track. The next step is to identify the reasons for the variation in the process. To do this all the different reasons that cause variance have to be listed. The quantities of those reasons show which are the biggest causes for variance. Those should be tackled to keep the process on track.

Kanban

Kanban is a system for just-in-time production. Although the system is commonly used in production organizations, you can also integrate it in a hospital environment. Kanban helps preventing product stock-outs, to make sure the process does not stop. An example of Kanban is having two bins of the same product. When the first bin is empty, it triggers the material handler to replenish the product for the warehouse. They available product in each bin is calculated based on usage, lead times from the supplier, and scrap rates. Kanban systems are designed to avoid over-stocking and stock-outs, which could cause unnecessary costs and risks.

Standardization of work

Imai (1997) states "Efficient daily management of resources, including personnel, information, equipment, and materials, requires standards." Standards are used to create processes that are the easiest and safest for the staff, and the most cost-effective and productive for the employer. A standard process ensures a satisfied customer. If staff operates according to those standards, a consistent outcome is created. Standards have the following key features (Imai, 1997):

- "Standards represent the best, easiest, and safest way to do a job
- Standards offer the best way to preserve know-how and expertise
- Standards provide a way to measure performance
- Standards show the relationship between cause and effect
- Standards provide a basis for both maintenance and improvement
- Standards provide objectives and indicate training goals
- Standards provide a basis for training
- Standards create a basis for audit or diagnosis
- Standards provide a means for preventing recurrence of errors and minimizing variability"

5S model

The 5S model is systematic way to create an organized, clean and safer workplace, resulting in better performance and less defects. It is a basis for continuous improvement. Imai (1997) stated: "As a general rule of thumb, introducing good workplace organization reduces process defects by 50%." The 5S model consists of five stages (John Bicheno, 2004):

Sort - To get a more organized and cleaner workspace all items that are not used should be eliminated. When an item is used often check if the quantity is correct. If an item is used less frequently or even rarely, think about storing it somewhere else where it would not be an obstacle.

Simplify - Locate the items that are often used in a location that is easy to reach, so arrange all items in the best positions. The location of those items should be standardized, so they can be used as quickly as possible. Repeat this stage whenever items or processes are changed.

Sweep - Make sure the workplace is clean and everything is on the right place. When an item is not located where it should be, immediately move the item to the standardized place. Make sure to do this all the time, this keeps the workplace clean and organized.

Standardize - This stage involves the development of standards for the first 3 S's.

Sustain - Maintain the established procedures and carry out audits to make sure everyone sticks by them. This will keep the workplace organized, clean and safer.

2.6 | Control

Objective of the control step is to complete all remaining work on the project and to hand off the improved process to the process owner (Montgomery et al., 2008). To be able to hand off the process, we develop a process control plan and other necessary procedures to ensure the improved process will be institutionalized. According to Montgomery et al. the process owner should be provided with before-and-after data on key process metrics, operations and training documents and the improved process maps. Next to that, the financial benefits of improving the process should be indicated. All of this should result in a control chart on critical process metrics. This control chart includes (Montgomery et al., 2008):

- Data on key process metrics before and after improvement
- Financial impact overview
- Process control plan
- A summary of lessons learned from improving the process
- A list of opportunities which were not covered within improving the process, but can be used to develop future improvement projects
- A list of opportunities resulting from improving the process which can be used in other parts of the organization

Part of the control step is a validation check several months after the completion of improving the process. However, the scope of this research does not allow us to include this.

What can be done to get to continuous improvement are the use of A3 reports and poka-yoke. A3 reports are used to implement the scientific method when solving problems. Within so called "A3 thinking" an A3 is actually used to systematically solve problems. Sections to be filled out on the A3 include "the theme, current conditions, target conditions, gap analysis, countermeasures and action plans, follow-up plans, measurement tracking, and reflections" (Bercaw, 2012). The A3 guides the problem solving efforts when identifying and eliminating waste. Poka-yoke (translated as "mistake-proofing/failure prevention") is an approach in which a process is designed to make it impossible to do the work improperly (Bercaw, 2012).

3 |Define

In chapter 3 we define the current situation in the ambulatory cardiology program at MSH. We use the tools described in chapter 2 to identify and define the processes for an ECG and ECHO. We describe the current funding model of health care in Ontario in paragraph 3.1. In paragraph 3.2 we map the value stream for both processes. We define the schedule for ECHOs in paragraph 3.3, the customer value in paragraph 3.4 and the goals of the program in paragraph 3.5.

Three day value stream event

The information used to measure and define the current situation is gathered both through a three day value stream event and observational studies.

The value stream event was held for three days from April 29 until May 1, 2014. Sixteen MSH employees attended, of which their functions sorted per department are shown in table 9. The manager for special projects from the urgent and critical care department facilitated the three day event.

Emergency and inpatient cardiology departments	**ECG and ECHO departments**	**Others**
Emergency Department Nurse	ECG Technician	Cardiologist/Director of ECHO lab
Emergency Department Clinical Coordinator	ECG Receptionist	Administrative Assistant to two MSH cardiologists
Cardiology Nurse	Chief Sonographer	Heart Function Program Clinical Nurse Specialist/Nurse Practitioner
Cardiology Clinical Nurse Specialist	Sonographer	Administrative Assistent to Heart Function Clinic
Cardiology Patient Navigator	ECHO Receptionist	Porter
	Clinical Coordinator Ambulatory Cardiology Program	

Table 9: Participants of the three day value stream event from April 29 until May 1, 2014

Roles in the ambulatory cardiology program

In both the ECG investigation and the ECHO investigations, different roles are involved in the process. We define these roles below.

Patient – The person who receives the cardiac investigation.

ECG Receptionist – The ECG Receptionist is responsible for booking patients for the different investigations that are performed in the ECG department and the registration of patients when they arrive.

ECHO Receptionist – The ECHO Receptionist is responsible for booking patients for the different investigations that are performed in the ECHO department and the registration of patients when they arrive.

ECG technician – This is the person who performs the different investigations in the ECG department.

Sonographer – This is the person who performs the ECHO and generates the preliminary report.

Fellow – This is a cardiologist in training. During an ECHO a sonographer learns a fellow how to perform an ECHO. This is done by letting the fellow perform the ECHO after the sonographer did this. The sonographer comments on the way the fellow performs the ECHO.

Cardiologist – A cardiologist is the doctor who reads the study, draws the conclusions and makes the final report for the investigation. A cardiologist can read both ECGs and ECHOs.

Referring doctors/offices – The patients referred to the cardiology department for a cardiac investigation have different origins.

- Internal MSH Cardiologists
  In total there are 13 cardiologists in the MSH with their own clinics.
- MSH Emergency Department and Inpatient Units
- External Family Physicians and Cardiologists
- Princess Margaret Hospital (PMH) (The PMH is located near the MSH and is attached to the MSH via a tunnel. Patients can use this tunnel to get from one hospital to the other.)

Porter – A porter is someone who can be called if a patient needs to be transported throughout the hospital. When a porter is required, they are ordered through the computer using an online portering system. In most cases porters are used for transporting inpatients who need to be picked up or returned to their room.

3.1 | Financial model of health care in Ontario

Since January 2012 the MOHLTC has been gradually changing the funding model for healthcare from Global Funding to a Patient-Based Funding model. Historically the funding model was based on lump-sum funding, which does not take into account the complexity of patients, does not reflect service levels and costs and does not encourage or stimulate better performance. The new Patient-Based Funding model gives priority to the most important stakeholder: the patient. The model is directly linked to the quality of care and to a smarter use of resources to create a more sustainable health care system.

The new model compensates Ontario's hospitals, Community Care Access Centres and long-term care homes based on the following four aspects:

- The amount of patients they look after
- The services they deliver
- The evidence-based quality of those services
- The specific needs of the broader population they serve

In 2015-2016, 70 per cent of the funding model will consist of Patient-Based Funding and the remaining 30 per cent will come from Global Funding. The 70 per cent of Patient-Based Funding will approximately consists of 40 per cent funding via the Health Based Allocation Model (HBAM) and 30 per cent via the Quality-Based Procedures. The Health Based Allocation Model is a model that predicts the future costs of funding based on the information of residents. The amount of funding depends on the demographics of the residents and the complexity of care and type of care they might need. The Quality-Based Procedures are based on a price times volume formula. This formula uses rates that are adjusted to the efficiency and best practice of each procedure. This results in the hospital getting paid for all the procedures the patient gets during a hospital visit.

This change will impact MSH, since the entire hospital needs to become more efficient in order to keep operating with less funding. The ECG and ECHO department will not be impacted directly by the changing financial model. However, since the hospital's budget will be impacted by the change, the budget of the ambulatory cardiology program will also be affected indirectly.

The funding for inpatients in the ambulatory cardiology program is based on the yearly budget of the program. The funding for outpatients is based partly on the yearly budget and partly on the number of investigations performed. For every investigation the MOHLTC pays a technical fee and a professional fee. The professional fee goes to the doctor and the technical fee goes to the department itself.

3.2 | Value stream

3.2.1 | ECG

The SIPOC diagram of an ECG is shown in table 10.

Suppliers	Inputs	Process	Outputs	Customers
Cardiologist's clinics	Requisition	ECG investigation	Final report	Patient Referring doctors
Family Practices				
General MSH departments				
Other hospitals				

Table 10: SIPOC diagram of an ECG

The current general value stream to get an ECG as an outpatient is shown in figure 1. A description of the detailed steps taken per general step can be found in appendix II. ECG investigations for outpatients are done on a walk-in basis. Although we studied the process from the moment a patient arrives until the moment a patient leaves the ECG department, the steps that happen after a patient has left are also included in the general value stream. These steps influence the part of the process in which the patient is present. Only the steps taken by the ECG Receptionist and ECG Technicians are described in detail in appendix II: the details of the reading by a cardiologist are not part of this research.

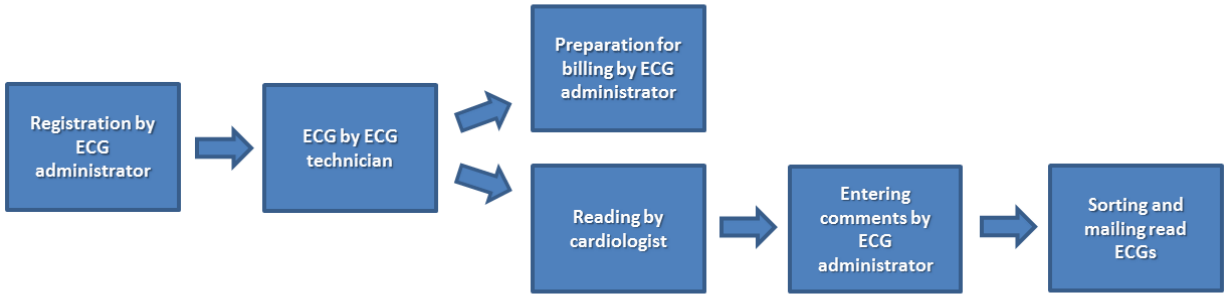


Figure 2: Current general value stream to get an ECG at MSH

3.2.2 | Other processes at the ECG department

The general steps as shown in figure 2 and as described in more detail in appendix II belong to the ECG process. A lot of the different steps are performed by the ECG receptionist. However, there are other tasks the ECG receptionist has to perform. We do not describe the other tasks in detail, but mention them here. These other tasks are important to take into account when studying ways to improve the administration part of an ECG.

Registration of Holter tests by ECG receptionist – The registration of a Holter test is similar to the registration of an ECG.

Registration of Blood Pressure tests by ECG receptionist – The registration of a Blood Pressure test is similar to the registration of an ECG.

Entering comments for Holter tests by ECG receptionist – Just like entering comments for ECGs, also comments for Holter tests are entered by the ECG receptionist.

Booking Holter tests and Blood Pressure tests by ECG receptionist – Holter tests and Blood Pressure tests are not walk-in based. Appointments for these tests are scheduled via incoming calls from patients.

Photocopying Holter tests – Holter tests are photocopied manually in order to fax the results of the tests to referring doctors.

The ECG technicians have several other tasks next to performing the ECG:

Editing ECGs done by Emergency Nurses – The ECGs which are done at the Emergency department have to be editted by ECG technicians. The nurses who perform the ECG at Emergency to not fill in the demographics of the patient correctly, so that the ECG technicians have to correct this.

Performing Holters – Based on appointment, the technicians also perform Holters.

Performing BPs – Based on appointment, the technicians also perform BPs.

3.2.3 | ECHO

The SIPOC diagram of an ECHO is shown in table 11.

Suppliers	Inputs	Process	Outputs	Customers
Cardiologist's clinics	Requisition	ECHO investigation	Final report	Patient
Family Practices				Referring doctors
General MSH departments				
Other hospitals				

Table 11: SIPOC diagram of an ECHO

Many different steps are needed to perform an investigation in the ECHO department. These steps can be subdivided in eight general steps, the exact amount of steps depends on whether it is an investigation for an inpatient or a clinic or non-clinic outpatient. These general steps are shown in figure 3. The reading of the investigation by the cardiologist is not part of this research, but is included in the general overview for the understandability of the process. Also, the steps performed by the ECHO receptionist, after the patient has left the department, are included in the general overview. These steps affect the process during the stay of the patient and need to be taken into account when improving the process. A detailed description of all the processes can be found in appendix III.

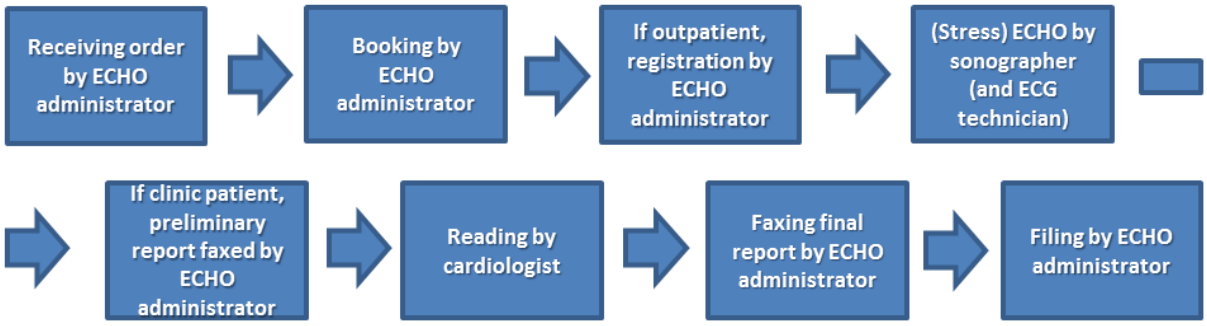


Figure 3: Current general value stream to get a (Stress) ECHO at MSH

3.3 | ECHO schedule

In the current ECHO schedule three ECHO exam rooms are available for ECHO investigations and one portable ECHO machine can be used for inpatient ECHOs. Each sonographer is assigned to one ECHO exam room during a working day. Every ECHO investigation is scheduled for 45 minutes except when a sonographer is working with a Fellow. Then, the ECHO investigations are scheduled for 60 minutes. A Fellow is always linked to one sonographer.

Outpatient

There are no reserved spots for outpatients only. Empty or cancelled spots can be booked for outpatients.

Inpatients

There are no reserved time slots for inpatients. Orders for inpatients that arrive after the ambulatory cardiology clinic closes for the day are booked into any available time slot the following clinic day. When orders for inpatients arrive during the day, the ECHO Receptionist books these ECHO investigations whenever a slot is available and the receptionist has time. On a regular basis there are more inpatient orders than available spots. There is no set time for how long a "normal" inpatient (not a STAT) order can wait before the actual ECHO is performed. The wait time for a true STAT may be immediate to four hours and the results are required the same day. If the ambulatory cardiology clinic is fully booked, STAT inpatient orders are triaged by the cardiologist.

Staffing

There is no balanced staffing schedule. The current staffing model for normal ECHOs is as follows:
Monday – Two sonographers
Tuesday – Three sonographers
Wednesday – Three or four sonographers
Thursday – Three sonographers, or four if no research takes place that day
Friday – Two sonographers

All sonographers start at 8:30 in the morning and are finished at 16:30. All sonographers take a one hour break from 12:15 to 13:15. Each sonographer has the ability to perform nine ECHOs a day. If there is a fellow with the sonographer they can only perform seven ECHOs that day.

Clinic outpatients

In the current schedule there are 82 time slots reserved for clinic outpatients. Clinic outpatients are outpatients that are patients of one of the MSH cardiologists. Some of these patients require an ECHO (and ECG) prior to seeing the cardiologists. Each cardiologist has his/her own dedicated clinic times during the week. The time slots within the ECHO schedule are determined, based on the cardiologists time slots.

Each cardiologist office informs the ECHO receptionist via email or fax which timeslots are booked and which time slots are available for other inpatient and non-clinic patients. There are currently no set rules on when and how cardiologists ECHO schedules are managed. When the receptionist receives the schedule the patients are entered into the Customer Appointment Manager. After entering the schedules the ECHO receptionist knows which of the reserved time slots are now available for other patients.

Table 12 below shows the current ECHO schedule based on the reserved time slots for the cardiologists. The red boxes represent heart failure clinics. The blue boxes represent general clinics, and the yellow boxes represent the breaks for the sonographers. The letters A, B, C and D at the top represent the different sonographers that are working during that day.

	Monday			
Time	**A**	**B**		
8:30 - 9:15	Dr. Gold	Dr. Gold		
9:15 - 10:00	Dr. Gold	Dr. Floras		
10:00 - 10:45	Dr. Gold	Dr. Gold	Dr. Sasson	
10:45 - 11:30	Dr. Sasson	Dr. Sasson		
11:30 - 12:15	Dr. Floras	Dr. Floras		
12:15 - 1:15				
1:15 - 2:00	Dr. Floras	Dr. Floras		
2:00 - 2:45				
2:45 - 3:30				
3:30 - 4:15				

	Tuesday			
Time	**A**	**B**	**C**	
8:30 - 9:15	Dr. Nesbitt			
9:15 - 10:00	Dr. Sasson	Dr. Colman	Dr. Nesbitt	Dr. Nesbitt
10:00 - 10:45	Dr. Sasson	Dr. Colman		
10:45 - 11:30	Dr. Sasson	Dr. Sasson	Dr. Colman	Dr. Nesbitt
11:30 - 12:15	Dr. Colman			
12:15 - 1:15				
1:15 - 2:00	Dr. Mak	Dr. Mak	Dr. Mak	
2:00 - 2:45	Dr. Mak	Dr. Mak	Dr. Mak	
2:45 - 3:30	Dr. Mak	Dr. Mak	Dr. Mak	
3:30 - 4:15	Dr. Mak			

	Wednesday			
Time	**A**	**B**	**C**	**(D)**
8:30 - 9:15	Dr. Gold	Dr. Balmain	Dr. Mak	
9:15 - 10:00	Dr. Gold	Dr. Balmain	Dr. Balmain	Dr. Mak
10:00 - 10:45	Dr. Gold	Dr. Gold	Dr. Balmain	
10:45 - 11:30	Dr. Balmain	Dr. Mak		
11:30 - 12:15				
12:15 - 1:15				
1:15 - 2:00	Dr. Balmain	Dr. Balmain		
2:00 - 2:45	Dr. Balmain	Dr. Balmain		
2:45 - 3:30	Dr. Balmain	Dr. Balmain		

3:30 - 4:15	Dr. Balmain	Dr. Balmain	Dr. Balmain	

	Thursday			
Time	**A**	**B**	**C**	**(D)**
8:30 - 9:15	Dr. Newton	Dr. Newton	Dr. Barolet	
9:15 - 10:00	Dr. Balmain	Dr. Balmain	Dr. Barolet	
10:00 - 10:45	Dr. Balmain	Dr. Balmain	Dr. Newton	
10:45 - 11:30	Dr. Newton	Dr. Newton		
11:30 - 12:15	Dr. Balmain			
12:15 - 1:15				
1:15 - 2:00	Dr. Balmain	Dr. Balmain		
2:00 - 2:45	Dr. Balmain	Dr. Balmain		
2:45 - 3:30	Dr. Balmain	Dr. Balmain		
3:30 - 4:15				

	Friday			
Time	**A**	**B**		
8:30 - 9:15	Dr. Wald	Dr. Wald		
9:15 - 10:00	Dr. Wald	Dr. Wald		
10:00 - 10:45	Dr. Wald	Dr. Wald		
10:45 - 11:30	Dr. Wald	Dr. Wald		
11:30 - 12:15				
12:15 - 1:15				
1:15 - 2:00				
2:00 - 2:45				
2:45 - 3:30				
3:30 - 4:15				

Table 12: Current ECHO schedule

3.4 | Customer value

As can be seen in the SIPOC diagrams shown in table 10 and 11, we distinguish between two different types of customers: patients and referring doctors. Patients are customers of the ECG and ECHO process, since they receive the ECG and/or ECHO investigations at MSH. Referring doctors are customers of the ECG and ECHO process, since they can choose which hospital they will send their patients too. For both customers , we identified seven indicators for customer value: quality of care, length of stay, length of time, confidentiality, accuracy, properness and movement. These indicators are sorted based on the categorization of Young and McClean (2008).

Clinical

Quality of care – The ECG and/or ECHO investigation the patient receives should achieve the best outcome for the patient. The quality of care can be measured by the average number of times a patient has to come back for a new ECG/ECHO, because the first one was not performed to standards.

Operational

Timely appointments and results for patients – The total amount of time, in minutes, it takes for a patient to get an ECG and/or ECHO from the moment the patient arrives at the ambulatory cardiology department until the time the test is complete and the patient can leave. A patient expects their length of stay to be as short as possible without decreasing the quality of care.

Experiential

Waiting time upon arrival – The time, in days, between submitting an requisition for an investigation and receiving the results from that investigation by the referring doctor. The referring doctor expects the results of the investigation as fast as possible after sending the patient for an appointment. The referring doctor keeps this in mind when choosing a hospital/clinic to send the patient for an investigation.

Confidentiality – Measured by the number of people who receive sensitive information on specific patients, the number of times information is left alone without supervision and the number of times information leaves the hospital unnecessarily. A patient expects sensitive information to be kept confidential, from anyone not authorized to read it.

Accuracy of information/results – Mistakes can be made when the same data needs to be entered more than once into different systems. This can be measured in the number of mistakes made by reentering the demographics of patients. All data entry errors need to be eliminated.

Clean and comfortable environment – It is important that a patient is investigated with clean equipment and in a proper investigation room. Measured by the degree in which the room and equipment is cleaned after an investigation.

Movement – The actual movement of the patient in meters. Patients do not want and sometimes are not able to travel long distances. Measured by the total meters a patient has to travel to get an ECG and/or ECHO. This amount needs to be as low as possible to improve the experience of the patient.

3.5 | Goals of the program

Besides the indicators for customer value discussed in paragraph 3.4 the ambulatory cardiology department has set its own goals which should be reached when improving the current process. These goals keep in mind the customer value and can be expressed in the following four objectives.

Achieve the 2014/2015 volume targets – To receive enough funding to cover all the costs at the ambulatory cardiology department, a certain number of investigations has to be performed. The

2014/2015 target is the minimum amount of investigations that should be performed to reach the needed budget to cover all the costs.

Increased utilization of resources – Measured in the amount of investigations actual done against the amount of time slots available for investigations. This rate needs to be as high as possible to be able to reach the 2014/2015 target and to work as efficient as possible.

Cost savings – The expenses of the ambulatory cardiology department should be reduced. This can be measured in the amount of money spent before and after the changes. This amount needs to be as high as possible, without compromising the patient experience.

Reduced paper – The amount of paper used by the ambulatory cardiology department should be reduced. A decrease in the amount of paper use is better for the environment. This can be measured in the amount of paper used at the department.

3.6 | Conclusion

In this chapter we discussed the current financial model of health care in Ontario and defined the current workflow, the current ECHO schedule and the customer value. We defined the workflow of the ambulatory cardiology program from our first research question:

1. *What is the workflow and performance of the ambulatory cardiology program at MSH?*

We found out the process of an ECG involves three actors (ECG administrator, ECG technician and cardiologist) and six different steps (registration, ECG, reading, entering comments, sorting and mailing, and preparation for billing).

The process of an ECHO also involves three actors (ECHO administrator, ECHO sonographer and cardiologist), but involves eight steps (receiving order, booking, registration, ECHO, faxing preliminary report, reading, faxing final report and filing). The difference in the number of steps between the process of an ECG and the process of an ECHO, exists mainly because ECGs are provided on a walk-in basis and ECHOs need to be booked.

Concerning the ECHO schedule, we found the following:

- There are no reserved time slots for outpatients only;
- There are no reserved time slots for inpatients;
- There is no balanced staffing schedule;
- More time slots are being booked at the same time than there are sonographers available that day;
- More clinic outpatients of the same doctor are booked at the same time.

We distinguish to types of customers: patients and referring offices. The customer value includes:

- The best quality of care

- Timely appointments and results for patients
- No waiting upon arrival
- Confidentiality
- Accuracy of information/results
- Clean and comfortable environment
- Reduced movement

The goals of the program include:

- Achieve the 2014/2015 volume targets
- Increased utilization of resources
- Cost savings
- Reduced paper

4 |Measure

After identifying the processes to get an ECG and ECHO in chapter 3, we measure different aspects of these processes in chapter 4. In paragraph 4.1 we show the average number of ECG and ECHO investigations which are done during the week, in 4.2 we show the results of direct time observations, and in 4.3 we measure the processes with a handoff process map.

4.1 | Number of investigations

We measured the number of investigations which were done per day for both ECGs and ECHOs. The number of ECGs was measured during the month May 2014 and the number of ECHOs was measured from May 1, 2014 until June 20, 2014. The numbers are shown in paragraph 4.2.1 and 4.2.2.

4.1.1 | ECG

In the table 13 the average number of ECGs done per day is shown, together with the maximum and minimum number of ECGs. We distinguish inpatients, outpatients and "emergency". Emergency ECGs are done in the emergency department by emergency nurses. However, the emergency ECGs require editing by ECG technicians. Numbers concerning outpatients are given for Monday to Friday. Numbers concerning inpatients and emergency are given for Monday to Thursday separately. For Friday, Saturday and Sunday the number is combined.

Day	Inpatients			Outpatients			Emergency		
	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Monday	24	11	30	26	18	37	52	38	65
Tuesday	36	15	79	48	36	57	45	30	52
Wednesday	43	26	58	57	50	63	50	33	70
Thursday	43	35	51	31	23	48	51	40	63
Friday (outpatients) or Friday/Saturday/Sunday (inpatient/emergency)	102	94	108	30	15	42	132	109	155

Table 13: Average, minimum and maximum number of ECGs done per day

On average, every day during the week 39 outpatient ECGs are done. From Monday to Thursday on average 38 inpatients ECGs are done.

4.1.2 | ECHO

In table 14, the average number of ECHOs done per day is shown. We distinguish inpatients, clinic outpatients and non-clinic outpatients. Clinic outpatients are patients who get an ECHO before they go to a clinic appointment. Other outpatients are patients who do not have a follow-up clinic appointment with a MSH cardiologist.

Tables 15 shows the average, maximum and minimum number of inpatient ECHO orders that come in every working day. To calculate the average amount of inpatients we measured the amount of incoming inpatient orders every day for six weeks during the months of May and June 2014. The number of inpatient orders per day consists of the total amount of inpatient orders received before the start of the receptionist's shift until the end of the receptionist's shift. All inpatient orders are counted from 16:00 the day before until 16:00 the day itself. Since no sonographers work during the weekend, all the orders from Friday after 16:00 till Monday 16:00 are counted for Monday.

Average number of ECHOs done per day

Day	Inpatients	Clinic outpatients	Non-clinic outpatients	PMH
Monday	7	6	5	1
Tuesday	6	11	8	1
Wednesday	5	14	6	2
Thursday	8	7	8	2
Friday	5	5	5	1

Table 14: Average number of ECHO's done per day

The total average number of ECHOs is 22 per day, consisting of 6 inpatient ECHOs and 16 outpatient ECHOs.

Average number of inpatient ECHO orders per day

Day	Average	Maximum	Minimum
Monday	14	9	17
Tuesday	4	1	5
Wednesday	6	1	8
Thursday	6	3	10
Friday	5	2	7

Table 15: Average, maximum and minimum number of inpatient ECHO orders per day

We can conclude that the average number of inpatient ECHO orders per day is equal to 7.

4.2 | Direct (time) observation

Direct observations were done at different times. On May 6, May 23 and May 28, 2014 with the office receptionists, on May 7, 2014 with the sonographers, on May 8, 2014 with the ECG technicians and on May 12, 2014 with the ECG technician and sonographer who perform Stress ECHOs. For every task within the process, the number of observations is shown, together with the average time to do that task. All of the data used for these numbers can be found in Appendix IV.

4.2.1 | ECG

In table 16 all different tasks within the ECG process are shown, including the number of observations and the average time for these tasks.

Task	Number of observations	Average
Registration by ECG receptionist	12 registrations	75.5 seconds per registration
ECG by ECG technician - Outpatient	8 ECGs	5.8 minutes per ECG
ECG by ECG technician - Inpatient	17 ECGs	10.1 minutes per ECG
Editing Emergency ECGs by ECG technician	11 ECGs	2.1 minutes per ECG
Preparation for billing by ECG receptionist	Two piles of around 134 ECGs/Holters	23.5 seconds per ECG/Holter
Entering comments by ECG receptionist - Written	27 ECGs (Percentage of doctors who write their comments: 70 percent)	27.8 seconds per ECG
Entering comments by ECG receptionist - Dictation	One pile of around 130 ECGs (Percentage of doctors who dictate their comments: 30 percent)	25.2 seconds per ECG
Entering comments by ECG receptionist - Total average	-	27 seconds per ECG
Sorting and mailing read ECGs by ECG receptionist	One pile of around 134 ECGs/Holters	24.6 seconds per ECG/Holter

Table 16: Number of observations and average time per task for an ECG

4.2.2 | ECHO

In table 17 the average time per tasks of the ECHO receptionist is displayed, as well as the number of observations done.

Task	Number of observations	Average
Booking by ECHO receptionist (no observation)	5 bookings	300 seconds per booking
Registering by ECHO receptionist – Outpatient ECHO	10 registrations	90.4 seconds per registration
Registering by ECHO receptionist – Outpatient Stress ECHO	10 registrations	111.6 seconds per registration
ECHO by sonographer - Outpatient	5 ECHOs	42 minutes per ECHO
ECHO by sonographer - Inpatient	3 ECHOs (Fellow: 1)	44 minutes per ECHO (Fellow: 72 minutes)
Stress ECHO by ECG technician	3 Stress ECHOs	46 minutes per Stress ECHO

and sonographer		
Faxing the preliminary report by ECHO receptionist if patient is a clinic patient (no observations)	7 preliminary reports	20 seconds per preliminary ECHO report
Faxing the final report by ECHO receptionist	2 final reports	25.8 seconds per ECHO report
Filing by ECHO receptionist (no observation)	-	40 seconds per ECHO report[1]

Table 17: Number of observations and average time per task for an ECHO

4.2.3 | Time spent per day

In this paragraph we study the different tasks for each role within the process, and combine them with the average time spent on each task. This will determine an average in the total time spent on each task each day. Paragraph 4.1.3.1 and 4.1.3.3 show these averages for the receptionist for both ECG and ECHO. Paragraph 4.1.3.2 and 4.1.3.4 show these averages for the ECG technicians and sonographers. Next to these averages, we also include the type and number of interruptions each role has to deal with during a day.

4.2.3.1 | ECG receptionist

Time per task per day

Task	Average quantity per day	Average time per unit in seconds	Total average time per day in minutes
Registering outpatient ECGs	39	76	49
Registering Holters	4	100	7
Registering Blood Pressures	1	82	2
Editing ECGs	151	28	71
Editing Holters	4	300	20
Sorting and mailing read ECGs and Holters	42	25	18
Prepare requisitions for billing	154	24	62
Booking Holters and BPs	3	180	9
Photocopying Holters	4	100	7
Total			**245**

Table 18: Time per task per day for the ECG receptionist

[1] This average is based on the knowledge and experience of the current ECHO receptionist. According to the ECHO receptionist it takes on average fifteen minutes a day to file all the final reports.

The total average time per day spend on the different tasks is 245 minutes, while a complete working day consists of 480 minutes with a 60 minute break. This means that the ECG receptionist spends only 245 minutes out of the 420 minutes or 58 percent of the time on receptionist duties.

Interruptions

The ECG office receptionist or ECG receptionist is sitting at the registration desk located immediately at the beginning of the ambulatory cardiology unit. Every person entering the unit via the elevators will pass this desk, which makes it a place where a lot of questions are being asked. The ECG registration desk is also located at the beginning of the inpatient cardiology unit: people arriving for this unit will also ask a lot of questions to the ECG receptionist.

Type of interruption	**May 6, 2014 (8:00 – 14:00)**	**May 23, 2014 (8:30-12:00) → No clinic**	**May 28, 2014 (13:00-16:00)**
People of the department asking things	?	5	4
People asking the way	?	8	11
People arriving for Echo, but admitting at the ECG desk instead of the Echo desk	5	6	4
Telephone calls: (1) for inpatients (2) wrong calls, among others for Echo (3) appointments for Holter/Blood Pressure (4) other	5/4/0/1	0/1/4/2	0/0/0/5
People bringing back a Holter monitor	0	3	0

Table 19: Interruptions per day for the ECG receptionist

The total number of interruption over the three observation days can be calculated with the average number of interruptions per hour multiplied with the number of working hours, this results in a total of 135 interruptions. Which means an average of 45 interruptions a day. We have to take into account that we observed only day parts instead of full working days, so the total amount of interruptions during a certain day is an estimation based on the number of interruptions during the hours of observation.

4.2.3.2 | ECG technicians

Time per task per day for all ECG technicians in total

Task	**Average quantity per day**	**Average time per unit in minutes**	**Total average time in minutes**
Outpatient ECG investigations	39	5.9	231
Inpatient ECG	38	10.1	384

investigations			
Holter investigations	4	19	76
BP investigations	1	20	20
Editing Emergency ECGs	66	2.1	139
Total			**850**

Table 20: Time per task per day for all ECG technicians in total

Interruptions

ECG technicians are interrupted by people speaking to them when walking to inpatients throughout the hospital. Also when editing emergency ECGs this is the case. The technicians then sit behind their desk in the technician room, where they speak a lot to each other and everyone passing by. If the ECG technicians are doing an outpatient ECG, the door is closed, which prevents them from being interrupted.

4.2.3.3 | ECHO receptionist

Time per task per day

Task	Average quantity per day	Average time per unit in seconds	Total average time in minutes
Calling for booking inpatients	8	300	40
Calling for booking outpatients	8	300	40
Faxing final report	21	26	9
Faxing preliminary report	8	20	3
Filing	26	40	17
Enter all patients in the schedule	-	-	15
Receive calls for booking	8	300	40
Receive calls for reports	2	300	10
Receive calls to check if patient is booked	4	120	8
Registering ECHO patients (including TEEs, Bubble studies and Contrast ECHOs)	15	90	23
Registering Stress ECHO patients (including Dobutamine's and Contrast Stress ECHOs)	5	112	9
Total			**215**

Table 21: Time per task per day for the ECHO receptionist

The total average time per day spend on the different tasks is 215 minutes, while a complete working day consists of 415 minutes with a 60 minute break. This means that the ECHO receptionist spends only 215 minutes out of the 420 minutes or 51 percent of the time on receptionist duties.

Interruptions

Interruption	Tuesday 6/5/2014 (8:00-14:00)	Friday 5/23/2014 (8:30–12:00)	Wednesday 5/28/2014 (13:00-16:00)
Another department asks a question	2	5	2
Calls a porter	2	0	0
Calls a referring office or doctor (no booking)	4	0	0
Calls or goes to a department (no booking)	3	3	4
Calls or goes to an sonographer	1	4	2
Doing not work related things	1	5	10
Fax machine gets stuck	0	0	3
Faxes preliminary report	1	0	2
Gets a call for booking a patient	5	5	3
Gets a call from a referring office or doctor (no booking)	2	3	1
Gets water	0	1	1
Goes to fellows	1	0	2
Patient asks a question	0	3	3
Sonographer asks a question	3	5	3
Total interruptions	**25**	**34**	**36**

Table 22: Interruptions per day for the ECHO receptionist

The total number of interruption over the three observation days can be calculated by the average number of interruptions per hour multiplied with the number of working hours, this results in a total of 187 interruptions. Which means an average of 62 interruptions a day. Again we have to take into account that we observed only day parts instead of full working days, so the total amount of interruptions during a certain day is an estimation based on the number of interruptions during the hours of observation.

4.2.3.4 | Sonographers

Table 23 shows the total average amount of time per day spent on ECHO investigations.

Time per task per day for all sonographers in total

Task	Average quantity per	Average time per unit	Total average time in

	day	in minutes	minutes
Outpatient ECHO investigations	14	42	588
Inpatient ECHO investigations	7	53	371
Total			959

Table 23: Time per task per day for all sonographers in total

Interruptions

ECHO sonographers are interrupted by other sonographers or cardiologists asking questions, the ECHO receptionist telling the sonographers the schedule has changed and discussions or noise outside the investigation room. These interruptions can result in an increase in the time spent on performing an ECHO.

4.3 | Handoff process maps

4.3.1 | ECG

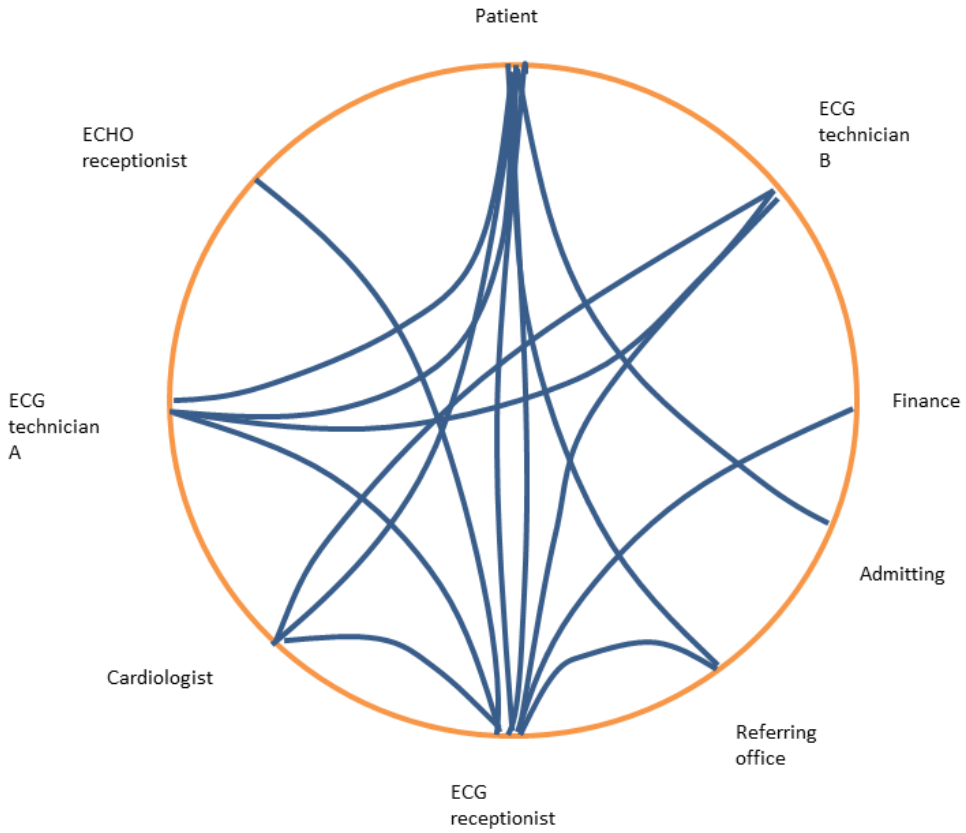


Figure 4: Current handoff process map for an ECG

There are 15 handoffs within the ECG process.

4.3.2 | ECHO

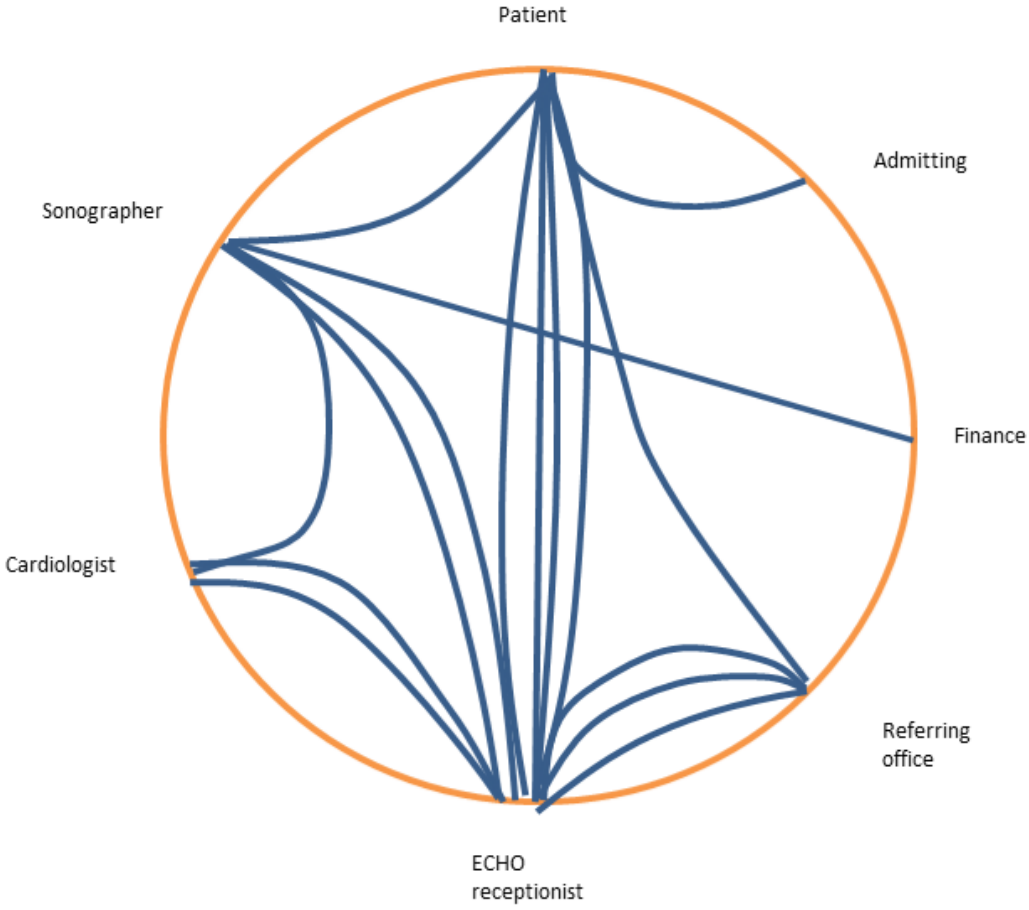


Figure 5: Current handoff process map for an ECHO

There are 16 handoffs within the ECHO process.

4.4 | Conclusion

In this chapter we measured the performance of the processes in the ambulatory cardiology program from our first research question:

1. *What is the workflow and performance of the ambulatory cardiology program at MSH?*

We measured the number of investigations, did direct (time) studies and measured the number of handoffs within the processes.

On average, every day during the week 39 outpatient ECGs, 38 inpatients ECGs, 16 outpatient ECHOs, 6 inpatient ECHOs are done. The average amount of inpatient ECHO orders that comes in per day is 7. Compared to 6 inpatient ECHOs being done on average per day, we can conclude that there is a shortage of 1 inpatient ECHO per day. On Monday, this shortage is even bigger, since on average 14 inpatient ECHO orders come in that day.

Observational studies have shown both the ECG receptionist as well as the ECHO receptionist have a lot of different tasks. Time studies have shown that the ECG receptionist spends 58 percent of her time on receptionist duties, while the ECHO receptionist spends 51 percent of her time on receptionist duties.

Both receptionists are interrupted a lot every day. On average, the ECG receptionist is interrupted 45 times a day, while the ECHO receptionist is interrupted 62 times a day. ECG technicians are not interrupted that often, just like the sonographers.

There are 15 handoffs within the ECG process and 16 handoffs within the ECHO process.

5 |Analyze

In chapter 5 we analyze the processes in the ambulatory cardiology program. We first show the demand of the different investigations of the program in paragraph 5.1. In paragraph 5.2 we discuss the different waiting times, followed by information about staffing in 5.3. We finish chapter 5 in paragraph 5.4 with a summary of all the problems extracted from the analysis in all the chapters and paragraphs before.

5.1 | Demand

Data about the demand for ECGs, Holters, ECHOs, Stress ECHOs, TEEs and Dobutamine tests on a yearly basis are available from 2008 until now. The data for the ECG department is shown in paragraph 5.1.1 and the data of the ECHO department in 5.1.2. In paragraph 5.1.3 we analyze the no show rate for ECHOs and in 5.1.4 we discuss the cardiologist clinic data.

We separate the demand for outpatients from the demand for inpatients. The financial year for the hospital is from April 1st to March 31st. Within the data of outpatients, we include the 2014-2015 ambulatory cardiology program targets. This 2014-2015 volume target is a 15% increase over the previous year based on the following assumptions (Clinical Coordinator Ambulatory Cardiology Program MSH, 2014):

1. "*Improve efficiency in patient scheduling and decrease the number of "no shows" by using Lean management strategies;*
2. *Initiate contract with GE whereby the department purchases 3D capable software and GE will provide loaner ECHO machine which will increase physician referrals;*
3. *Decrease printing costs by introducing a better outpatient referral form;*
4. *To improve the flow between the ECHO department and clinic schedules;*
5. *Increase internal referrals through ER."*

Along with the 15% increases in volume targets the ambulatory cardiology program must perform at least 150 TEEs per year. This increase in TEE volume will provide enough patients for medical students to gain the experience and knowledge required while at MSH. Inpatient volumes are expected to be similar to the previous year.

5.1.1 | ECG

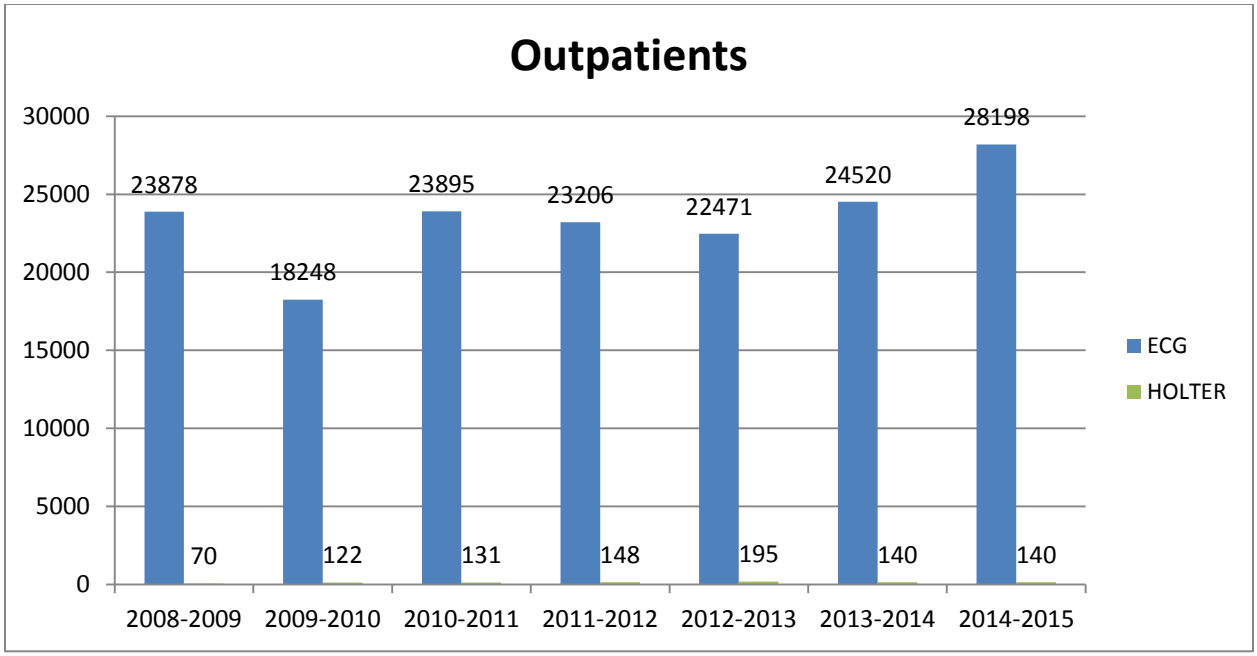


Figure 6: Yearly demand for outpatient ECGs, Stress tests and Holters from 2008 until 2015, MSH files

We can conclude that the total demand of outpatient ECGs and Holters fluctuates strongly over the last few years. The number of outpatient ECGs that needs to be performed to reach the 2014/2015 target is much larger than the amount of ECGs done in the past.

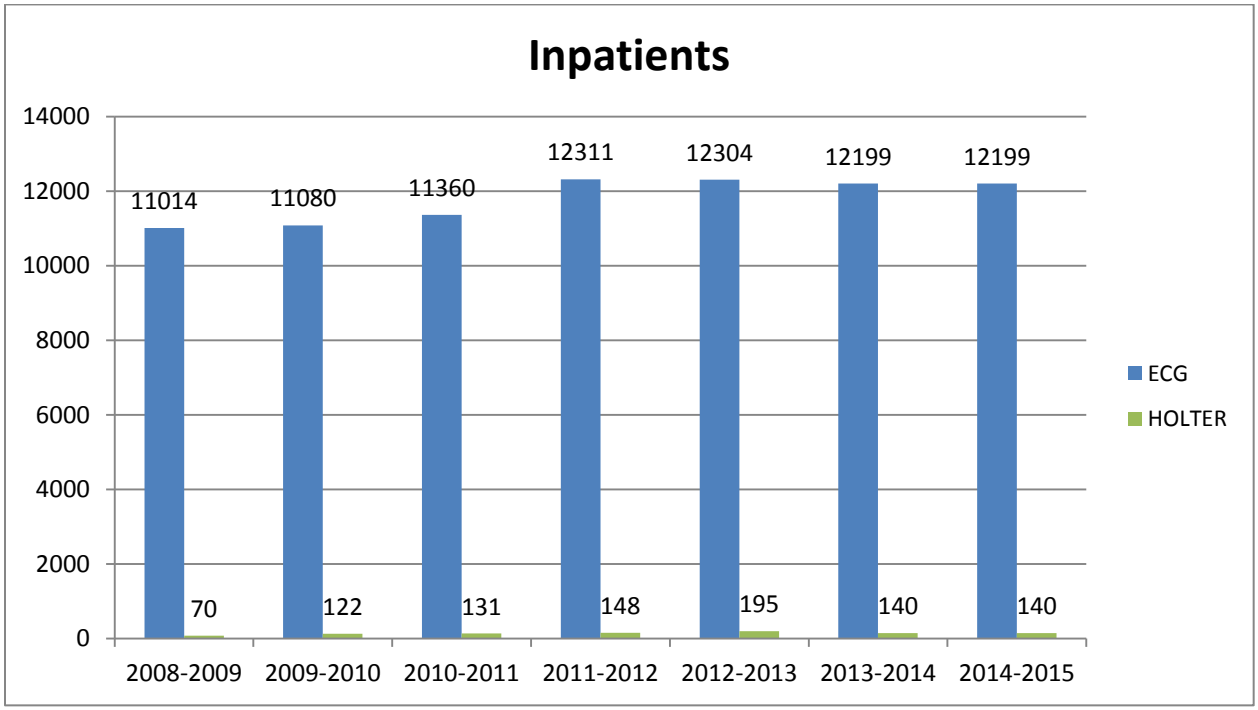


Figure 7: Yearly demand for inpatient ECGs, Stress tests and Holters from 2008 until 2015, MSH files

The total demand of inpatient ECGs does not fluctuate that much compared to the outpatient ECGs.

5.1.2 | ECHO

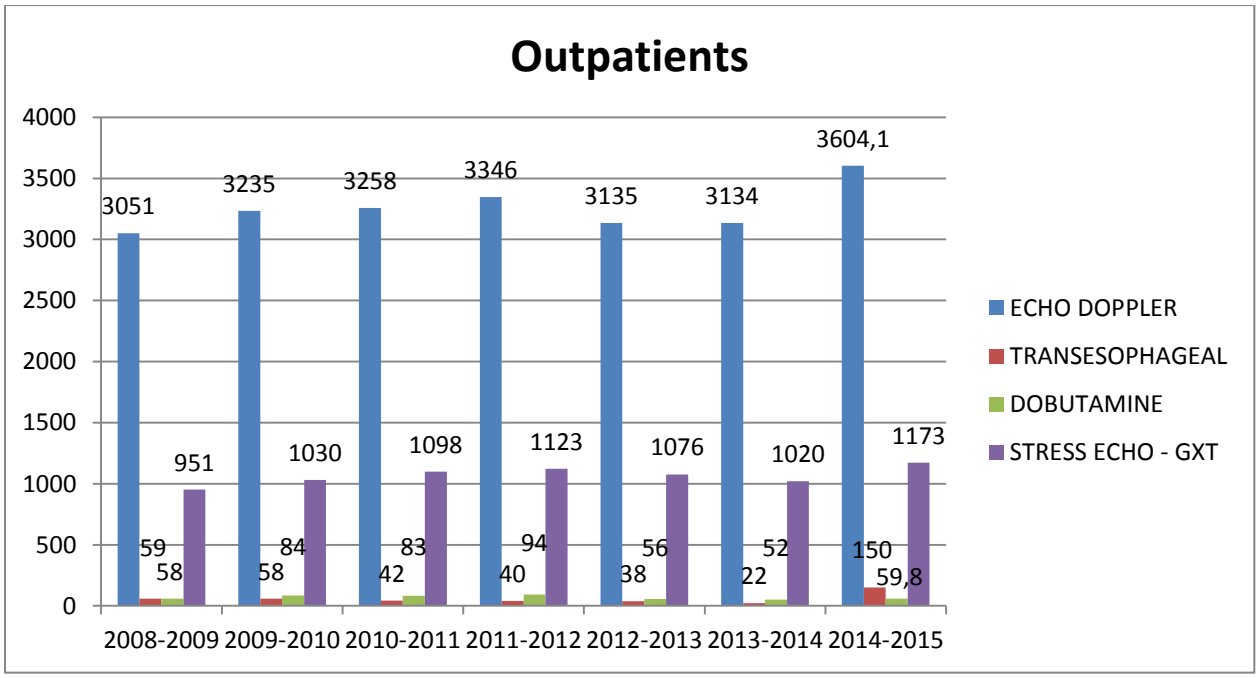


Figure 8: Yearly demand for outpatient ECHO's, TEEs, Dobutamine tests and Stress ECHO's from 2008 until 2015, MSH files

As we study the demand of outpatient ECHOs over the last few years we can see a significant drop in the last two years. The other investigations performed at the ECHO department show the same drop in demand.

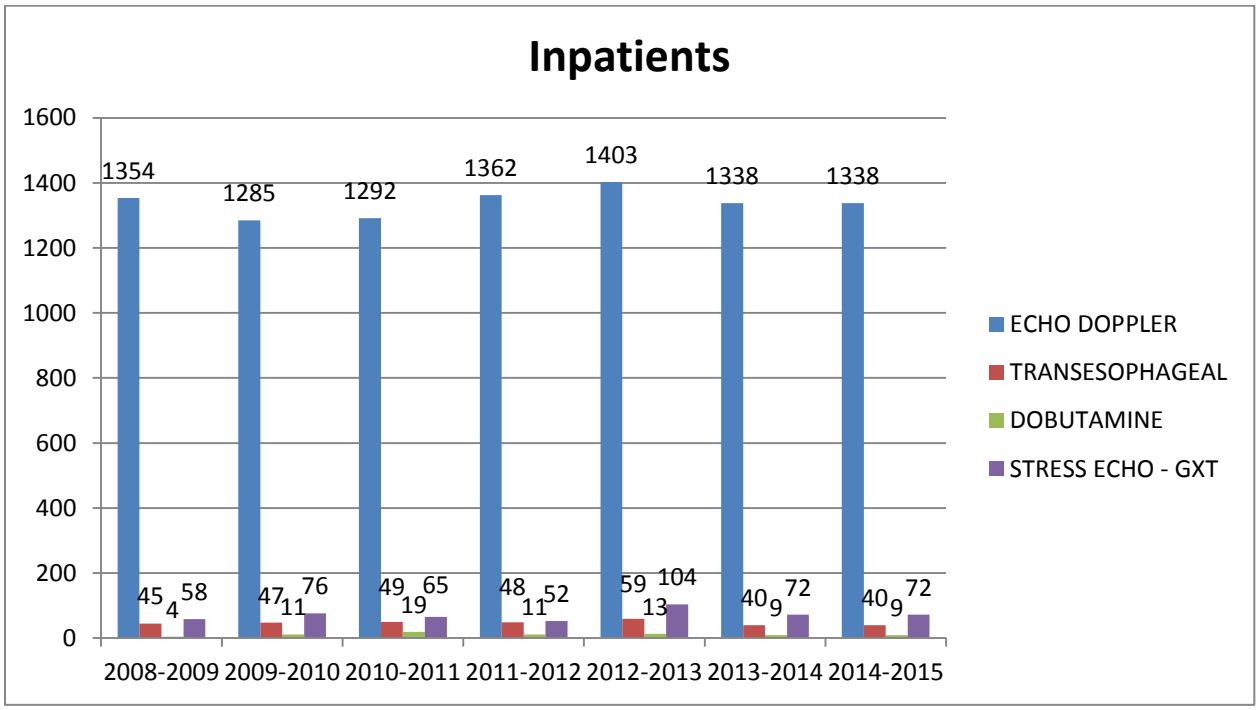


Figure 9: Yearly demand for inpatient ECHO's, TEEs, Dobutamine tests and Stress ECHO's from 2008 until 2015, MSH files

The demand of all different inpatient test performed at the ECHO department also dropped last year.

5.1.3 | No show rate outpatient ECHOs

Based on the data from May 1, 2014 until June 20, 2014, we calculated the no show rate per weekday for outpatient ECHOs. We found the following numbers.

Day	Average number of outpatient ECHOs done	Average number of no shows	Average no show rate for outpatient ECHOs (%)
Monday	11	1.2	10.9
Tuesday	19	1.5	7.9
Wednesday	20	2.6	13
Thursday	15	1.6	10.7
Friday	10	0.7	7.0

Table 24: Average no show rate for ECHO's

The average no show rate for outpatient ECHOs is 10% per day. The average cancellation rate for outpatient ECHOs is 12%, based on the data from the same period of time.

5.1.4 | Utilization rate ECHO

To calculate the utilization rate for the ECHO department we divided the total amount of available ECHO slots by the number of investigations done during that period. To determine the amount of available slots we have multiplied the amount of available slots during a day by the number of ECHO exam rooms. This is excluding the use of the portable ECHO machine, the ECHO exam rooms reserved for TEEs (the department only performed 62 TEEs during the year 2013-2014) and the increased time spent on an investment while a fellow is working. This means that there are 6480 slots available to perform ECHO investigations, considering that there a 240 working days in a year. In the year 2013-2014 4657 investigations were performed, resulting in a utilization rate of approximately 72 per cent.

5.1.5 | Clinics

ECHO time slots per cardiologist

We calculated the average number of clinic outpatients which were actually booked for each cardiologist, using data from September 30, 2013 until June 22, 2014. In table 25 the number of reserved time slots per clinic and the average number of time slots that are actually used by the cardiologists is shown.

The data shows that every cardiologist has more reserved slots than they actually use. This results in unused time slots. To get a better overview of the actual used timeslots and to see if the use of slots changed over time, we created a bar chart of the actual used time slots for every cardiologist for the period September 30, 2013 until June 22, 2014. These charts are included in appendix V.

Cancellation of clinics

During the period from September 30, 2013 until June 22, 2014, 32 percent of all the clinics were cancelled. We found two important reasons why clinics are cancelled: cardiologists can be on call or at a conference/out of town, which makes them unable to hold their clinic. We determined the percentage of clinic cancellations per cardiologist. Sometimes it was stated in Customer Appointment Manager that clinics were cancelled, but other times it was not. Based on information from multiple cardiologists' secretaries, we assume clinics were cancelled if no ECHOs were booked within the reserved time slots, even if it was not mentioned in Customer Appointment Manager that the clinic was cancelled. The percentages of cancelled clinics per cardiologist can be found in table 25.

Day	Cardiologist who is having a clinic	Reserved	Actual	Percentage of cancelled clinics
Monday	Dr. Gold	5	4.1	34
	Dr. Floras	5	2.4	18
	Dr. Sasson	3	1.8	27
Tuesday	Dr. Colman	4 (every two weeks)	3.6	71

	Dr. Mak	10	6.4	11
	Dr. Nesbitt	4	3	26
	Dr. Sasson	4 (every other two weeks then Dr. Colman)	2	54
Wednesday	Dr. Balmain	14	9.2	17
	Dr. Gold	4	3.7	39
	Dr. Mak	3	2	11
Thursday	Dr. Barolet	2	1.3	44
	Dr. Balmain	11	4.2	44
	Dr. Newton	5	3.8	9
Friday	Dr. Wald	8	7.3	47

Table 25: Reserved and actual used time slots per cardiologists' clinic

5.2 | Waiting times

5.2.1 | ECG

We can distinguish two different waiting times for ECGs. The time it takes for the patient to get registered and amount of time between the registration and the performance of the EGC. We calculated the average waiting time based on 34 ECG investigations. The waiting times are shown in table 26.

	Average time in minutes
Waiting time registration	1
Waiting time ECG investigation	8
Total	9

Table 26: Average waiting times concerning the ECG process

5.2.2 | ECHO

The waiting time before an ECHO can also be distinguished in the two different waiting times mentioned in paragraph 5.2.1. The waiting times can be found in table 27. These numbers are based on 16 ECHO investigations.

	Average time in minutes
Waiting time registration	1
Waiting time ECHO investigation	10
Total	11

Table 27: Average waiting times concerning the ECHO process

5.2.2.1 | Booking waiting time outpatient

Besides these two waiting times another waiting time can be determined. Because the ECHO investigations are pre-booked there is also waiting time from the time an order is received until the time

the patient has its investigation: the "booking waiting time". Based on a random sample of 50 outpatient orders from 2014 we calculated the number of waiting days. The number of waiting days is shown in figure 10. The data shows that only twenty per cent of the outpatient ECHOs is performed within five days.

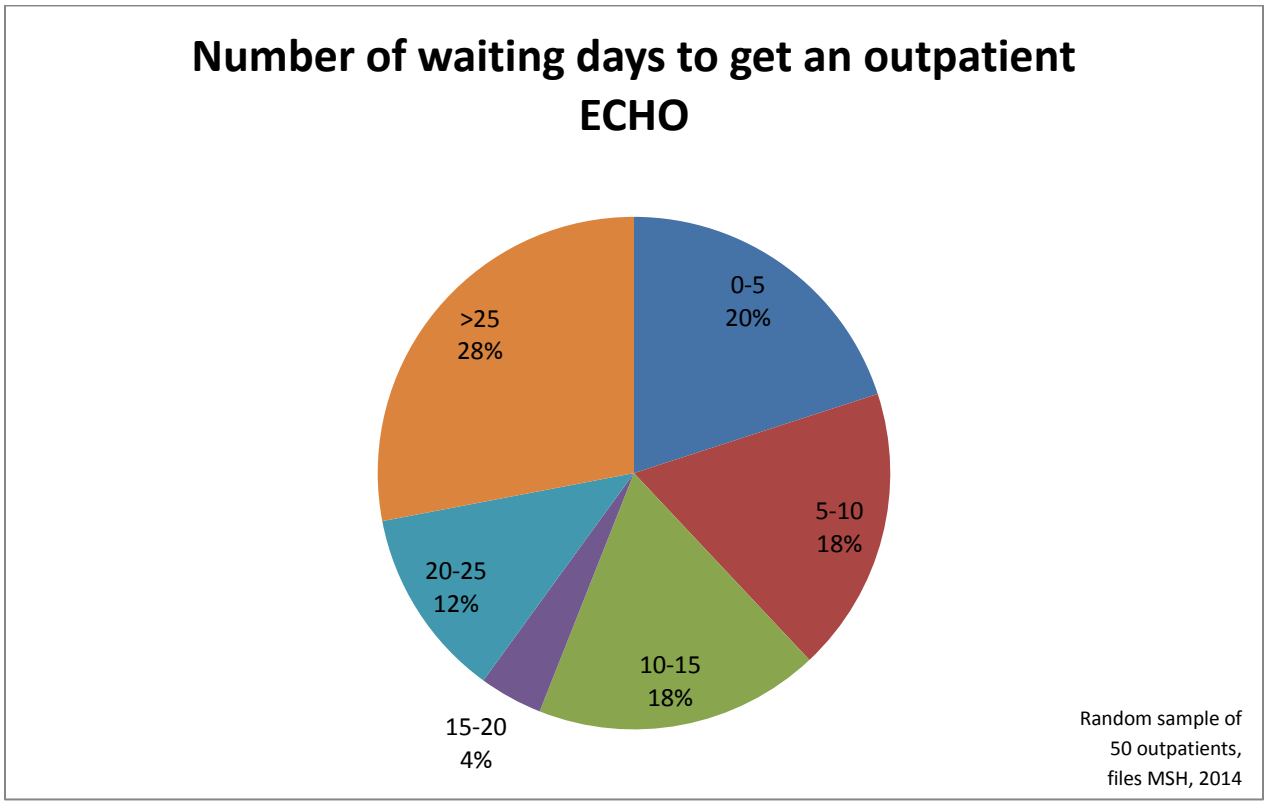
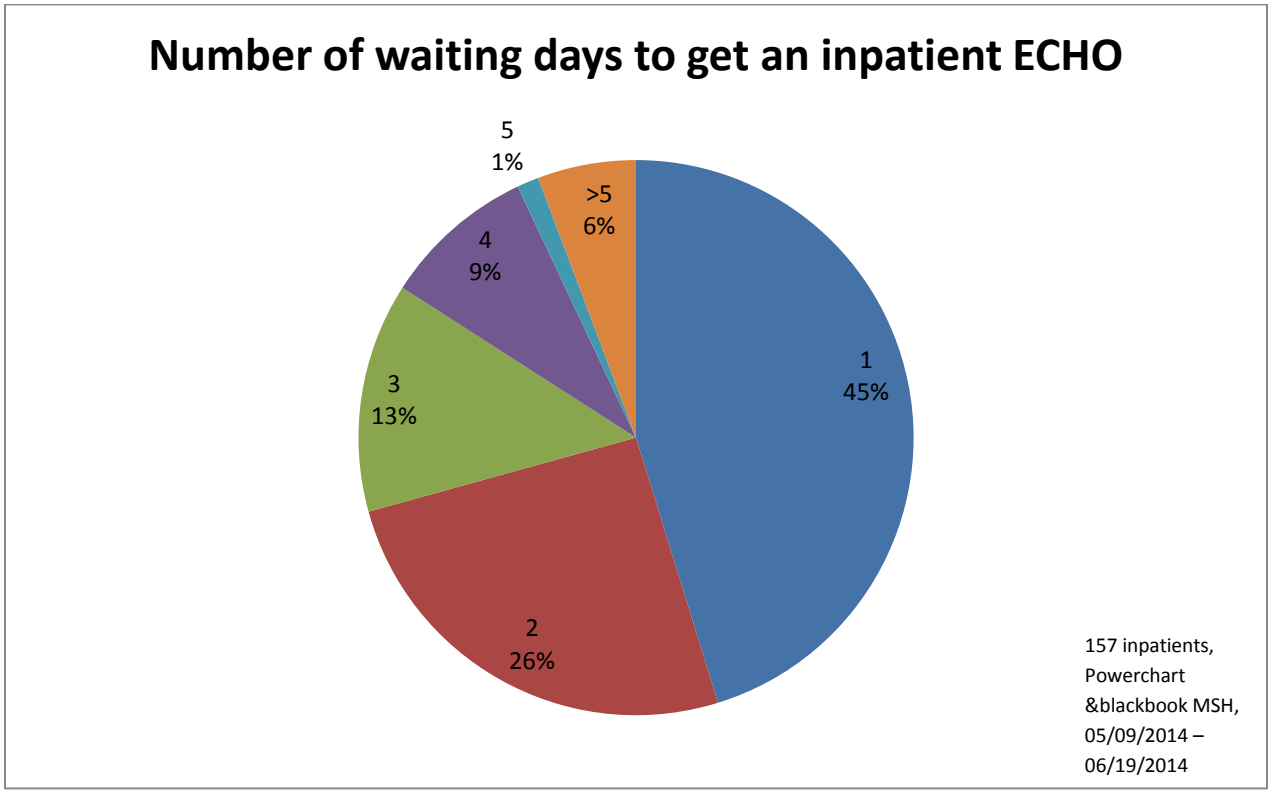


Figure 10: Number of waiting days to get an outpatient ECHO

5.2.2.2 | Booking waiting time inpatient

The booking waiting time can also be determined for inpatients. This is the time between the inpatient order comes in and the date the test is done. The amount of days is shown in figure 11. One day means the investigation is done on the same day as the order is received or the next day if the order is received after the shift of the ECHO Receptionist. This is only 45 per cent of all inpatient ECHOs.



Figrue 11: Number of waiting days to get an inpatient ECHO

5.3 | Staffing

5.3.1 | ECG

The staffing can be determined in the amount of full time employers (FTE) used during a year. In table 28 the amount of FTEs used for performing both inpatient and outpatient ECGs during the fiscal year from 2008 until 2014 are presented. A fiscal year ends at March 31. If we divide the total amount of ECGs by the amount of FTEs used, the number of investigations per FTE is calculated. The number of investigations per FTEs are shown in figure 12 . The numbers fluctuate a lot, from only 4979 ECGs per FTE in 2010 until 6499 ECGs per FTE in 2014. This means that the efficiency is not the same every year.

Fiscal Year (end = 31-03)	FTEs used for ECG
2008	5.36
2009	5.63
2010	5.89
2011	5.61
2012	5.78
2013	5.85
2014	5.65

Table 28: Number of FTEs for ECGs per fiscal year from 2008 until 2014

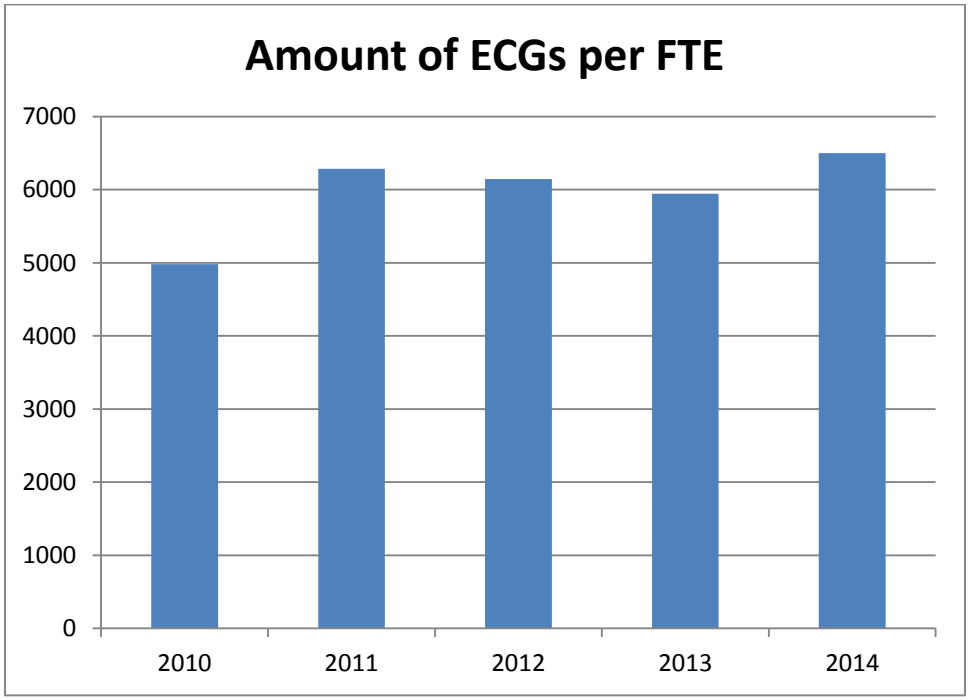


Figure 12: Number of ECGs per FTE per year, files MSH, 2010 until 2014

5.3.2 | ECHO

We calculated the same data for the ECHOs as we did in paragraph 5.3.1 for ECG. The number of ECHOs includes the amount of TEEs and Dobutamines performed during that year. Those investigations are also included in the amount of FTEs used. In table 29 the amount of FTEs used for performing both inpatient and outpatient ECHOs during the fiscal year from 2008 until 2014 are displayed. The amount of ECHOs fluctuates, just like the ECGs, a lot. In 2012 only 935 ECHOs per FTE where performed, while in 2011 1089 ECHOs per FTE were executed. As can be seen in figure 13, the last few years the efficiency is decreased.

Fiscal Year (end = 31-03)	FTEs used for ECHO
2008	4.89
2009	4.69
2010	4.52
2011	4.46
2012	5.41
2013	4.75
2014	5.03

Table 29: Number of FTEs for ECHO's per fiscal year from 2008 until 2014

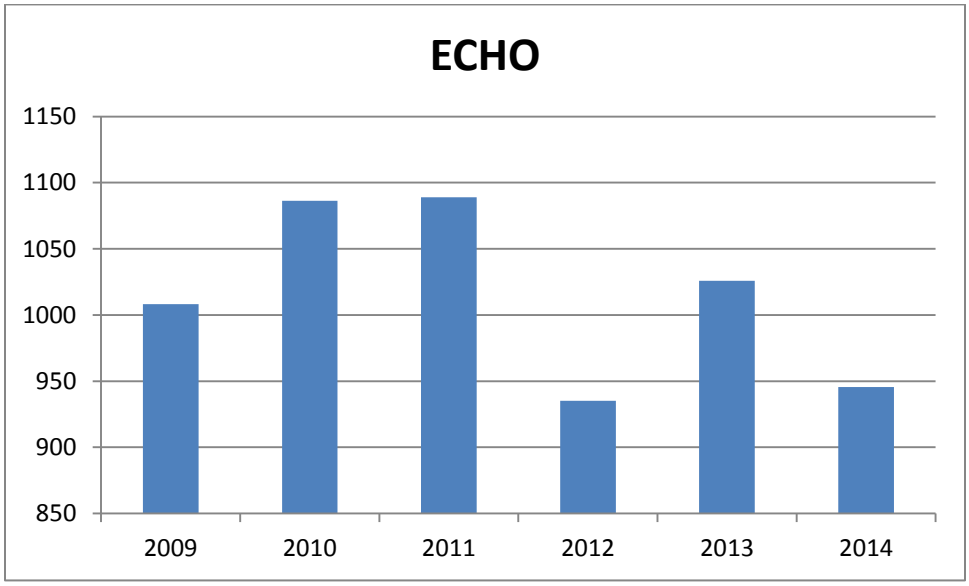


Figure 13: Number of ECHO's per FTE per year, files MSH, 2010 until 2014

5.4 | Problems

5.4.1 | Value added and non-value added

Performing an ECG or an ECHO involves different steps, as can be seen in paragraph 3.2. Not all of those steps add value. During the three day value stream event it was discussed which of the steps add value. According to the participants the only general steps within the process which are value added are the following:

- ECG by ECG technician/ECHO by sonographer
- Reading by cardiologist

When reviewing the current value stream, and within the context of LEAN, the value added steps are the only steps which are transformational and where a customer (the patient) would be willing to pay for. All the other steps are considered non-value adding. Within the non-value added steps we identified different problems. We categorized these problems in the eight existing types of waste (see paragraph 2.1). An overview of this categorization is shown in table 30.

Overproduction	-
Waiting	- Patient waits for their test once they arrive - Patient waits for their clinic appointment with the cardiologist - Patients/staff wait for responses to emails and phone message - ECHO receptionist is not aware if a read ECHO is waiting to be send to the referring doctor. - Inpatients waiting for an ECHO - Patients waiting at the ECG and ECHO receptions during lunch - Sonographers waiting for patients

	- Inpatients waiting for a porter - Referring doctors have to wait for the final report - Waiting for a signed consent form for a Stress ECHO - Elevators are slow - Referring doctors waiting for final reports, because cardiologists have too much to do at work
Transportation	- ECHO receptionist has to walk to a box with read ECHOs in the sonographer's room - ECHO receptionist or sonographer needs to get patient from ECG waiting area
Extra (Over) Processing	- ECGs are always printed with a previous ECG - ECG receptionist has to type dictations or hand written comments - Demographics of one patient have to be entered multiple times (both by ECG receptionist and ECG technician) - Patients ask for directions - Patients for ECHO arriving at ECG desk - ECG technicians have to use a chart to recalculate weight and height - No labels available for ECG technicians when doing an ECG on the floor - No MSH card available for ECG technicians when doing an ECG on the floor - ECGs and requisitions are first attached to each other and then separated - ECG technicians have to correct ECGs performed by nurses on other floors - A lot of different incoming requisitions - ECHO receptionist calls patients randomly to book an appointment and decides randomly when to stop calling - ECHO receptionist does not have enough spots available on certain moments, while empty spots exist at other moments - ECHO receptionist files while not necessary - ECHO receptionist has to change the status of a patient again when the patient is moved in schedule - ECHO receptionist has to use a paper order form to order a TEE while a digital TEE order form is available - ECHO receptionist prints daily schedules for every sonographer and the receptionist - ECHO receptionist prints preliminary report twice (one for reading and one for ECHO) - ECHO receptionist prints the previous report, in case no description is added to the requisition

	- ECHO receptionist stamps two blank pages for Stress ECHO while mostly not used - Investigations are sometimes mentioned as STAT, while they are not a STAT - Patients sometimes do not respond to a call from ECHO receptionist - Sonographers are asking questions to ECHO admin - Sonographers write administration and conclusions in Black Book - Billing with paper requisitions - Requisitions contain unnecessary fields
Inventory	- Excess requisitions in stock - Inventory of inpatients waiting for their ECHO - Requisitions not booked - Sometimes not enough materials available for investigations
Motion	- ECG receptionist brings requisitions to the Finance department by hand - Requisitions for ECGs come in at the 16th floor while technicians can be at other floors - ECG receptionist has to walk to the technician to notify them that patient is waiting - ECG technicians adjust the order of ECGs on the floor to the situation at the floor (if a patient is eating/sleeping a technician will come back later) - ECG technicians have to search for ECG machines at emergency - Calling back and forth when booking an appointment - ECHO receptionist has to walk to the sonographers to mention a patient is waiting - ECHO receptionist has to search for someone who can perform the bubble test - ECHO receptionist often has to call multiple times to find an inpatient who is able to come at that time - Sonographers have to search for materials - Employees have to walk to 16 north to get a refreshment - Clinical coordinator is often not present on the floor itself
Defects	- Messy desk at ECG administration and ECHO reception - Requisitions get lost - Billing is not accurate - Staff arriving late in the morning - Cardiologists take ECGs home to comment - ECHO receptionist arrives to late, because of that she is not able to book inpatients before the technicians start in the morning

	- ECHO receptionist uses the log in information of the previous ECHO receptionist to log on the computer - Patients arrive without an appointment - Preliminary reports are sent to referring doctors while not read by cardiologist - Requisitions from emergency for ECHO are often filled in incorrect (room and bed missing) - Sometimes the description why the patient needs an ECHO and where the sonographer should pay attention to on the requisition is not filled in by the referring doctor - Sometimes the telephone number is missing on the requisition - Final reports made before 2007 are not available anymore in ECHOWeb - Space of ECHOWeb is getting fuller and fuller and nobody knows what happens if it is full - Isolation at ECHO sometimes not properly mentioned on requisition
Underutilized Human Potential	- Staff are not cross-trained to perform other duties/tests - ECHO receptionist never had a training for the ECHO receptionist position - No proper use of the booking system by other users than the ECHO receptionist - Nobody can take over the receptionist

Table 30: Problems within the process of an ECG and ECHO categorized per type of waste

Metrics of time efficiency

The Process Cycle Efficiency for one investigation can be calculated by dividing the time spent on value added steps by the time it takes to complete one investigation. As stated in paragraph 5.4.1.1 and 5.4.1.2 the only value added steps in ECG are the test performed by an ECG technician and the reading of the ECG by a cardiologist, and for ECHO, the investigation by a sonographer and the reading by a cardiologist. To calculate the Process Cycle Efficiency of the actual investigation, we only include the ECG performed by an ECG technician and the investigation by a sonographer. We can calculate the Process Cycle Efficiency for both outpatient and inpatient investigations.

Test	ECG	VA Time (min)	Cycle Time (min)	Process Cycle Efficiency (%)
ECG	*Outpatient*	2	16	13%
	Inpatient	2	10	20%
ECHO	*Outpatient*	17	55	31%
	Inpatient	15	54	28%
	Investigation with a fellow	16	85	19%

Table 31: Process Cycle Efficiency for one investigation

5.4.2 | Ishikawa diagram

While defining, measuring and analyzing the processes at the ambulatory cardiology program, we found different problems. In paragraph 5.2.1 we sort all these problems based on the eight types of waste. In this paragraph, we study the problems in general, and develop a Ishikawa diagram. We do this to identify the key process input variables that should be tackled to improve the key output variables. The cause and effect diagram is shown in figure 14.

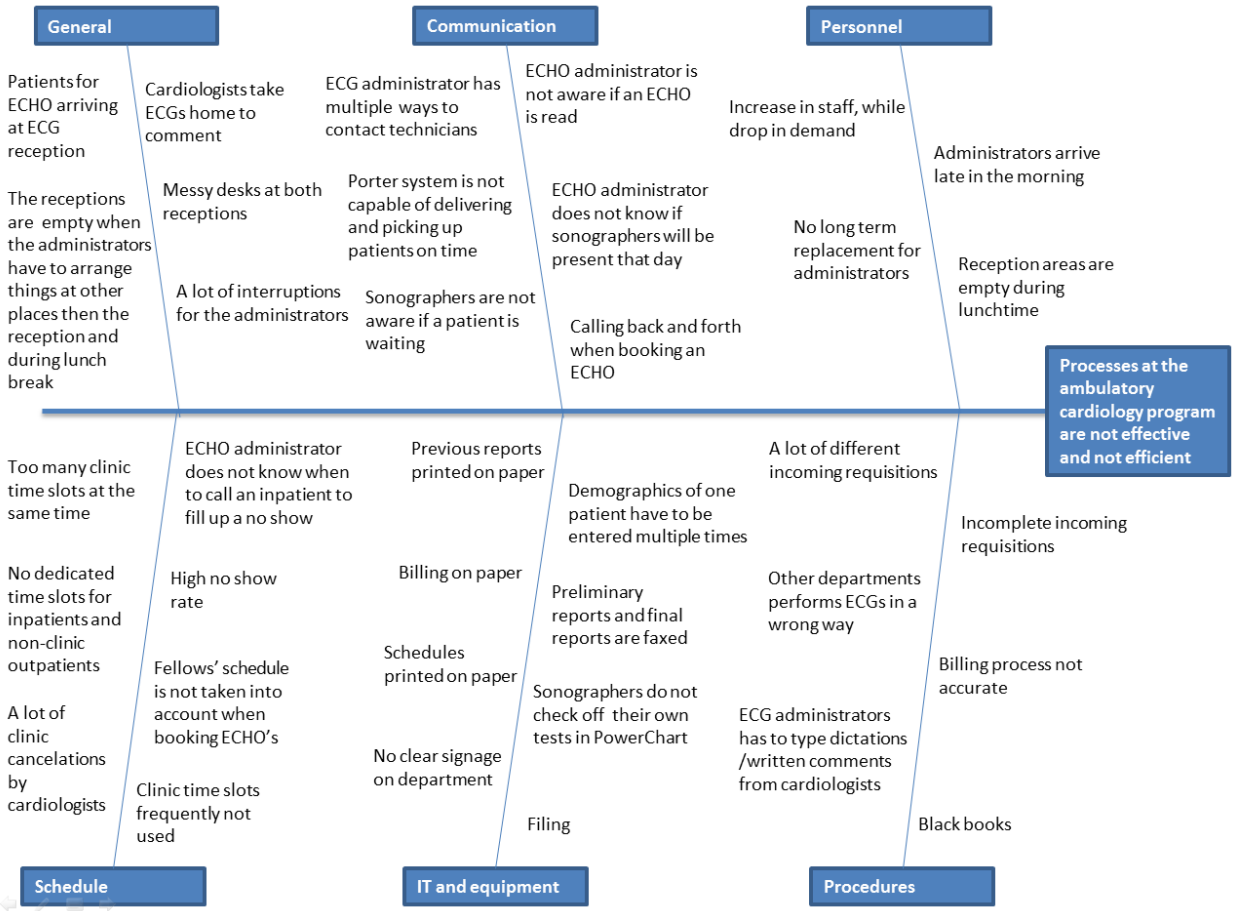


Figure 14: Ishikawa diagram

The Ishikawa diagram helps us to find the six general areas of problems which should be improved to increase the effectiveness and efficiency of the processes at the ambulatory cardiology program at MSH.

5.5 | Conclusion

In this chapter we analyzed the current process on workload, disturbances and demand, answering our second research question:

2. *What is the workload and demand of the ambulatory cardiology program at MSH, and what are the disturbances?*

We found an increase in the demand of 15% in order to reach the 2014/2015 target. This increase is rather big compared to the trend of the last seven years, both for ECGs as ECHOs.

The average no show rate for outpatient ECHOs is 10% per day, while the utilization rate of the available time slots is around 70%. The cancellation rate for outpatient ECHOs is 12% per day. The cancellation rate of all clinics is 32% on average.

The average waiting time for registration of an ECG is 1 minute and the average waiting time to get an ECG is 8 minutes. The average waiting time for registration of an ECHO is also 1 minute and the average waiting time to get an ECHO is 10 minutes.

28% of all outpatients getting an ECHO have to wait for more than 25 days to get the ECHO, while only 20% gets the ECHO within 5 days. For inpatients 6% of the patients have to wait for more than 5 days to get the ECHO. 45% of the inpatients is helped within 1 day.

The efficiency of the staff is not the same every year and fluctuates a lot. Especially the ECHO staff became inefficient from 2012 until now.
While defining, measuring and analyzing the processes at the ambulatory cardiology program, we found different problems which can be categorized in six general areas of problems: general, communication, personnel, schedule, IT and equipment and procedures.

6 |Improve

In chapter six we study how to improve the processes for an ECG and an ECHO in the ambulatory cardiology program at MSH. First we describe the ideal situation in paragraph 6.1. Then we suggest ways to improve in the short term in paragraph 6.2 and in the long term in 6.3. We categorize our suggested improvements, first based on the following general steps within the process of getting an ECG or ECHO: booking, administration, ECG investigation, ECHO investigation and reading. Second we categorize the improvements based on the six general areas of problems found with the Ishikawa diagram (see paragraph 5.4.2). In appendix VI it is stated which customer value(s) and goals would be impacted by that improvement. We describe our concepts for a combined ambulatory cardiology administration and the ECHO schedule separately in paragraph 6.4 and 6.5.

6.1 | Ideal situation

The ideal situation from an outpatient patient's perspective

If a patient wants to book an appointment for an investigation he/she can book an appointment online or immediately at the referring doctor. The available time slots are displayed and the patient can choose which date and time is the most suitable to him/her. The system will automatically send the patient a confirmation of the appointment. A few days before the actual investigation, the patient will receive an email or an automatic telephone call to remind the patient of their appointment.

In the ideal situation the patients would register themselves using a self-service kiosk, upon arrival, if they are capable and comfortable of performing this task.. The patient would swipe their OHIP card which would prompt the patient to verify some key demographic information and automatically register the patient for their appointment.
Upon completion of the registration the demographics of the patient would be automatically uploaded into the ECG machine.

If the patient is not capable of checking themselves in, they would be directed to the reception area for assistance. After the registration the patient is asked to wait in the waiting area.

In the waiting area a monitor would display the current waiting time. When a room is available the patient would be prompted to walk to the exam room for their investigation.

The ideal situation from the ECG technician's perspective

When the ECG technician is available for the next patient he/she will inform the system, which will notify the next patient in the queue to proceed to the exam room.

The ideal situation from the sonographer's perspective

When the sonographer is available for the next patient he/she will inform the system, which will notify the next patient in the queue to proceed to the exam room. The sonographer can read the requisition with the reason for the ECHO and the previous report on his/her computer. The demographics of the patient are automatically uploaded into the ECHO machine. If the patient is seeing a cardiologist

immediately after the investigation the preliminary report is sent to the clinic automatically. The preliminary report also goes automatically in a queue for the cardiologists to read.

The ideal situation from the reading cardiologist's perspective
The performed investigations are placed in a queue. Once there is a new investigation that has to be read, the cardiologist receives a message. The cardiologists will read the investigation and by signing off the report, the report will be send automatically to the referring doctor.

6.2 | Short term

6.2.1 | Booking

Schedule

A *Amount of clinic time slots should be reconsidered*
Currently almost every cardiologist uses less time slots than they are assigned. This results in unused spots in the schedule which could be used by inpatients or non-clinic outpatients. That is why we suggest reconsidering the amount of clinic time slots each cardiologist is allocated. Additional spots will be available for inpatients or non-clinic patients and those spots can be assigned to the patients sooner.

B *Protocol for when to call an inpatient in case of a no show*
All patients are asked to arrive at the cardiology department fifteen minutes before the actual investigation starts. If a patient has still not arrived five minutes before the actual investigation should start, we suggest the receptionist searches for inpatients that are able to come quickly to the cardiology department. Most of the time these inpatients will come from 16 North, since they are located very close to the ambulatory cardiology program. If the patient has not arrived when the investigation should start, the receptionist calls the department of the found inpatient and asks if the patient is able to come to the cardiology department within five minutes. If there is a patient that can be quickly transported to the cardiology department, the inpatient is booked at that time slot. If there is no patient that is able to get to the department quickly, the time slot is left open.

C *Dedicated time slots for inpatients and non-clinic outpatients*
We suggest assigning time slots to inpatients and non-clinic outpatients, so that the booking process will be more efficient. That way, more investigations can be scheduled each day.

D *Pre-scheduled room for fellows*
To make sure investigations are scheduled for the right amount of time, every day one ECHO exam room should be pre-scheduled for a fellow. In our future schedule this would be the inpatient room. This prevents delays and prevents the waiting time to increase.

E *Protocol for receiving clinic schedules*
In order to optimize the use of clinic time slots, rules need be established regarding changes to the clinic schedules. The following rules should be adapted:

- The secretary of the cardiologist must inform the receptionist of any changes to the clinic schedule at minimum one week in advance

- All open clinic spots, not booked one week in advance, can be used by the cardiology clinic to book outpatients.

F *E-Requisitions and booking from clinics via own computer*
All cardiologists' secretaries would be able to complete and on-line requisition and recommend an appointment time for their patient. The Heart Function clinic would be able to book and manage their own appointments.

G *Guidelines/scripting for calling non-clinic outpatients to book ECHOs*
Booking non-clinic outpatients only happens between 10:30 AM and 13:30 PM every day. If an outpatient is not answering the phone a voice message should be left. At minimum the voice message should include the following information:

- person calling
- to schedule an ECHO requested by your referring doctor
- telephone number and hours of ambulatory cardiology reception

If the patient does not have an answer machine the requisition is placed in a folder sorted by call date and last name.
If the patient fails to contact the ambulatory cardiology reception after 3 attempts, the requisition is faxed back to the referring doctor with a notation that the patient appointment could not be booked.

6.2.2 | Administration

General

H *Combined ambulatory cardiology reception*
In the future state the ambulatory cardiology program could combine both the ECHO and ECG reception area. This would reduce the number of interruptions and ensure a receptionist is present and visible during the whole day. During a part of the day, also a back office receptionist will be present. This concept will be explained later on. Patients for an ECHO cannot arrive at the ECG reception anymore and the receptionist is able to see immediately if a patient could do an ECG before or after having an ECHO. The signage of the ambulatory cardiology program itself does not have to be improved, because the combined ambulatory cardiology reception is at the beginning of the department and reduces the chance the patient will walk in the wrong direction. One ambulatory cardiology reception would mean that the current ECHO waiting area can be removed, resulting in more space in the hallway. Every patient could wait in the same waiting area, which is now used as the ECG waiting area.

I *Teaching the receptionists the 5S model*
To create a more organized, cleaner and safer workplace the receptionists could be taught the 5S model. When the desks of the receptionists are more organized and cleaner the amount of time spend on searching for things will be reduced. This will also reduce the amount of lost requisitions.

J *Call overnight inpatients ECHO orders first thing in the morning*
To reduce the waiting time for inpatient ECHO orders, the receptionist would book all inpatients at 8:00 am each day. Orders not completed or that arrive late in the day can be scheduled for the next day, prior to the receptionist leaving.

Communication

K *MSH card to let ECG technicians know a patient is waiting*

To inform the ECG technicians that a patient has arrived, the receptionist would use the MSH card to queue the patients. We use this system at the moment an electronic system is not present yet. The visibility of the MSH card would trigger the ECG technicians that a patient is waiting and also provide the demographics of the patient.

L *There needs to be three sonographers every day*

In the new ECHO schedule there are three sonographers available to meet the demands of the department. Two sonographers will be dedicated to clinic patients and outpatients and one will be assigned to complete all inpatient testing for the day.

M *Final reports are faxed on fixed times during the day*

Until the faxing of final reports is fully automated, we suggest to fax the final reports at fixed times during the day. Currently final reports are faxed at random times during the day. We suggest the receptionist faxes final reports twice per day. This means that almost all final reports should be sent the same day to the referring cardiologists.

N *Call bell ECHO inpatients along the hallway*

For safety reasons there needs to be a call bell system available for patients waiting in the hallway for their test.

O *Receptionist should use electronic TEE form*

To book a TEE at the 6th floor, only the electronic TEE form should be used. This form is already available.

P *Remove blank papers for Stress ECHOs*

We suggest removing the blank papers for Stress ECHOs, because they are rarely if ever used.

IT and equipment

Q *One Customer Appointment Manager account for all investigations and staff*

To have a clear overview of all the scheduled investigation, all appointments should be displayed in the same Customer Appointment Manager. This is also necessary since one receptionist will be responsible for registering all patients.

R *Excel sheet as replacement for pink requisitions*

A temporary solution, until the billing process is fully automated, is to summarize all patient test information on an excel spreadsheet. This would eliminate the need for the pink billing requisitions and streamline the process in which the cardiology program and cardiologists are compensated. This information includes the name of the patient, MRN number, health care number, visit number (FIN), accountant code, reading cardiologist, billing number of reading cardiologist, referring physician and the billing number of the referring physician. *Accuracy* – Less mistakes can be made, since the number of tests are not counted manually anymore based on pink requisitions, which can also get lost.

S *No more filing of requisitions and final reports*
All the incoming ECHO requisitions should be scanned and saved in a folder on the computer. The final reports are already stored online in ECHOWeb.

T *Rules to be on time*
If the receptionist arrives late in the morning, the calling of inpatients is delayed. This results in open time slots in the morning. Other problems that arise if the receptionist arrives late is the registration of patients and the fact that nobody can assist the patients if needed. To assure the receptionists arrive on time, consequences for being to late should be introduced.

U *Full time coverage of reception area*
To ensure that the reception area is always covered there should always be two receptionists available trained from Monday to Friday. This model would protect and support coverage int he event of illness or vacation.

Procedures
V *A complete requisition is mandatory for booking an appointment*
For the safety of the patients to ensure that the patient is receiving the appropriate test, the clinic should only accept completed requisitions. Referring physician would be required to complete all required information prior to an appointment being made for the patient. An incomplete requisition would be returned to the referring physician for completion.

W *Inpatient ECHO orders should include the isolation status*
To notify the clinic and sonographer of any isolation precautions and to take into account the time for cleaning the ECHO exam room after the ECHO investigation.

X *Reminders for outpatients*
In order to decrease the number of no shows and trying to know as early as possible if a patient wants to cancel his/her appointment, we suggest implementing reminders for outpatient appointments. We suggest using emails for this if the patient has an email address and is willing to share this for reminder purposes. If a patient does not have email, we suggest using the telephone to remind them.

6.2.3 | ECG investigation

IT and equipment
Z *Inpatient ECG orders received on pager/mobile device*
To reduce the amount of time ECG technicians spend on walking back to the ambulatory cardiology department to check if there are any new inpatient orders, the orders should be sent to a pager or mobile device that is carried by the ECG technicians. The pager/mobile device would show the demographics of the patient with the floor and room number. This would reduce the walking time ECG technicians.

AA *Broken Holter monitor should be fixed*
The broken Holter monitor should be fixed to reduce the time spend on correcting the output of the monitor.

Protocols
BB *Set spots for ECG machines at ER*
To reduce the time the ECG technicians are searching for the ECG machines at the ER department to be able to transfer all the ECGs to the system, the ECG machines have to be put back on set spots at the ER department. This is a temporary solution until the staff working at the ER are able to transfer the ECGs themselves

CC *ER should transfer the ECG themselves*
To prevent the ECG technicians for going to the ER department and transferring all the performed ECGs, the staff at the ER department should transfer the ECGs themselves. This would save a lot of time for the ECG technicians.

DD *Cardiac Care Unit and Labour & Delivery department should create labels with patient demographics*
Until the billing process is digitalized the Cardiac Care Unit and the Labour & Delivery department have to create labels with the patient demographics for the ECG technician to stick on the billing paper. An EGC is only performed by the ECG technicians if the label is available. This should be communicated to the Cardiac Care Unit and the Labour & Delivery Department.

EE *Complete patient demographics in ECG machine*
ECGs are only read by a cardiologist if all the demographics of the patient are entered into the ECG machine. This should be communicated throughout the whole hospital. This ensures that the ECG technicians do not have to edit all the ECGs done by staff from other departments.

FF *Mobile phones of sonographers and ECG technicians should be turned off during investigations*
To prevent the investigation from being disturbed, the mobile phones of technicians should be turned off during investigations.

6.2.4 | ECHO investigation

General
GG *Sonographers faxing the preliminary report*
Currently the preliminary reports are printed and brought to the reception area for faxing. To improve the process we recommend that the sonographers fax the preliminary reports to the clinic cardiologist immediately after the test is complete and the preliminary report is generated.

HH *Material inventory with Kanban system*
To make sure that the appropriate levels of stock are on-hand while eliminating the risk of a shortage, a Kanban system could be introduced. This method would set stock levels and provide triggers for re-ordering *of stay*

IT and equipment

II *A computer in every ECHO exam room*

To reduce the amount of paper and provide real time information to the sonographers, each ECHO room should be equipped with a computer. This would eliminate the need to print previous reports, see who is waiting for a test and signing off patients immediately following the test.

Protocol

JJ *Protocol for when to request a Porter*

Inpatients are regularly late for their appointments and there seems to be confusions around who is responsible for booking the porter for transport. Clear protocols need to be established that clearly define who is responsible for booking porters and when they should arrive to deliver or return patients to their units.

KK *Schedule one sonographer to perform a TEE*

During a TEE the physicians would like to have a sonographer to support them. The staffing schedule needs to be adjusted so that a sonographer is available for every TEE.

LL *Every ECHO exam room has the same lay-out*

To decrease the time spent on searching for equipment and supplies, every ECHO exam room should have exactly the same lay-out. *Length of stay*

MM *A nurse should be available during a bubble test*

An injection is necessary in order to do the bubble test. This injection has to be done by a nurse: sonographers are not allowed to do the injection.

NN *Doors of ECHO exam room should be closed during investigation*

To prevent the investigation from being disturbed, the door of the ECHO exam room should be closed during investigations. A closed door means that an investigation takes place and that the ECHO technician cannot be disturbed. The ECHO technician should only be interrupted during an emergency. This will reduce the length of stay, and the number of interruptions.

OO *Pager to notify sonographers an ECHO patient is waiting*

Until the monitors with the schedule are placed in the ECHO exam rooms, the sonographers are notified that there is a patient waiting via a shared pager that is placed in the ECHO sonographer's room. This will reduce the amount of walking to the reception to check if the next patient is already there.

6.2.5 | Reading

Protocol

PP *Prohibit ECGs to be taken home by cardiologists*

Currently the cardiologists take paper ECGs to their homes to comment. This practice violates MSH's policy around privacy, confidentiality and security.

6.3 | Long term

6.3.1 | Booking

A *Automatic reminders via email to patients*

By sending automatic reminders to patients the no show rate should be reduced. Since the patients are reminded of their appointment the chance they forget their appointment is reduced and if they are not able to come it will stimulate them to contact the clinic to cancel the appointment in advance.

B *Online booking for inpatients*

Currently, an order from an inpatient comes in via the order entry system. Ideally, the Ward Clerk would be able to book an appointment with the clinic online. This will reduce the amount of back and forth calling when booking an ECHO.

C *Online booking for non-clinic patients*

Non-clinic outpatients or referring doctors are able to book an appointment online. They just have to choose a date and time and fill in their details. The only thing the receptionist has to do is to accept the booking. This will reduce the amount of back and forth calling when booking an ECHO.

- *Length of time* – The length of time will be reduced.
- *Less paper use*

6.3.2 | Administration

IT and equipment

D *Fully automated billing process*

The billing process should be fully automated. This should happen automatically when a reading cardiologist signs off. The name of the patient, MRN number, health care number, visit number (FIN), accountant code, reading physician, billing number of reading physician, referring physician and the billing number of the referring physician should go automatically into a file that can be sent to the finance department.

E *Preliminary reports read on the computer by cardiologists*

Clinic physicians have the ability to read the preliminary reports on their own computers.

F *Final reports for referring offices are send via email (semi-long term)*

To reduce the amount of paper, final reports could be send via email to the referring offices on a semi-long term period. This would mean a decrease in the amount of paper used, because the final report does not have to be printed and faxed anymore.

G *Final reports are send automatically*

The final reports should be automatically send to the referring doctors when the physician has read the ECHO and generated the final report. This would ensure that every test that is read has a final report sent to the referring doctor much earlier than the current process.

H *Demographics information interfaced with ECHOWeb*
To eliminate duplicate keystroking of patient demographics and errors between registration and ECHOWeb, demographics should be automatically uploaded into the ECG and ECHO machines.

Procedures
I *Only digital requisitions are excepted*
To reduce the use of paper, all requisitions should be received digital. A requisition is complete if the original requisition from the ambulatory cardiology program at MSH is used containing all the demographics of the patient, the telephone number of the patient and a description which tells the sonographer why the patient needs an ECHO.
If some details are missing on the requisition, the booking system will not except the request to book an appointment and will automatically ask the referring doctor to fill in all mandatory boxes.

6.3.3 | ECG investigation

J *Monitors in ECG technician room*
If the pink requisitions are no longer used, another way to let the ECG technicians know there is a patient waiting should be introduced. This can be done by installing a monitor in the ECG technicians' room that is linked to the schedule system and shows all the waiting patients including the time they are waiting already.

6.3.4 | ECHO investigation

K *Monitors in sonographers room*
We suggest installing a monitor in the sonographers room that is linked to the schedule system and shows all the waiting patients including the time they are waiting already.

6.3.5 | Reading

L *Reading ECGs digitally by cardiologists*
Currently the cardiologists use paper ECGs to comment. The cardiologists take these paper ECGs to their home, while that is illegal since those ECGs contain privacy-sensitive information. To make sure this would not happen in the future the editing of ECGs should become digital. This means that the ECGs cannot get lost while traveling. Changing to digital editing results in an increase of the confidentiality.

6.4 | Combined reception area in detail

Time studies have determined that the ECG receptionist spends 245 minutes per day on receptionist tasks and the ECHO receptionist spends 215 minutes per day on this kind of tasks (see paragraph 4.2). All the different kind of interruptions and the number of different tasks done at the same time, cause the tasks to be done in an inefficient way. That is why we suggest using a combined reception area with separated tasks done at different times during the day.

We separate two receptionists working every day. One receptionist from 8:00 am to 4:00 pm (receptionist 1) and the other one from 10:00 am to 2:00 pm (receptionist 2). Receptionist 1 covers the registration desk from 8:00 am to 10:00 and from 2:00 pm to 4:00 pm. Receptionist 2 covers the registration desk from 10:00 am to 2:00 pm, and the receptionists cover each other when taking a break, making sure the registration desk is covered during the whole day.

During the time receptionist 2 covers the registration desk, receptionist 1 will work in a back office, mainly to book outpatient appointments. All of the tasks done per moment of the day are shown in table 32. The tasks are divided in “On Demand” and “Ad Hoc”. On Demand tasks should be done right away, while Ad Hoc tasks can wait to be done till a moment the receptionist has time.

Time	Receptionist 1		Receptionist 2	
	On Demand	**Ad Hoc**	**On Demand**	**Ad Hoc**
8:00 - 8:30	Schedule inpatients for ECHOs. Register arriving patients. Page ECG technicians for any STAT calls			
8:30 - 10:00	Schedule inpatients for ECHOs. Register arriving patients. Page ECG technicians for any STAT calls Fax preliminary ECHO reports to MSH Cardiologists Answering incoming calls (if time permits) Book Holters and BPs	Answer incoming calls Fax final ECHO reports to referring MDs if already at reception Sort and mail read ECGs and Holters		

10:00 - 11:30		Book clinic patients Book outpatient ECHOs and Stress ECHOs Call patients to confirm appointments Fax final ECHO reports to referring MDs Photocopy Holters Sort and mail read ECGs and Holters Filing as required	Schedule inpatients for ECHOs. Register arriving patients. Page ECG technicians for any STAT calls Fax preliminary ECHO reports to MSH Cardiologists Answering incoming calls (if time permits) Book Holters and BPs	Fax final ECHO reports to referring MDs Answer incoming calls Sort and mail read ECGs and Holters
11:30 - 12:30	Lunch			
12:30 - 12:45	Cover Registration Desk		Break	
12:45 - 2:00		Book clinic patients Book outpatient ECHOs, Stress ECHOs Call patients to confirm appointments Fax final ECHO reports to referring MDs Answer incoming calls Photocopy Holters Sort and mail read ECGs and Holters Filing as required	Schedule IPs for ECHOs. Register arriving patients. Page ECG Tech for any STAT calls Fax preliminary ECHO reports to MSH Cardiologists Answering incoming calls (if time permits) Book Holters and BPs	Answer incoming calls Fax final ECHO reports to referring MDs if already at reception Sort and mail read ECGs and Holters

2:00 - 3:30	Schedule IPs for ECHOs. Register arriving patients. Page ECG Tech for any STAT calls Fax preliminary ECHO reports to MSH Cardiologists Answering incoming calls (if time permits) Book Holters and BPs	Answer incoming calls Fax final ECHO reports to referring MDs if already at reception Sort and mail read ECGs and Holters	
3:30 - 4:00	Schedule inpatients for next day ECHOs. Register arriving patients. Page ECG Tech for any STAT calls		

Table 32: Schedule for the combined ambulatory cardiology program reception area

6.5 | ECHO schedule

By improving the current ECHO booking schedule we will increase the customer value by impacting three of the six indicators: length of stay, length of time and quality of care.

The future schedule will continue to use three exam rooms, but one room will be dedicated for inpatient ECHOs. This will increase access to block space for inpatient ECHOs and reduce the need to use the portable ECHO machine. According to the cardiologists, the quality of the images made with the portable machine is inferior to the stationary ECHO machines. Portable ECHOs will be limited to patients who cannot be safely transported.

In the future schedule, the sonographer will still work an eight hour shift and each ECHO investigation will still be scheduled for 45 minutes. Our time observations showed the average time for an outpatient ECHO is 42 minutes and for an inpatient ECHO is 44 minutes, which means 45 minutes time slots are representative for the actual duration of the investigation. ECHO scheduled with a fellow will remain at 60 minutes. Actual work time/day for a sonographer is 420 minutes (480 minutes – 60 minutes for lunch and breaks), meaning each sonographer can perform nine ECHOs every day and seven if working with a fellow.

Yearly target for ECHO investigations

The number of outpatient ECHOs that is required per day to meet the yearly target can be calculated by dividing the target by the number of working days in a year. Paragraph 4.1.2 shows the ambulatory cardiology program has a target of 3,605 outpatients ECHO investigations for the fiscal year 2014/15 (April 1, 2014 to until March 31, 2015). The current no show rate is ten percent, meaning at least 3,966 outpatient ECHOs have to be booked to reach the target. There are approximately 240 working days in a year, which means seventeen outpatient ECHOs should be done each day to achieve the target (240x17=4080). Only two ECHO exam rooms are required to achieve the target.

The number of inpatient ECHOs as shown in paragraph 4.1.2 is not expected to rise significantly in the future. The future schedule will attempt to complete all inpatient ECHOs on the same day it was ordered. If an order is received after the clinic is closed it will be completed in the morning of the following day. To be able to perform all the inpatient ECHOs we suggest preschedule inpatient slots in the schedule. Based on inpatient demand one dedicated ECHO room is required every day, however on Mondays, additional spots are required to complete the orders received over the weekend (see paragraph 3.3.2.2).

Fellows

The scheduled time for an ECHO with a fellow is 60 minutes and the normal set time is 45 minutes. Because the fellow's schedule consistently changes it has been difficult to plan their ECHO time without either revising the patient schedules or causing delays for patients. To prevent future investigations from being delayed, the fellow should perform all the ECHO investigations in the ECHO exam room reserved for inpatients, were time slots are set at one hour intervals. Since most inpatients are booked in the morning, this would best meet the schedule of the fellows.

Meet the target

The ambulatory cardiology program's new target is to complete all inpatient ECHOs the same day the order is received, and performs at least seventeen outpatient ECHOs a day. Since the average demand for inpatient ECHOs on Monday morning is fourteen, the clinic and outpatient volume will need to be lowered. Typically, 25 ECHOs can be performed each day with three sonographers; eighteen outpatients and seven inpatients. Because the demand for inpatient ECHOs is much lower on the remaining days, the lost outpatient volume can easily be made up by scheduling in the inpatient room.

Cardiologist clinics

The future schedule has two ECHO exam rooms dedicated for outpatients. Since a cardiology clinic appointment on the 18th floors takes approximately fifteen minutes, the ECHO schedule will have staggered start times so patient wait times to see there cardiologist will be eliminated or a least decreased. The future schedule will have one outpatient ECHO room with slots from 8:15 am to 4:00 pm and one ECHO room from 8:30 am to 4:30 pm.

Reserved time slots per cardiologist

Based on both the average number of actual time slots used and historical trends we adjusted the number of dedicated time slots for each cardiologist.

	Cardiologist	Number of time slots needed
Monday	Dr. Gold	5
	Dr. Floras	2
	Dr. Sasson	3
Tuesday	Dr. Colman	3
	Dr. Mak	8
	Dr. Nesbitt	3
	Dr. Sasson	3
Wednesday	Dr. Balmain	13
	Dr. Gold	4
	Dr. Mak	3
Thursday	Dr. Barolet	1
	Dr. Balmain	6
	Dr. Newton	4
Friday	Dr. Wald	8

Table 33: Reserved time slots per cardiologist

Clinic cancellations

Currently, 32% of all clinics are cancelled, resulting in many unused time slots, which could be used for both non clinic outpatients and inpatients. To significantly reduce the number of unused time slots, we suggest introducing strict rules for the use of clinic time slots. The sooner the receptionist is notified that that assigned spots will be available, the greater the chance outpatients can be contacted and booked at these times. The following rules are recommended for the ambulatory cardiology program:

- Dedicated cardiologist clinic slots not booked five days prior to the appointment, will be available for booking outpatient ECHOs.
- Every cardiologist must inform the receptionist as soon as they know that they are going to cancel their clinic.

Staffing

To achieve the future ECHO performance targets, the number of sonographers working each day needs to be balanced. Three sonographers are needed every day of the week, one assigned to each of the 3 rooms.

With all the above details in mind, we developed the future schedule as shown below. The blue boxes are the assigned timeslots for the clinics of all the cardiologists. The orange boxes are assigned to inpatients and the green boxes are assigned to non-clinic outpatients.

Monday					
OP/IP		**OP/IP**		**IP**	
8:15 - 9:00	Dr. Gold	**8:30 - 9:15**	Dr. Gold	**8:30 - 9:30**	
9:00 - 09:45	Dr. Gold	**9:15 - 10:00**	Dr. Gold	**9:30 - 10:30**	
9:45 - 10:30	Dr. Gold	**10:00 - 10:45**	Dr. Floras	**10:30 - 11:30**	
10:30 - 11:15	Dr. Floras	**10:45 - 11:30**	Dr. Sasson	**11:30 -12:30**	
11:15 - 12:00	Dr. Sasson	**11:30 - 12:15**	Dr. Sasson	**12:30 - 13:30**	
12:00 - 13:00		**12:15 - 13:15**		**13:30 - 14:30**	
13:00 - 13:45		**13:15 - 14:00**		**14:30 - 15:30**	
13:45 - 14:30		**14:00 - 14:45**		**15:30 - 16:30**	
14:30 - 15:15		**14:45 - 15:30**			
15:15 - 16:00		**15:30 - 16:15**			

Tuesday					
OP		**OP**		**IP**	
8:15 - 9:00	Dr. Nesbitt	**8:30 - 9:15**	Dr. Nesbitt	**8:30 - 9:30**	
9:00 - 09:45	Dr. Nesbitt	**9:15 - 10:00**	Dr. Sasson/Dr. Colman	**9:30 - 10:30**	
9:45 - 10:30	Dr. Sasson/Dr. Colman	**10:00 - 10:45**	Dr. Sasson/Dr. Colman	**10:30 - 11:30**	
10:30 - 11:15		**10:45 - 11:30**		**11:30 -12:30**	
11:15 - 12:00		**11:30 - 12:15**		**12:30 - 13:30**	
12:00 - 13:00		**12:15 - 13:15**		**13:30 - 14:30**	
13:00 - 13:45	Dr. Mak	**13:15 - 14:00**	Dr. Mak	**14:30 - 15:30**	
13:45 - 14:30	Dr. Mak	**14:00 - 14:45**	Dr. Mak	**15:30 - 16:30**	
14:30 - 15:15	Dr. Mak	**14:45 - 15:30**	Dr. Mak		
15:15 - 16:00	Dr. Mak	**15:30 - 16:15**	Dr. Mak		

Wednesday					
OP		**OP**		**IP**	
8:15 - 9:00	Dr. Gold	**8:30 - 9:15**	Dr. Gold	**8:30 - 9:30**	
9:00 - 09:45	Dr. Gold	**9:15 - 10:00**	Dr. Gold	**9:30 - 10:30**	
9:45 - 10:30	Dr. Mak	**10:00 - 10:45**	Dr. Mak	**10:30 - 11:30**	
10:30 - 11:15	Dr. Mak	**10:45 - 11:30**	Dr. Balmain	**11:30 -12:30**	
11:15 - 12:00	Dr. Balmain	**11:30 - 12:15**	Dr. Balmain	**12:30 - 13:30**	
12:00 - 13:00		**12:15 - 13:15**		**13:30 - 14:30**	
13:00 - 13:45	Dr. Balmain	**13:15 - 14:00**	Dr. Balmain	**14:30 - 15:30**	
13:45 - 14:30	Dr. Balmain	**14:00 - 14:45**	Dr. Balmain	**15:30 - 16:30**	
14:30 - 15:15	Dr. Balmain	**14:45 - 15:30**	Dr. Balmain		
15:15 - 16:00	Dr. Balmain	**15:30 - 16:15**	Dr. Balmain		

Thursday					
OP		**OP**		**IP**	
8:15 - 9:00	Dr. Barolet	**8:30 - 9:15**	Dr. Newton	**8:30 - 9:30**	
9:00 - 09:45	Dr. Newton	**9:15 - 10:00**	Dr. Newton	**9:30 - 10:30**	
9:45 - 10:30	Dr. Newton	**10:00 - 10:45**		**10:30 - 11:30**	
10:30 - 11:15		**10:45 - 11:30**		**11:30 -12:30**	
11:15 - 12:00	Dr. Balmain	**11:30 - 12:15**	Dr. Balmain	**12:30 - 13:30**	
12:00 - 13:00		**12:15 - 13:15**		**13:30 - 14:30**	
13:00 - 13:45	Dr. Balmain	**13:15 - 14:00**	Dr. Balmain	**14:30 - 15:30**	
13:45 - 14:30	Dr. Balmain	**14:00 - 14:45**	Dr. Balmain	**15:30 - 16:30**	
14:30 - 15:15	Dr. Balmain	**14:45 - 15:30**	Dr. Balmain		
15:15 - 16:00		**15:30 - 16:15**			

Friday					
OP		**OP**		**IP**	
8:15 - 9:00	Dr. Wald	**8:30 - 9:15**	Dr. Wald	**8:30 - 9:30**	
9:00 - 09:45	Dr. Wald	**9:15 - 10:00**	Dr. Wald	**9:30 - 10:30**	
9:45 - 10:30	Dr. Wald	**10:00 - 10:45**	Dr. Wald	**10:30 - 11:30**	
10:30 - 11:15	Dr. Wald	**10:45 - 11:30**	Dr. Wald	**11:30 -12:30**	
11:15 - 12:00		**11:30 - 12:15**		**12:30 - 13:30**	
12:00 - 13:00		**12:15 - 13:15**		**13:30 - 14:30**	
13:00 - 13:45		**13:15 - 14:00**		**14:30 - 15:30**	
13:45 - 14:30		**14:00 - 14:45**		**15:30 - 16:30**	
14:30 - 15:15		**14:45 - 15:30**			
15:15 - 16:00		**15:30 - 16:15**			

Table 34: Future ECHO schedule

6.6 | Conclusion

In this chapter we developed ways to improve the processes for an ECG and ECHO by formulating the ideal situation and improvements for the short term and the long term, as followed from our third and fourth research questions:

3. *How can we improve the processes of providing an ECG and an ECHO at MSH?*
4. *Which alternatives exist on the short and the long term for redesigning the processes of providing an ECG and an ECHO at MSH?*

We found 41 short term improvements and 12 long term improvements. We described a combined reception area in which two receptionists work every day: one from 8:00 am to 4:00 pm and one from 10:00 to 2:00. In this period of time all receptionist duties can be done.

We adjusted the number of dedicated time slots for each cardiologist's clinic and determined that 17 outpatient ECHOs need to be done every day, in order to reach the 2014/2015 target. Every day three sonographers have to work to be able to also do all inpatient ECHOs at the same day. One room should be completely dedicated to inpatient ECHOs and two to outpatient ECHOs. Fellows perform mostly inpatient ECHOs and sonographers get different shift times in order to stagger the outpatients going to a clinic after getting an ECHO.

7 |Implement

In chapter 7 we investigate how to implement the solutions as described in chapter 6. For the ambulatory cardiology program it is important to develop plans to implement changes both in the short term and the long term. In paragraph 7.1 we study implementation theories and in paragraph 7.2 we use the multi criteria analysis SMART to make a suggested order in which the improvements should be implemented. The effects of implementing the improvements is described in paragraph 7.3.

7.1 | Implementation theories

7.1.1 | Roles

As described in chapter 2, when introducing lean thinking in an organization, three key concepts should be taken into account: leadership, culture and process (Womack et al., 2005). Next to those three key concepts, it is important to keep in mind which parts of an organization/hospital are impacted when implementing change (Boddy, 2008). Boddy developed a model which helps identify the different parts of the organization which could be impacted. Just like the internal parts of an organization, it is also important to take into account the external environment. When implementing each of the solutions it is important to use Boddy's model to make sure each affected actor is taken into account.

Figure 14: Boddy's implementation model (Boddy, 2008)

7.1.2 | Eight steps for change

As a guideline to change and improve the processes in the ambulatory cardiology program, we refer to the model developed by John P. Kotter (1995). As Kotter states: "*The most general lesson to be learned from the more successful [change] cases is that the change process goes through a series of phases that, in total, usually require a considerable length of time. Skipping steps creates only the illusion of speed and never produces a satisfying result.*" It is therefore important to implement changes based on all eight steps within Kotter's model:

1. Establishing a sense of urgency
2. Forming a powerful guiding coalition
3. Creating a vision
4. Communicating the vision
5. Empowering others to act on the vision
6. Planning for and creating short-term wins
7. Consolidating improvements and producing still more change
8. Institutionalizing new approaches

The first three steps are meant to create an atmosphere for change within the organisation. After that, steps four to six are part of the actual implementation, followed by steps seven and eight which make sure the changes will be sustainable for a long period of time. When going through the different phases it is also important to realise that "*(…) critical mistakes in any of the phases can have a devastating impact, slowing momentum and negating hard-won gains*" (Kotter, 1995). Examples of mistakes that can be made are the following: under communicating the vision, not removing obstacles to the new vision, not systematically planning and creating short-term wins and declaring victory too soon.

During our research within the ambulatory cardiology program at MSH, the program had already started with creating an atmosphere for change. During the three day Kaizen event a sense of urgency was established and a vision was created. After the event a guiding coalition was formed looking for the gaps and waste within the processes that should be eliminated or changed. Since the opportunities to change the process to be more efficient and increase patient experience are identified, it is now up to the guiding coalition to start communicating the vision and empowering others to act on the vision. Planning for and creating short-term wins has also started, so that the next step will be to consolidate improvements while producing still more change. To guide the program in creating short-term wins and consolidating improvements, we developed a suggested order to implement the improvements, see paragraph 7.2.

7.1.3 | Implementation of Lean

Next to the recommended improvements as described in chapter 6, we suggest implementing a Lean model within the ambulatory cardiology program. Because implementing Lean is an extensive process, we describe a separate implementation model designed for Lean. We describe a simplified model of

Bicheno's "Lean transformation framework" (2009), see figure 15. When using the steps as described in this model, Kotter's model should always be taken into consideration.

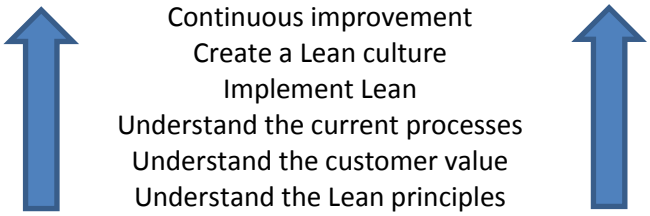


Figure 15: A simplified version of Bicheno's "Lean transformation framework"(Bicheno, 2009)

During the value stream event, the program's team was introduced to the Lean principles. However, the complete team was not present during the event, which is why additional lean training is recommended. Every employee within the cardiology program should be familiar with the principles. When employees are familiar with the Lean principles, customer values, current process and the goals of the program, , it is much easier to implement these changes. Our research also identified the customer value and every step taken within the processes. This information could help others understand the customer value and processes.
After that it is time to implement Lean and create a Lean culture, resulting in continuous improvement, which should involve all the employees within the program. In the end you want everyone to be part of and think about continuous improvement.

7.2 | SMART method

In this paragraph we will execute a multi criteria analysis on the different improvements given in paragraph 6.2 and 6.3. This will result in an objective ranking of all different improvements, which creates a guideline of the order in which each of the solutions should be implemented. To score each solution, we developed the following attributes:

- *Increase in customer value* – The number of customer value indicators (paragraph 3.4) that will increase when a certain solution is implemented.
- *Goals of the program* – The number of goals that the program wants to reach (paragraph 3.5) that will increase when a certain solution is implemented.
- *Costs* – The amount of money that has to be invested to implement a certain solution.
- *Implementation time* – The amount of time it will take to implement a certain solution.
- *Acceptance of cardiology personnel* – The degree in which the personnel at the ambulatory cardiology department will accept a certain solution.

All solutions are scored on these five attributes.

7.2.1 | Scoring short term improvements

Each attribute uses a different scoring scale as defined in table 35.

Attribute	Scoring
Costs	None, low, medium, high
Implementation time	Very short, short, long, very long
Acceptance of cardiology personnel	Very low, low, medium, high, very high
Increase in customer value	0 to 4
Goals of the program	0 to 3

Table 35: Scoring scale per attribute

Table 36 scores the attributes for all 41 short terms solutions (A to OO).

Improvement	Costs	Implementation time	Acceptance of cardiology personnel	Increase in customer value	Goals of the program
A	None	Long	Very low	1	2
B	None	Very short	Very high	1	1
C	None	Long	High	1	2
D	None	Long	High	1	1
E	None	Very short	Medium	1	2
F	Low	Long	High	1	0
G	None	Very short	High	1	2
H	Low	Short	Medium	2	1
I	Low	Short	Low	1	0
J	None	Very short	High	1	1
K	None	Very short	Very high	1	2
L	Medium	Long	Very low	1	3
M	None	Very short	High	1	0
N	Low	Short	Low	1	0
O	None	Very short	Very high	0	1
P	None	Very short	Very high	0	1
Q	Low	Short	High	0	1
R	Low	Short	High	1	2
S	Low	Short	Very high	1	1
T	None	Very short	Very low	2	1
U	Medium	Long	Very high	2	0
V	None	Short	Very high	2	0

W	None	Long	Very high	2	0
X	None	Short	Medium	1	2
Z	None	Long	Very high	1	1
AA	Low	Short	Very high	1	0
BB	None	Short	Very high	1	0
CC	None	Short	Very high	1	1
DD	None	Short	Very high	1	0
EE	None	Short	Very high	2	1
FF	None	Very short	Very low	2	0
GG	Low	Short	Low	1	1
HH	Low	Short	Medium	4	0
II	High	Long	Medium	2	0
JJ	None	Very short	High	1	1
KK	Medium	Very short	High	1	0
LL	Low	Short	Very high	1	0
MM	Low	Short	Very high	2	0
NN	None	Very short	Medium	2	0
OO	Low	Short	Medium	1	0
PP	None	Very short	Very low	1	0

Table 36: Attributes scored per short term improvement

Measure performance of alternatives on attributes

After scoring the attributes for each improvement, we created standardized scales for each attribute. For each attribute the lowest score is 0 and the highest score is 100, with scores in between. For example: the score of a long implementation time gets 0 points, while a score of short implementation gets 100 points. The scales for each attribute were based on personal experience and knowledge and are shown in table 37.

Costs		**Implementation time**		**Acceptance of cardiology personnel**		**Increase in customer value**		**Goals of the program**	
None	100	Very short	100	Very low	0	0	0	0	0
Low	60	Short	70	Low	25	1	25	1	33
Medium	30	Long	0	Medium	50	2	50	2	66
High	0	Very long	NA	High	75	3	75	3	100
				Very high	100	4	100		

Table 37: Standardized scales per attribute

Weights of attributes

We considered the most important scoring attribute to be *increase in customer value*, therefore it is weighted at 100%. The remaining attributes are *goals of the program*, *costs to implement*,

implementation time and *acceptance by the cardiology personnel* with respective weights of 90%, 70%, 60% and 30%. The total sum of our weights is equal to 350. The weight per attribute is calculated by dividing the weight of an attribute by the total weight of all attributes. In table 38 the scores in points are displayed for all solutions. The total score is calculated by multiplying the weight and the score per attribute and summing the different scores per attribute.

Improvement	Costs	Implementation time	Acceptance of cardiology personnel	Increase in customer value	Goals of the program	Total
A	100	0	0	25	66	44.1
B	100	100	100	25	33	61.3
C	100	0	75	25	66	50.5
D	100	0	75	25	33	42.1
E	100	100	50	25	66	65.5
F	60	0	75	25	0	25.6
G	100	100	75	25	66	67.7
H	100	70	75	50	33	61.2
I	60	70	25	25	0	33.3
J	100	100	75	25	33	59.2
K	100	100	100	25	66	69.8
L	30	0	0	25	100	38.9
M	100	100	75	25	0	50.7
N	60	70	25	25	0	33.3
O	100	100	100	0	33	54.2
P	100	100	100	0	33	54.2
Q	60	70	75	0	33	38.9
R	60	70	75	25	66	54.5
S	60	70	100	25	33	48.2
T	100	100	0	50	33	59.9
U	30	0	100	50	0	28.9
V	100	70	100	50	0	54.9
W	100	0	100	50	0	42.9
X	100	70	50	25	66	60.4
Z	100	0	100	25	33	44.2
AA	60	70	100	25	0	39.7
BB	100	70	100	25	0	47.7
CC	100	70	100	25	33	56.2
DD	100	70	100	25	0	47.7
EE	100	70	100	50	33	63.3

FF	100	100	0	50	0	51.4
GG	60	70	25	25	33	41.8
HH	60	70	50	100	0	56.9
II	0	70	50	50	0	30.6
JJ	100	100	75	25	33	59.2
KK	30	100	75	25	33	45.2
LL	60	70	100	25	33	48.2
MM	60	70	100	50	0	46.9
NN	100	100	75	50	0	57.9
OO	60	70	50	25	0	35.4
PP	100	100	0	25	0	44.3
Weight	70	60	30	100	90	350
%	0.2	0.17	0.09	0.29	0.26	1

Table 38: Standardized scoring per short term improvement

With those scores a ranking can be made, the highest score is ranked as number 1 and the lowest score is ranked as number 41.The ranking of all the short term improvements is displayed in table 39.

Rank	Solution	Rank	Solution	Rank	Solution	Rank	Solution	Rank	Solution
1	K	**11**	NN	**21**	S	**31**	D	**41**	F
2	G	**12**	HH		LL	**32**	GG		
3	E	**13**	CC	**23**	BB	**33**	AA		
4	EE	**14**	V		DD	**34**	Q		
5	B	**15**	R	**25**	MM	**35**	L		
6	H	**16**	O	**26**	KK	**36**	OO		
7	X		P	**27**	PP	**37**	I		
8	T	**18**	FF	**28**	Z		N		
9	J	**19**	M	**29**	A	**39**	II		
	JJ	**20**	C	**30**	W	**40**	U		

Table 39: Ranking of all the short term improvements

7.2.2 | Scoring long term improvements

The same method is used for ranking the long term improvements. The only difference between the short term and the long term is the attribute *increase in customer value*. The range of the *increase in customer value* is changed to 0 to 3 instead of 0 to 4. In table 40 the scores for each attribute for all the solutions is shown. In table 41 the scores are standardized for all attributes and in table 42 the ranking of long-term solutions is displayed.

Solution	Costs	Implementation time	Acceptance of cardiology personnel	Increase in customer value	Goals of the program
A	Medium	Short	Very high	1	2
B	High	Short	Very high	1	1
C	High	Very long	Very high	1	1
D	High	Long	Very high	2	1
E	None	Short	Low	1	1
F	None	Long	High	1	1
G	Medium	Very long	Very high	1	1
H	High	Long	Very high	2	0
I	None	Very long	Very high	3	1
J	Medium	Very short	High	1	0
K	Medium	Short	High	1	0
L	None	Short	Very low	2	1

Table 40: Attributes scored per long term improvement

Solution	Costs	Implementation time	Acceptance of cardiology personnel	Increase in customer value	Goals of the program	Total
A	30	75	100	0	100	53.1
B	0	75	100	0	50	34.3
C	0	0	100	0	50	21.4
D	0	25	100	50	50	40.0
E	100	75	25	0	50	47.9
F	100	25	75	0	50	43.6
G	30	0	100	0	50	27.4
H	0	25	100	50	0	27.1
I	100	0	100	100	50	70.0
J	30	100	75	0	0	29.6
K	30	75	75	0	0	25.3
L	100	75	0	50	50	60.0
Weight	70	60	30	100	90	350
%	0.2	0.17	0.09	0.29	0.26	1

Table 41: Standardized scoring per long term improvement

Rank	Solution	Rank	Solution
1	J	**8**	K
2	M	**9**	H

3	A	**10**	I
4	F	**11**	L
5	G	**12**	C
6	E		
7	B		

Table 42: Ranking of all the long term improvements

7.3 | Effects of implementing improvements

When all the suggested improvements are implemented in the processes and schedule of the ambulatory cardiology program, this would result in an increase of time efficiency and a decrease of the number of handoffs. In this paragraph we show the time efficiency for the short term, the long term and in the ideal state. Handoff process maps are also given for the short term, the long term and the ideal state.

In the current state the ECG process involves 15 handoffs and has a time efficiency of 13% for outpatients and 20% for inpatients. The current ECHO process involves 16 handoffs and has a time efficiency of 31% for outpatients, 28% for inpatients and 19% for investigations with a fellow.

7.3.1 | Time efficiency

Implementing the recommendations will lead to the following time efficiency for the investigations:

Short term

Test	ECG	VA Time (min)	Cycle Time (min)	Process Cycle Efficiency (%)
ECG	*Outpatient*	2	15	13%
	Inpatient	2	8	25%
ECHO	*Outpatient*	17	53	32%
	Inpatient	15	52	30%
	Investigation with a fellow	16	85	19%

Table 43:Time efficiency for the short term

Long term

Test	ECG	VA Time (min)	Cycle Time (min)	Process Cycle Efficiency (%)
ECG	*Outpatient*	2	11	18%
	Inpatient	2	7	29%
ECHO	*Outpatient*	17	45	38%
	Inpatient	15	46	33%
	Investigation with a fellow	16	70	23%

Table 44:Time efficiency for the long term

Ideal state

Test	ECG	VA Time (min)	Cycle Time (min)	Process Cycle Efficiency (%)
ECG	*Outpatient*	2	9	22%
	Inpatient	2	7	29%
ECHO	*Outpatient*	17	41	41%
	Inpatient	15	42	36%
	Investigation with a fellow	16	24	24%

Table 45:Time efficiency in the ideal state

The tables show an increase in time efficiency when changing from current state to short term state, from short term state to long term state and form long term state to ideal state. Meaning that implementing the recommendations both in the short term, long term and ideal state is valuable.

7.3.2 | Handoff process maps

Short term ECG

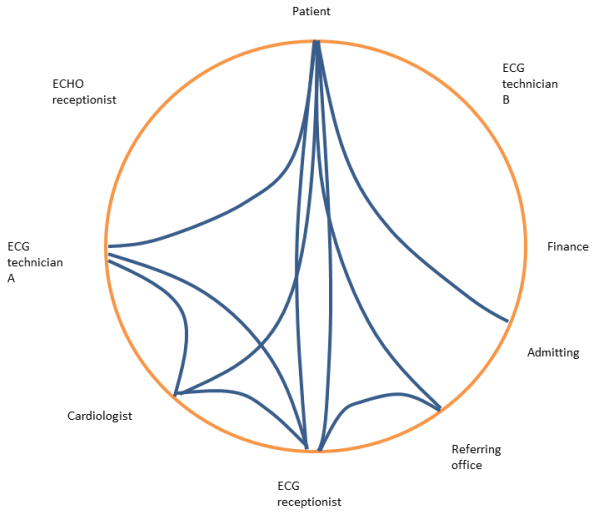


Figure 16: Future short term handoff process map for an ECG

The amount of handoffs is reduced to 10 when implementing the recommendations for the ECG process on the short term.

Long term ECG

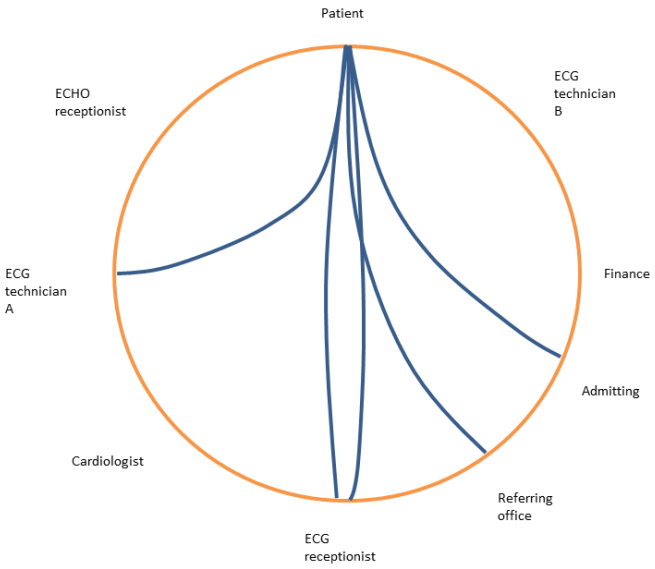


Figure 17: Future long term handoff process map for an ECG

The amount of handoffs is reduced to 5 when implementing the recommendations for the ECG process on the long term.

Ideal state ECG

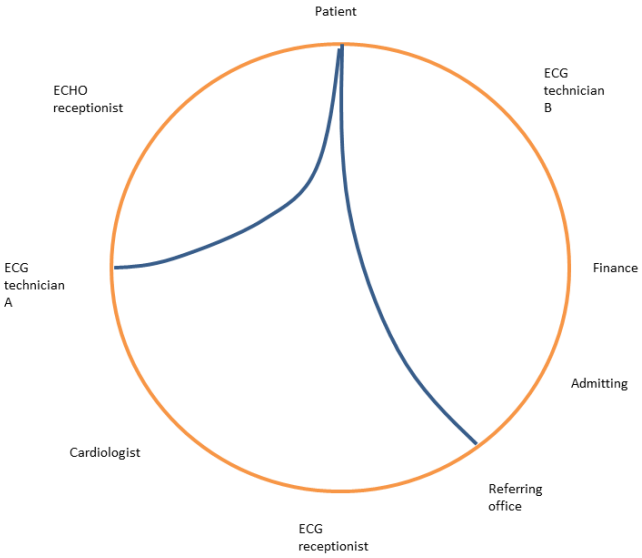
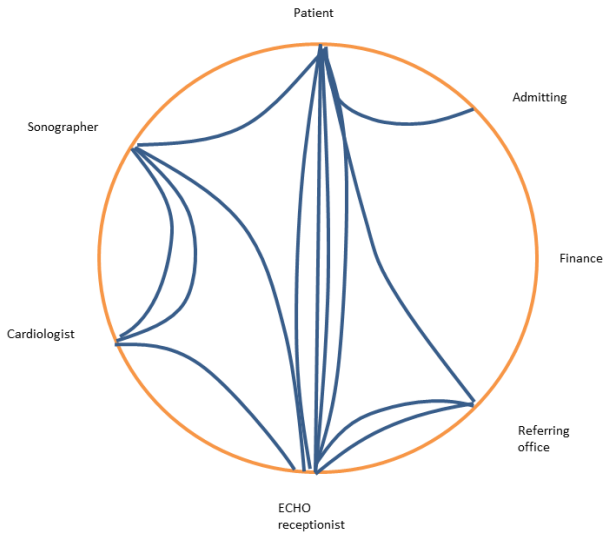


Figure 18: Ideal state handoff process map for an ECG

In the ideal situation the total amount of handoffs for an ECG is reduced to 2.

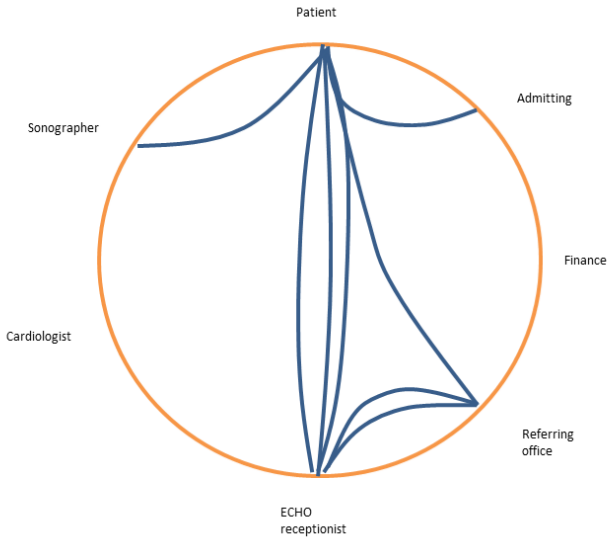
Short term ECHO



The amount of handoffs is reduced to 13 when implementing the recommendations for the ECHO process on the short term.

Figure 19: Future short term handoff process map for an ECHO

Long term ECHO



The amount of handoffs is reduced to 8 when implementing the recommendations for the ECHO process on the long term.

Figure 20: Future long term handoff process map for an ECHO

Ideal state ECHO

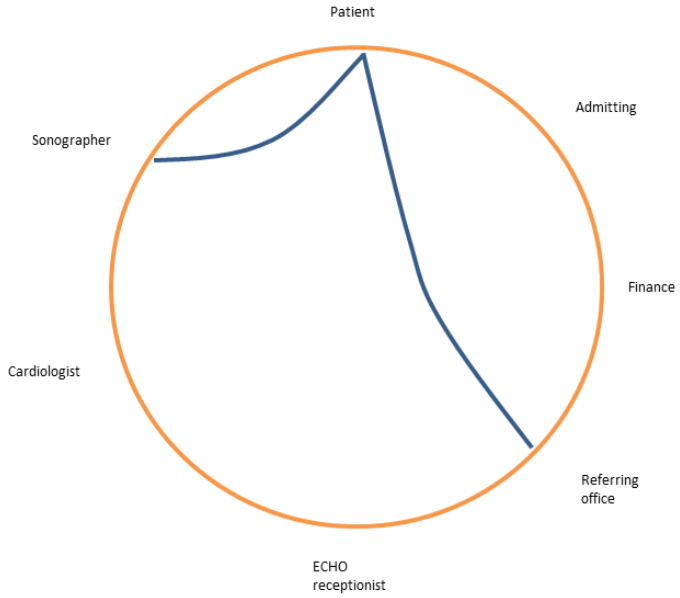


Figure 21: Ideal state handoff process map for an ECHO

In the ideal situation the total amount of handoffs for an ECHO is reduced to 2.

7.4| Conclusion

In this chapter studied implementation theories in order to answer our fifth research question:

5. *How should the alternatives for redesigning the processes be implemented?*

We found eight steps for change, which can be used for implementing each improvement:

1. Establishing a sense of urgency
2. Forming a powerful guiding coalition
3. Creating a vision
4. Communicating the vision
5. Empowering others to act on the vision
6. Planning for and creating short-term wins
7. Consolidating improvements and producing still more change
8. Institutionalizing new approaches

Next to that, the “Lean transformation framework” helps MSH to implement Lean.

We executed a multi criteria analysis (SMART) on the different improvements formulated in chapter 6, resulting in a suggested order in which each of the solutions should be implemented. Implementing all of the improvements would lead to an increase of time efficiency and an decrease of the number of handoffs.

8 |Conclusion and discussion

In chapter 8 we describe our recommendations in paragraph 8.1, followed by our conclusion in paragraph 8.2. We end with a discussion of our research in paragraph 8.3.

8.1 | Recommendations

From the analysis as described in this report, recommendations are provided for the ambulatory cardiology program of the Mount Sinai Hospital. The recommendations are divided in short term and long term for the processes of an ECG and ECHO. We suggest implementing these changes in the order as shown below. For the ECHO schedule, separate recommendations are made, which should be implemented all at once.

8.1.1 | Short term

1. MSH card to let ECG technicians know a patient is waiting (this change is necessary after the pink requisitions are removed, recommendation 15).
2. Guidelines/scripting for calling non-clinic outpatients to book ECHOs
3. Protocol for receiving clinic schedules
4. Complete patient demographics in ECG machine
5. Protocol for when to call an inpatient in case of a no show
6. Combined ambulatory cardiology reception
7. Reminders for outpatients
8. Rules to be on time
9. Call overnight inpatients ECHO orders first thing in the morning
   Protocol for when to request a porter
11. Doors of ECHO exam room should be closed during investigation
12. Material inventory with Kanban system
13. ER should transfer the ECGs themselves
14. A complete requisition is mandatory for booking an appointment
15. Excel sheet as replacement for pink requisitions
16. Receptionist should use electronic TEE form
    Remove blank papers for Stress ECHOs
18. Mobile phones of sonographers and ECG technicians should be turned off during investigations
19. Final reports are faxed on fixed times during the day
20. Dedicated times slots for inpatients and non-clinic outpatients
21. No more filing of requisitions and final reports
    Every ECHO exam room has the same lay-out
23. Set spots for ECG machines at ER
    Cardiac Care Unit and Labour & Delivery department should create labels with patient demographics
25. A nurse should be available during a bubble test
26. Schedule one sonographer to perform a TEE
27. Prohibit ECGs to be taken home by cardiologists

28. Inpatient ECG orders received on pager/mobile device
29. Amount of clinic time slots should be reconsidered
30. Inpatient ECHO orders should include the isolation status
31. Pre-scheduled room for fellows
32. Sonographers faxing the preliminary report
33. Broken Holter monitor should be fixed
34. One Customer Appointment Manager account for all investigations and staff
35. There needs to be three sonographers every day
36. Pager to notify sonographers an ECHO patient is waiting
37. Teaching the receptionists the 5S model
    Call bell ECHO inpatients along the hallway
39. A computer in every ECHO exam room
40. Full time coverage of reception area
41. E-Requisitions and booking from clinics via own computer

8.1.2 | Long term

1. Only digital requisitions are excepted
2. Reading ECGs digitally by cardiologists
3. Automatic reminders via email to patients
4. Preliminary reports read on the computer by cardiologists
5. Final reports for referring offices are send via email (semi-long term)
6. Fully automated billing process
7. Online booking for inpatients
8. Monitors in ECG technician room
9. Final reports are send automatically
10. Demographics information interfaced with ECHOWeb
11. Monitors in sonographers room
12. Online booking for non-clinic patients

8.1.3 | ECHO schedule

- 17 outpatient ECHOs done per day
- All inpatients done at the same day
- Two outpatient rooms and one inpatient room
- Three sonographers working full time
- Fellows perform mostly inpatient ECHOs
- Different shift times for sonographers
- Clinic blocks redesign
- Rules regarding cancellation of clinics

8.2 | Conclusion

The objective of this research is as follows:

"To review the existing processes associated with both an ECG investigation and a trans-thoracic ECHO investigation, to determine whether and how the processes could be improved in terms of effectiveness and efficiency, while improving the quality and patient experience."

We started with defining the current processes associated with an ECG and ECHO in chapter 3, just like the current ECHO schedule, the customer value and the goals of the ambulatory cardiology program. In chapter 4 we measured the time spend on these processes and determined the number of handoffs necessary for the processes. Together with the demand, waiting times and staffing from chapter 5 we were able to determine all problems at the ambulatory cardiology program.

These problems were categorized based on the eight types of waste. Based on the analysis of these chapters and thinking of the value-added steps within the process, we made suggestions how the processes could be improved. We conclude there is plenty of room to improve the processes at the ambulatory cardiology program. We formulated 41 ways of improvement in the short term and 12 ways of improvement in the long term. Next to that, we formulated an ideal situation.

In order to start improving the processes in terms of effectiveness and efficiency, in the short term the program should start with the following changes:

1. Guidelines/scripting for calling non-clinic outpatients to book ECHOs
2. Protocol for receiving clinic schedules
3. Complete patient demographics in ECG machine at other floors
4. Protocol for when to call an inpatient in case of a no show
5. Combined ambulatory cardiology reception
6. Reminders for outpatients

In the long term, the first changes to implement should be:

1. Only digital requisitions are excepted
2. Reading ECGs digitally by cardiologists
3. Automatic reminders via email to patients
4. Preliminary reports read on the computer by cardiologists
5. Final reports for referring offices are send via email (semi-long term)

The changes to implement in the ECHO schedule should be:

- 17 outpatient ECHOs done per day
- All inpatients done at the same day
- Two outpatient rooms and one inpatient room
- Three sonographers working full time
- Fellows perform mostly inpatient ECHOs
- Different shift times for sonographers
- Clinic blocks redesign

- Rules regarding cancellation of clinics

Fully implementing all recommendations both in the short term as the long term would result in an increase of the time efficiency as shown in table 46 and a decrease in handoffs as shown in table 47. Also the time efficiency and the number of handoffs in the current situation and the ideal state is given.

	ECG				**ECHO**			
	Current	*Short*	*Long*	*Ideal*	*Current*	*Short*	*Long*	*Ideal*
Outpatient	13%	13%	18%	22%	31%	32%	38%	41%
Inpatient	20%	25%	29%	29%	28%	30%	33%	36%
With fellow	NA	NA	NA	NA	19%	19%	23%	24%

Table 46: Time efficiency for the short term, long term and ideal state

	ECG	**ECHO**
Current	15	16
Short term	10	13
Long term	5	8
Ideal state	2	2

Table 47: Number of handoffs in the current, short term, long term and ideal state

8.3 | Discussion

The objective of this research was to review the existing processes associated with both an ECG investigation and ECHO investigation and to make recommendations how to improve the effectiveness and the efficiency, as well as the quality of care and the patient experience. We think we succeeded in this so that we created guidelines how to improve the processes at the ambulatory cardiology program. However, there are some limitations to the results that we discuss in paragraph 8.3.1. To improve the process in the ambulatory cardiology program even more, further research is necessary. This is described in paragraph 8.3.2.

8.3.1 | Research

During the three day value stream event at the beginning of our research we were able to get a lot of information in a very little time. This was a really good start for our research. We learned a lot during those days and were able to meet a lot of staff members and get a good overview of all the different processes and investigations at the ambulatory cardiology department.

A limitation to our research is the number of observations we did. We could have gained more data about the time spend on different tasks and verify if all steps were really performed. Especially the duration of the investigations and waiting times is based on a limited amount of observations. However, every task is quite similar all the time and only exceptions will result in other outcomes. So in our opinion more observations were, also due to a limited time period, not necessary.

Another possible limitation is the fact that the people we observed knew that they were being watched. This can have an impact on their normal working behavior and can result in abnormal behaviour and

unreliable time studies. Although the staff members seemed very open about their work, there is still a major change that they (unknowingly) manipulated the findings.

Finally, our research was conducted during the summer. The summer is the quietest period of the year in the hospital, because a lot of patients postpone their investigations until after the summer. This might result in different observations than during busier periods of the year and can cause that some of the data is not applicable during other seasons. However, because of the quiet period, changes are made much easier and there is more time to talk to the staff members. We also used historical data from the other parts of the year, which decreases the change of unreliable data.

8.3.2 | Further research

To get a clearer picture of the whole process at the ambulatory cardiology program, we suggest that the scope should be broadened. Also the reading of the cardiologists and the other investigations performed at the ambulatory cardiology program (Stress ECHO, Dobutamine, Bubble studie, TEE, Holter, BP and Stress Cardiolite) should be studied. This will result in a better overview of all activities at the department.

Another area that should be studied are the referring doctors. They play a very big role in the whole process, because they are one of the two types of customers we distinguished in paragraph 3.4. They are sending their patients to the MSH. All the changes made to the processes in the ambulatory cardiology program could have a great effect on the referring offices. The changes made to the processes are therefore also dependent on the willingness of referring offices to change their processes as well. Further research is necessary to observe what opportunities there are to improve the flow of information and results between MSH and the referring offices.

There is not a clear inside in the current billing process. More research should be done on the billing process of the whole ambulatory cardiology department. At this moment the billing process is unclear, very inefficient and uses a lot of expensive paper. Even the salaries of the cardiologists contain errors, resulting in unfair paying.

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Appendices

Appendix I – List of definitions

OHIP (card) - Ontario Health Insurance Plan. "Every resident of Ontario must have a health card to show that he or she is entitled to health care services paid for by OHIP." (Ontario Ministry of Health and Long-Term Care, 2013)

MSH card – Mount Sinai Hospital Card. Every patient in MSH has to have a MSH card to receive care.

Outpatient – "A patient who attends a hospital for treatment without staying there overnight." (Oxford Dictionaries, 2014b). At the ambulatory cardiology program outpatients can come in for an ECG, Holter, BP, ECHO and Stress ECHO. These patients come in for this investigation or a clinic related to the investigation and leave the hospital immediately after their investigion or clinic.

Inpatient – "A patient who lives in hospital while under treatment." (Oxford Dictionairies, 2014c). In the ambulatory cardiology program an inpatient can get an ECG, ECHO, Stress ECHO or TEE. ECGs are done in the patient's room. Most inpatient ECHOs are completed in the ECHO department on the 16th floor and occasionally in the patient's room using a portable ECHO machine. Stress ECHOs can only be done in the ECHO department and TEEs are done in either the ECHO department or the Post-Anaesthetic Care Unit.

ECG department – "The ECG department provides the following investigations:

- ECG
- Holter monitoring
- Patient-activated ECG monitoring
- Treadmill stress ECG
- Stress Cardiolite"

ECHO department – "The ECHO department provides the following investigations:

- Trans-thoracic ECHO
- Portable trans-thoracic ECHO
- Trans-esophageal ECHO
- Stress ECHO (treadmill and pharmacological stress)"

Electrocardiogram (ECG) – Recording of the electrical activity of the heart (MedicineNet, 2014a). The investigation uses electrodes attached on the arms, legs and chest of the patient which are connected to an ECG machine that records the impulses generated by each heartbeat. In the ambulatory cardiology program, ECGs for outpatients are done Monday to Friday on a walk-in basis. ECGs for inpatients are done every day of the week.

Holter monitoring (Holter) – This investigation uses a portable ECG machine and measures the electric activity of the heart for 24 hours, 48 hours or 72 hours. By measuring the electric activity for a longer

period of time, the physicians can identify occurrences that would not happen all the time. The patient takes the Holter monitor home and is not required to stay in the hospital.

Blood pressure (BP) – This investigation measures the blood preassure for 24 hours. The patient takes the blood pressure monitor home and is not required to stay in the hospital.

Trans-thoracic ECHO (ECHO) – This investigation is used to make images of the beating heart by using an ultrasound probe. With those images the physician can see how the blood is flowing and how well the heart works. If the ECHO does not give clear images, a contrast liquid is injected in the patient's blood vessels to improve the quality of the pictures. If the physician wants to check for holes and shunts (abnormal connection between body parts that allows fluid to flow from one to the other), the patient can also be injected with gas. This is called a Bubble study. In the ambulatory cardiology program, ECHOs are done Monday to Friday.

Portable trans-thoracic ECHO – This is exactly the same test as the Trans-thoracic ECHO, only this ECHO machine is portable and can be used on inpatients without moving them from their room to the ECHO department.

Stress ECHO – This investigation contains two trans-thoracic ECHOs, one ECHO before the exercise and one directly after the exercise. The exercise can be done in several ways, the patient can walk on a treadmill or use stationary cycling. When the patient is not able to exercise, dobutamine is used to make the heart beat faster and harder. With this investigation the physician can get images of the heart under a curtain amount of stress.

Trans-esophageal ECHO (TEE) – This investigation is almost the same as a trans-thoracic ECHO. The difference is the ultrasound probe the sonographer is using. A TEE uses a probe that is placed in the esophagus (gullet) to get closer to the heart, resulting in clearer pictures (Johns Hopkins Medicine, 2014). This test is used when a trans-thoracic ECHO does not provide enough details.

Dobutamine – Dobutamine is a drug that can be used to generate an increase in the force of the contradiction of the heart, resulting in an increase in the amount of blood pumped by the heart. It imitates a heart during exercising and is used for patients that are not able to walk on a treadmill or bike on a stationary bicycle. The investigation is the same as a Stress ECHO.

STAT – Used if an investigation should happen immediately.

ECHOWeb – The software used to read and comment on ECHOs. Sonographers use it to create a preliminary report and cardiologists to create a final report.

Powerchart – The software application used throughout the entire hospital to store all patient test results.

Customer Appointment Manager – The program used to book appointments for Holters, BPs, ECHOs and Stress ECHOs.

PM Launch – The program used to register all outpatients for the ambulatory cardiology department.

Tracemaster – The software used in the ECG department to edit ECGs.

Appendix II – Detailed steps ECG

Sometimes it is stated that one ECG technician does a step at another time than another ECG technician. Then the step is mentioned twice, including the person who did it at what moment. Sometimes also the department where that step is applicable is mentioned.

Registration by ECG receptionist

1. Patient arrives with requisition from one of the suppliers.
2. Asks the patient for the OHIP card and the MSH card.
   (2b. If the patient does not have a MSH card, the patient should go to admitting on the main floor first to get a MSH card.
   2c. If the patient does have a MSH card, but forgot it, the ECG receptionist seeks for the patient in the system based on the name of the patient.)
3. Checks the validity of the OHIP card.
4. Stamps the MSH card on a blank pink requisition.
5. Fills in the pink requisition: (1) patient type, (2) ECG date & time, (3) ordering doctor (4) type of investigation (= "ECG Tech.").
6. Asks patient to take a seat in the waiting area.
7. Puts the pink requisition on the desk for the technician.
8. Registers the patient in PM Launch:
   (1) Enters MRN and checks if the name matches with the patient;
   (2) Adds encounter by entering: means of arrival, date, time, ordering doctor;
   (3) Submits encounter.

ECG by ECG technician

Outpatient ECG

1. Sees a requisition in the box at the ECG reception desk.
2. Checks if room is clean.
3. If the room is not clean, gets rid of dirty linen.
4. If the room is not clean, puts new linen on the bed.
5. Gets the requisition from the box at the ECG reception desk.
6. *(ECG technician 1) Goes to the ECG exam room.*
7. *(ECG technician 1) Enters the demographics of the patient into the ECG machine.*
8. Gets patient from waiting area.
9. Asks patient to get undressed. If the patient is male, he only has to clear his chest and the ECG technician can stay in the room. If the patient is female, the patient has to put on a gown.
10. If the patient is a female, the ECG technician leaves the ECG exam room.
11. Waits until the patient is ready.
12. Goes back into the ECG exam room.
13. *(ECG technician 2) Enters the demographics of the patient into the ECG machine.*
14. Puts gloves on.
15. Puts electrodes on the body of the patient.
16. Puts wires on the electrodes.

17. Performs the ECG investigation.
18. Removes electrodes and wires from the body of the patient.
19. Takes off used gloves.
20. Prints ECG (automatically a previous ECG, if available, is printed). If the patient goes directly to a clinic, the ECG is printed twice.
21. If the patient goes directly to a clinic, the ECG technician puts the ECG in an envelope.
22. Tells the patient to get dressed and leave the room. If the patient goes directly to a clinic, the technician gives the envelope to the patient.
23. Attaches the requisition to the ECG and possible previous ECG.
24. Puts the documents into the upper basket in the technician room for the cardiologist to read. The upper basket is for outpatients, the middle basket for inpatients and the lower basket for the emergency department only.

Inpatient ECG

1. Gets the order from the printer at the ECG technician room.
2. Checks on the order which floor and room the patient is in.
3. Takes an ECG machine.
4. Goes to the right floor.
5. *(ECG technician 2: Cardiac Care Unit & Labour and Delivery Department) Searches for the OHIP card from the patient who will get an ECG.*
6. *(ECG technician 2: Cardiac Care Unit & Labour and Delivery Department) Stamps the OHIP card on a label.*
7. *(ECG technician 2: Cardiac Care Unit & Labour and Delivery Department) Puts this label in the drawer of the ECG machine.*
8. Goes to the room of the patient.
9. *At pre-admission, takes the pink requisition from the basket at the room.*
10. Checks if the patient is available for doing an ECG. If the patient is not available at that moment, the ECG technician goes to the next patient.
11. *(ECG technician 1) If the patient is ready, the ECG technician enters the demographics of the patient into the ECG machine.*
12. Put gloves on.
13. Walks to the patient.
14. Undresses the chest and legs of the patient.
15. Puts electrodes on the body of the patient.
16. Puts wires on the electrodes. *ECG technician 1 first attaches the wires to the electrodes and then the electrodes to the body of the patient.*
17. *(ECG technician 2) Enters the demographics of the patient into the ECG machine.*
18. *(ECG technician 2) Asks the patient for his/her age.*
19. Performs the ECG investigation.
20. Removes stickers and wires from the body of the patient.
21. Prints ECG.
22. *(ECG technician 1) Takes off used gloves.*
23. Walks outside the room with the ECG machine.

24. *At pre-admission, puts the copy of the ECG in the basket at the room.*
25. *(ECG technician 1) Puts on new gloves.*
26. Gets Virox from the wall next to the door of the room.
27. Cleans ECG machine and wires with Virox.
28. Takes off used gloves.
29. Goes to the reception of the department.
30. Gives the receptionist a copy of the ECG.
31. Goes back to the ECG technician room at the cardiology department.
32. While going back, the ECG technician transfers the data to the system.
33. *(ECG technician 2: CCU & Pregnant Women) While going back, the ECG technician puts the label on a pink requisition.*
34. *(ECG technician 2: CCU & Pregnant Women) Fills in the pink requisition.*
35. Attaches the ECG to the order of the right patient/the pink requisition. If a previous ECG is present (and printed), also the previous report is attached.
36. Puts the documents into the middle basket in the technician room for the cardiologist to read. The upper basket is for outpatients, the middle basket for inpatients and the lower basket for the emergency department only.
37. Goes to a computer in the technician room.
38. Checks off the patient in PowerChart.

Preparation for billing by ECG receptionist

1. Sorts requisitions on date & time.
2. Searches billing number of referring doctor.
3. Writes down the billing number on the requisition.
4. Sorts requisitions in three piles on inpatients, outpatient and emergency (ER).
5. Counts the number of requisitions: counts number of inpatient and number of outpatient/ER.
6. Writes down the counts and the name of the cardiologist who read the ECGs on a sticky note.
7. Stamps the pile of ER requisitions with “241794” and the pile of in- and outpatient with the name of the cardiologist who reads.
8. Bundles all the requisitions together with the sticky note.
9. Writes down the counts in the folder for statistics of the ECG department.
10. Brings the bundle of requisitions to the Finance department by hand.

Entering comments by ECG receptionist

Cardiologists are allowed to comment on ECGs either by dictation or written. The steps the ECG receptionist has to take differ per type of comments. After every step we stated if the step is done for the whole pile of ECGs at the same time, or for only one ECG.

Written

1. Removes paperclips from current and previous ECGs (pile of ECGs).
2. Make three piles: current ECGs with a written B with comments, current ECGs with a written B without comments and previous ECGs (pile of ECGs).
3. Scans the barcode of all the current ECGs with a B without comments (pile of ECGs).

4. Checks if the ECG is outpatient and checks at the same time if every ECG has an age and name on it (pile of ECGs).
5. If the ECG is from an outpatient, the ECG receptionist keeps the printout of the ECG to mail to the referring doctor.
6. Confirms all the scanned ECGs at the same time in the computer (pile of ECGs).
7. Scans the barcode of all the current ECGs with a B with comments (pile of ECGs).
4. Clicks on the ECG to edit (one ECG).
5. Types the dictations written by the reading cardiologist (one ECG).
6. Saves the edited ECG (one ECG).
7. If the ECG is from an outpatient, the ECG receptionist prints the edited ECG to mail to the referring doctor (one ECG).
8. Shred all the old printouts of ECGs (pile of ECGs).

Dictation

1. Removes paperclips from current and previous ECGs (pile of ECGs).
2. Separates previous ECGs from current ECGs (pile of ECGs).
3. Scans the barcode of all the current ECGs (pile of ECGs = 1 minute).
4. Clicks on the right ECG (one ECG).
5. Types the dictations while listening to the dictations from the reading cardiologist (one ECG).
6. Saves the edited ECG (one ECG).
7. If the ECG is from an outpatient, the ECG receptionist prints the edited ECG to mail to the referring doctor (one ECG).
8. Shreds all the old printouts of ECGs (pile of ECGs).

Sorting and mailing read ECGs (and Holters) by ECG receptionist

1. Sorts ECGs (and Holters) per referring doctor.
2. Searches for the address of the referring doctor.
3. a. If the referring doctor is working at MSH, the ECG receptionist writes the name of the referring doctor on an inter-department mail envelope.
   b. If the referring doctor is working outside MSH, the ECG receptionist writes the name and address of the referring doctor on a brown envelope and stamps the envelope.
4. a. If the referring doctor is working outside MSH or on any floor at MSH except from the 16th floor, the ECG receptionist puts the ECGs (and Holters) of one referring doctor in the correct envelope.
   b. If the referring doctor is working on the 16th floor at MSH, the ECG receptionist separates the ECGs (and Holters).
5. Puts the envelopes in the OUT-mailbox and brings the ECGs (and Holters) of a referring doctor on the 16th floor to that doctor personally.

Appendix III – Detailed steps ECHO

Sometimes it is stated that one sonographer does a step at another time than another sonographer. Then the step is mentioned twice, including the person who did it at what moment.

Receiving an order by ECHO receptionist

Before the ECHO receptionist can schedule an appointment for an ECHO or Stress ECHO an order for an investigation needs to be received. It depends on the supplier how the order is submitted. The cardiologists that are working for MSH have their own clinics during the week. To let their patients have an ECHO before they come to the clinic, the cardiologists have reserved timeslots in the ECHO schedule. They can use these spots for their patients. The ECHO receptionist receives these schedules via email and puts them into Customer Appointment Manager. The ECHO receptionist does not have to contact the patient about this.

If a family practice wants their patient to have an investigation they have to send a requisition. The process of receiving a requisition for an outpatient is as follows:

Outpatient order

1. An order comes in via the fax at the ECHO reception.
2. If the ECHO receptionist has time to make an appointment, the ECHO receptionist will call the patient right away. Otherwise, the order will be placed in a folder with outpatients that still need to be booked.

If the patient is an inpatient or comes from the Princess Margaret Hospital (patients from Princess Margaret Hospital are treated as inpatients) the receiving process of an order is as follows:

Inpatient order

1. An order comes in via the fax (a fax is used for inpatient orders only) at the ECHO reception.
2. Takes the order from the fax.
3. Makes a copy of the order.
4. Gets a copy of a billing form from a pile of billing forms.
5. Staples the two orders and the billing form.
6. Puts the bundle of papers in a folder for inpatients.

Booking by ECHO receptionist

If an order for an investigation is placed the ECHO receptionist has to schedule an appointment for the patient. Again, the way of booking depends on whether the patient is an inpatient or outpatient. The steps for both outpatient and inpatient are as follows:

Outpatient ECHO

1. When the ECHO receptionist has time to call the patient for an appointment, the ECHO receptionist dials the patients phone number that is on the order. If the patient answers the phone an appointment is scheduled. If the patient does not answer the phone the ECHO receptionist leaves a voicemail message if possible.

2. If an appointment is made, the ECHO receptionist enters the appointment in the Customer Appointment Manager system.
3. Stores the requisition into the filing cabinet located in the ECHO reception on the date of the appointment. When the appointment is scheduled within two months, the requisitions are sorted by day. When the appointment is scheduled for longer than two months, the requisitions are sorted by month.
4. If the patient did not answer the phone and the ECHO receptionist could leave a message the ECHO receptionist writes on the requisition that the patient has been called and a message is left. If the ECHO receptionist could not leave a message the ECHO receptionist writes on the requisition the date the patient is called and that the patient did not answer the phone.

Inpatient ECHO

1. When there is an empty slot in the schedule the ECHO receptionist wants to fill it up with an inpatient. The inpatients in the folder are ranked by their importance by a patient navigator.
2. Looks for a patient that would fit into the schedule. This decision is made with the knowledge of the receptionist and based on past experience. For example when a patient is needed immediately, the receptionist will search for a patient down the hall at 16 north.
3. When the ECHO receptionist found a potential patient, the ECHO receptionist calls to the department where the patient is staying to ask whether it is possible to do the investigation at the stated time slot.
4. When the patient is able to come to the cardiology department at the stated time slot, the ECHO receptionist asks who is booking a porter. When the patient is not able to come for an ECHO, the process starts again at step 2.
5. If needed, the ECHO receptionist books a porter via the Porter Easy Call system.
6. Places both order forms of the patient with the attached billing form in the folder of the sonographer that will perform the ECHO.

Registration by ECHO receptionist

If an outpatient shows up at the ECHO reception desk, the ECHO receptionist needs to register the patient. Only outpatients are registered. The registration of both ECHO and Stress ECHO are as follows:

Outpatient ECHO

1. Checks if patient is having a normal ECHO or a Stress ECHO, only when the patient did not mention this when arrived. The ECHO receptionist checks this on the schedule or asks the patient.
2. Asks the patient if it is their first ECHO at MSH.
3. Seeks for the requisition on the desk at the ECHO reception.
4. At the same time the ECHO receptionist asks the patient for the OHIP and MSH card.
5. When the ECHO receptionist found the requisition, the ECHO receptionist checks the OHIP card. If the OHIP card is green (the new OHIP card), only showing the card is enough because it remains valid for life. If the patient has an old OHIP card, the ECHO receptionist has to check the date on the card for validity.
6. If there is no requisition, the ECHO receptionist gets a new one.

7. If the patient never had an ECHO before at MSH the ECHO receptionist takes a white folder.
8. Takes the MSH card of the patient and puts it into the stamping machine.
9. Stamps the requisition and when needed the white folder.
10. Gives the MSH card back to the patient and tells the patient to wait in waiting area.
11. If the ECHO receptionist could not find the requisition and stamped a new requisition, the ECHO receptionist fills in the stamped requisition. If the requisition was not filled in completely by the referring doctor or office, the ECHO receptionist will fill in the required fields.
12. If there is no description on the requisition or the requisition tells the sonographer to compare with the previous report, the ECHO receptionist prints the previous report if there is one.
13. If a folder is needed, the ECHO receptionist puts stickers on the folder. The upper sticker contains the last two digits of the year (this sticker is already on the folder). The three stickers on the bottom of the file contain the last three numbers of the MSH number of the patient.
14. When a folder is needed, writes the remaining digits by hand between the upper and the bottom stickers.
15. Puts the requisition and the folder (when needed) in the box of the sonographer that will perform the ECHO.
16. Changes the status of the patient to "completed" in Customer Appointment Manager.
17. Registers the patient in PM Launch.
    (1) Enters MRN and checks if the name matches with the patient;
    (2) Adds encounter by entering: means of arrival, date, time, ordering doctor;
    (3) Submits encounter.

Outpatient Stress ECHO

1. Checks if patient is having a normal ECHO or a Stress ECHO, only when the patient did not mention this when arriving. The ECHO receptionist checks the schedule or asks the patient to do this.
2. Seeks for the requisition on the desk at the ECHO reception.
3. At the same time the ECHO receptionist asks the patient for the OHIP and MSH card.
4. When the ECHO receptionist found the requisition, the ECHO receptionist checks the OHIP card. If the OHIP card is green (the new OHIP card), only showing the card is enough because it remains valid for life. If the patient has an old OHIP card, the ECHO receptionist has to check the date on the card for validity.
5. If there is no requisition, the ECHO receptionist gets a new one.
6. Gets two blank papers, a brown folder, a consent form and a treadmill form.
7. Takes the MSH card of the patient.
8. Puts the MSH card into the stamping machine.
9. Stamps the requisition, two blank papers, a folder, a consent form and a treadmill form.
10. Gives the MSH card back to the patient.
11. Tells patient to wait in waiting area.
12. Fills in the billing form of the ECG.
13. If the ECHO receptionist could not find the requisition and stamped a new requisition, the ECHO receptionist fills in the stamped requisition. If the requisition was not filled in completely by the referring doctor or office, the ECHO receptionist will fill in the required fields.

14. Puts stickers on the folder. The upper sticker contains the last two digits of the year (this sticker is already on the folder). The three stickers on the bottom of the file contain the last three numbers of the MSH number of the patient.
15. Writes the remaining digits by hand between the upper and the bottom stickers.
16. If there is no description on the requisition or the requisition tells the sonographer to compare with the previous report, the ECHO receptionist prints the previous report if there is one.
17. Attaches the stamped requisition, the two stamped blank papers, the stamped folder, the stamped billing form, the stamped consent form and the stamped treadmill form to each other with a paper clip.
18. Puts the bundle of paper on the reception desk.
19. Changes the status of the patient to "completed" in Customer Appointment Manager.
20. Registers the patient in PM Launch.
    (1) Enters MRN and checks if the name matches with the patient;
    (2) Adds encounter by entering: means of arrival, date, time, ordering doctor;
    (3) Submits encounter.

(Stress) ECHO by sonographer (and ECG technician)

Outpatient ECHO

1. Transforming the ECHO exam room from left to right or right to left handed if necessary.
2. Checks if there is a requisition in the technician's own folder at the ECHO reception.
3. *(Sonographer 1) Goes back to ECHO exam room.*
4. *(Sonographer 1) While walking, reads the previous report or the description on the requisition to know why the patient needs an ECHO and where to look for.*
5. *(Sonographer 1) Enters patient demographics into the ECHO machine.*
6. Gets the patient from the waiting area.
7. While walking the sonographer introduces himself/herself to the patient.
8. Asks if patient has had an ECHO before. If yes, the sonographer does not have to explain the investigation. If no, the sonographer explains the investigation.
9. Asks the patient to get undressed and to put a gown on.
10. Closes the curtain.
11. *(Sonographer 2) Reads the previous report or the description on the requisition to know why the patient needs an ECHO and where to look for.*
12. While the patient gets undressed, the sonographer walks to the shared computer in the sonographer room.
13. Sonographer writes initials of the sonographer, name of the patient, MRN of the patient, the ECHO number and referring doctor of the patient in the black book.
14. While the patient gets undressed, fills in the billing form.
15. Puts billing form into a pile of billing forms.
16. Goes back to ECHO exam room.
17. Asks if patient is ready; if not the sonographer has to wait.
18. *(Sonographer 1) Adjust stickers to the patient.*
19. *(Sonographer 2) Enters patient demographics into the ECHO machine.*
20. Asks the height and weight of the patient.

21. Enters height and weight into the ECHO machine.
22. *(Sonographer 2) Adjust stickers to the patient.*
23. Turns the lights off.
24. Puts gloves on.
25. Asks the patient to lay down in the correct way.
26. Performs the ECHO investigation.
27. Gets stickers off the chest of the patient.
28. Gives a towel to the patient, so that the patient is able to clean his/her chest.
29. Turns the lights on.
30. Asks patient to get dressed again.
31. Throws used gloves away.
32. Tells the patient to go.
33. *(Sonographer 1) Cleans probe with dirty linen.*
34. Gets rid of dirty linen.
35. Puts new linen on the bed.
36. Cleans probe with spray.
37. Cleans wires with tissues.
38. Generates the preliminary report by measuring the images taken during the ECHO.
39. Fills in the referring doctor.
40. Prints the preliminary report (once if the patient does not go to a clinic, twice if the patient does go to a clinic)
41. Picks up the preliminary report(s) from the printer in the sonographers room.
42. Attaches the preliminary report to the order and possible previous report.
43. Puts the documents in the box of the reading cardiologist.
44. If the patient goes to a clinic, the sonographer gives one copy of the preliminary report to the ECHO receptionist to fax the report.

- Transmits the images to the system: this sometimes happens directly after doing the measurements and sometimes at the end of the day. It depends if a new patient is already waiting or not.

Inpatient ECHO

1. Transforms the ECHO exam room from left to right or right to left handed if necessary.
2. Checks if there is a requisition in the technician's own folder at the ECHO reception.
3. *(Sonographer 1) Goes back to ECHO exam room.*
4. *(Sonographer 1) While walking, reads the previous report or the description on the requisition to know why the patient needs an ECHO and where to look for.*
5. *(Sonographer 1) Enters patient demographics into the ECHO machine.*
6. Transforms the ECHO exam room to fit a stretcher in the room, if necessary.
7. Gets the patient from the waiting area.
8. If the patient is an inpatient, lies on a stretcher and cannot get out of bed, the sonographer drives the bed inside the ECHO exam room.
9. While walking the sonographer introduces himself/herself to the patient.

10. Asks if patient has had an ECHO before. If yes, the sonographer does not have to explain the investigation. If no, the sonographer explains the investigation.
11. Closes the curtain.
12. The sonographer helps the patient with opening the gown, if necessary.
13. *(Sonographer 2) Reads the previous report or the description on the requisition to know why the patient needs an ECHO and where to look for.*
14. *(Sonographer 1) Adjust stickers to the patient.*
15. *(Sonographer 2) Enters patient demographics into the ECHO machine.*
16. Asks the height and weight of the patient.
17. Enters height and weight into the ECHO machine.
18. *(Sonographer 2) Adjust stickers to the patient.*
19. Turns the lights off.
20. Puts gloves on.
21. Asks the patient to lay down in the correct way.
22. Performs the ECHO investigation.
23. Gets stickers off the chest of the patient.
24. Gives a towel to the patient, so that the patient is able to clean his/her chest.
25. Turns the lights on.
26. The sonographer helps the patient with closing the gown, if necessary.
27. Throws used gloves away.
28. Brings patient back to hallway.
29. Transforming the ECHO exam room back to normal, if necessary.
30. Walks to the shared computer in the sonographer room.
31. Writes initials of the sonographer, name of the patient, MRN of the patient, the ECHO number and referring doctor of the patient in the black book.
32. Fills in the billing form.
33. Puts billing form into a pile of billing forms.
34. Goes back to ECHO exam room
35. *(Sonographer 1) Cleans probe with dirty linen.*
36. Gets rid of dirty linen.
37. Puts new linen on the bed.
38. Cleans probe with spray.
39. Cleans wires with tissues.
40. Generates the preliminary report by measuring the images taken during the ECHO.
41. Fills in the referring doctor.
42. Prints the preliminary report.
43. Picks up the preliminary report(s) from the printer in the sonographers room.
44. Separates one order from the orders and the billing form.
45. Attaches the preliminary report to the separated order and possible previous report.
46. Puts the attached preliminary report to the separated order in the box of the reading cardiologist.
47. Puts the order that is still attached to the billing form in the box for the billing.

- Transmits the images to the system: this sometimes happens directly after doing the measurements and sometimes at the end of the day. It depends if a new patient is already waiting or not.

Stress ECHO

1. ECG technician checks if there is a requisition at the ECHO reception desk.
2. ECG technician walks to the patient in the waiting area.
3. ECG technician tells patient to get undressed in the dressing room. If the patient is male, he only has to clear his chest. If the patient is female, she has to put on a gown as well. If there is still a patient in the Stress ECHO exam room, the ECG technician can ask the patient to sign the consent form after the patient is undressed.
4. While the patient is getting undressed, the ECG technician enters the demographics of the patient into the ECG machine.
5. When the patient is ready, the ECG technician scrubs the skin of the patient.
6. The ECG technician puts the electrode on the skin of the patient.
7. In the meantime, the sonographer enters the demographics of the patient into the ECHO machine.
8. ECG technician asks patient about medication for blood.
9. ECG technician attaches wires to the electrodes with tape.
10. *(One time) Patient reads and signs consent form.*
11. ECG technician asks patient to lie on the bed.
12. ECG technician asks for weight and height
13. ECG technician enters height and weight into the ECG machine.
14. *(One time) ECG technician attaches oxygen meter to the finger of the patient.*
15. *(One time) ECG technician measures oxygen grade.*
16. *(One time) ECG technician writes down the oxygen grade.*
17. *(One time) ECG technician takes off the oxygen meter.*
18. Sonographer performs the first ECHO investigation.
19. In the meantime, the ECG technician enters details into the computer.
20. In the meantime, the ECG technician checks if the next patient is already registered. If the next patient is already there, the ECG technician lets the patient get undressed in another dressing room.
21. Sonographer tells ECG technician that the ECHO is finished.
22. ECG technician asks the patient to step on the treadmill.
23. *(Another time) Patient reads and signs consent form.*
24. ECG technician puts blood pressure meter on.
25. ECG technician measures the blood pressure.
26. ECG technician performs the treadmill ECG.
27. In the meantime, the sonographer writes the diagnoses of the patient in the black book.
28. ECG technician takes blood pressure meter off.
29. ECG technician asks patient to lie on bed immediately.
30. Sonographer performs the second ECHO investigation.
31. In the meantime, ECG technician enters data in the computer.

32. *(Another time) ECG technician attaches oxygen meter to the finger of the patient.*
33. *(Another time) ECG technician measures oxygen grade.*
34. *(Another time) ECG technician writes down the oxygen grade.*
35. *(Another time) ECG technician takes off the oxygen meter.*
36. ECG technician puts blood pressure meter on.
37. ECG technician measures the blood pressure.
38. ECG technician takes blood pressure meter off.
39. ECG technician removes stickers and wires from the patient (When sonographer finishes ECHO investigation).
40. *(One time) Sonographer gives patient a clean towel to clean the chest of the patient.*
41. Tells patient to get dressed and leave the dressing room.
42. ECG technician removes dirty linen.
43. ECG technician puts new linen on the bed.
44. ECG technician cleans hands.
45. ECG technician puts gloves on.
46. ECG technician cleans treadmill and ECG machine with Virox.
47. ECG technician cleans blood pressure meter with alcohol.
48. ECG technician takes used gloves off.
49. ECG technician generates report.
50. ECG technician prints report.
51. ECG technician attaches all the documents to each other.
52. ECG technician puts the documents in the box for the cardiologist to read.
53. ECG technician fills in the billing form.
54. Sonographer generates measurements.
55. Sonographer writes down his/her findings in the black book.

Faxing the preliminary report by ECHO receptionist

1. Sonographer gives preliminary report to ECHO receptionist.
2. Puts the preliminary report in the faxing machine.
3. Types fax number into the faxing machine.
4. Faxes preliminary report.
5. Throws the preliminary report away.

Faxing the final report by ECHO receptionist

If the ECHO is read by the physician and the final report is typed, the final report needs to be faxed to the referring office or doctor. This happens for both inpatients and outpatients in the same way. The final reports attached to the requisition are placed in a basket in the ECHO reading room.

1. Goes to the reading room of the cardiologists to get all the final reports attached to the requisition and the preliminary report with a paper clip. Most of the time the final reports are combined with the requisition and preliminary reports that belongs to the same person. If the papers are not sorted, the final reports and requisitions are mixed up.
2. If there are any final reports the ECHO receptionist takes them to the receptionist desk.

3. If needed the ECHO receptionist combines the final reports with the right requisitions.
4. Sorts all combined final reports, requisitions and preliminary reports per referring office or doctor. When there are more final reports that have to go to one referring office or doctor, the ECHO receptionist can fax them all at the same time. This means the receptionist only has to enter the fax number once.
5. Separates all the final reports, requisitions and preliminary reports by referring office or doctor.
6. Puts the final reports in the faxing machine.
7. Puts the requisition on a desk.
8. Throws the preliminary report away.
9. Types fax number into the faxing machine. When the ECHO receptionist does not know the fax number of the referring office or doctor by heart, the receptionist has to search for the number in a book.
10. Faxes report.
11. Takes the final report out of the fax machine.
12. Attaches the final report to the requisition and places them on a pile. If there was also a folder attached to the final report, the documents are placed in the folder.

Filing by ECHO receptionist

Both the final report and the requisition are filed in a filling room. The ECHOs and Stress ECHOs are filed separately, but in the same room.

1. Takes the pile of final reports attached to the requisitions and the folders to the filing room.
2. Placed the pile of final reports on a car.
3. When the final report is not in a new folder, the ECHO receptionist checks the second to last digit of the MRN of the patient. All the files are first sorted on the second to last digit, then on the last digit and then on the third to last digit.
4. Walks to the right filing cabinet and searches for the last digit.
5. Searches for the right folder. If the documents are placed in a new folder, the ECHO receptionist places the folder on the right spot in the filing cabinet.
6. If the documents are not in a new folder, the documents are placed in the folder of the corresponding patient on top of the previous documents.

Appendix IV – Direct time studies

ECG registration

No.	Component Task	1	2	3	4	5	6	7	8	9	10	11	12	Average (seconds)
1	Admin asks for OHIP/MSH	55	15	10	24	31	30	16	20	15	30	20	20	
2	Admin checks validity		30									21		
3	Admin stamps MSH card								10	10			5	
4	Admin asks Pt to wait			15			25	39	22	25	27	15	21	
5	Admin fills in Pink Req													
6	Admin puts Pink Req on desk													
7	Admin registers Pt in Amb. Reg.	95	30	20	22	26	28	18	20	30	25	21	20	
Time for 1 cycle		150	75	45	46	57	83	73	72	80	82	77	66	75,5

Outpatient ECG investigation

No.	Component Task	1	2	3	4	5	6	7	8	Average (minutes)
1	Sees a requisition	2	0	1	1,5	1	1	1	1	
2	Checks if room is clean									
3	Gets rid of dirty linnen, if necessary									
4	Puts new linen on the bed, if necessary									
5	Gets requisition		3							
6	*(ECG technician 1)* Goes to ECG exam room		0	NA	NA	NA	NA	NA	NA	
7	(ECG technician 1)			NA	NA	NA	NA	NA	NA	

	Enters demographics of patient into the ECG machine									
8	Gets patient from waiting area		^	^	^	^	^	^		
9	Asks patient to get undressed	3	^	3	3,5	2	3	4	3	
10	Leaves ECG exam room, if necessary									
11	Waits until patient is ready									
12	Goes back into ECG exam room									
13	*(ECG technician 2)* Goes to ECG exam room	NA	NA							
14	*(ECG technician 2)* Enters demographics of patient into the ECG machine	NA	NA							
15	Puts gloves on	0,33	0							
16	Puts electrodes on the body of the patient	1,67	1							
17	Puts wires on the electrodes		0,33							
18	Performs the ECG investigation	0,35	0,67							
19	Removes electrodes and wires	1,25	1							
20	Takes off used gloves		0							
21	Prints ECG		^	1	1	2	1	1	1	
22	Puts ECG in an envelope, if necessary									
23	Tells patient to leave the ECG exam room									
24	Attaches requisition to ECG and possible previous ECG									

25	Puts documents into basket for cardiologist to read									
Time for 1 Cycle		8,6	6	5	6	5	5	6	5	5,825

Inpatient ECG investigation

No.	Component Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Average (minutes)
1	Gets the order from the printer		0	0	0														
2	Checks which floor and room the patient is in		0	0	0	6		NA						NA			10		
3	Takes an ECG machine		0	0	0														
4	Goes to the right floor		0	0	3			2											
5	*(ECG technician 2: CCU & Pregnant Women) Searches for the OHIP card*	3	NA	NA	NA	NA	NA		NA	NA	NA	NA	NA		NA	2		4	
6	*(ECG technician 2: CCU & Pregnant Women) Stamps the OHIP card on a label*		NA	NA	NA	NA		4						6			NA		
7	*ECG technician 2: CCU & Pregnant Women) Puts this label in the drawer of ECG machine*		NA	NA	NA	NA													
8	Goes to the room of the patient		1,33	0,83	^	^	0,1	0,1	0,1	2	0,1	0,5	1		1		^		

9	*At pre-admission, takes the pink requisition from the basket at the room*		NA	NA	NA	0,15	1	NA	NA	NA	NA	NA	NA	NA	NA	NA			
10	Checks if the patient is available for doing an ECG		^	^	^														
11	*(ECG technician 1 + 3) Enters the demographics of the patient into the ECG machine*		0,5	2,02	1,33						2								
12	Put gloves on		^		0,97			1											
13	Walks to patient		^				1												
14	Undresses chest and legs		^	0,17	6,5	6												4	
15	Put electrodes on the body of the patient		1,83	1,97					7	5		4	4	3	4	6	3		
16	Puts wires on the electrodes																		
17	*(ECG technician 2) Enters the demographics of the patient into the ECG machine*		NA	NA			^	1			3								
18	*(ECG technician 2) Asks patient for his/her age*		NA	NA															
19	Performs the ECG investigation		1,08	0,2			4												
20	Removes stickers and	0,83	1,12	0,5															

	wires																		
21	Prints ECG			0,3															
22	*(ECG technician 1) Takes off used gloves*	0,17	1,23																
23	Walks outside the room																		
24	*At pre-admission, puts the copy of the ECG in the basket at the room*	NA	NA	NA	NA			NA	NA	NA	NA	NA	NA	NA	NA	NA		NA	
25	*(ECG technician 1) Puts on new gloves*	0,5																	
26	Gets Virox from the wall next to the door of the room		1,17	0,53					1		3	2	1	1	1	^		^	
27	Cleans ECG machine and wires	1			^			NA		NA							2		
28	Takes off used gloves																		
29	Goes to reception of the department																		
30	Gives the receptionist a copy of the ECG			0,75			2				NA	NA	3	NA	2	1		1	
31	Goes back to the ECG technician room and transfers the data to the system	NA	NA	NA	4	NA	NA	NA	NA	NA	NA	NA	NA	NA	4	3	5	4	
32	*(ECG*				0														

	technician 2: CCU & Pregnant Women) While going back, the ECG technician puts label on a pink requisition																		
33	*ECG technician 2: CCU & Pregnant Women) Fills in pink requisition*				0														
34	Attaches the ECG to the order and possible previous report				NA														
35	Puts the documents in the basket for the cardiologist to read																		
36	Goes to a computer														NA	NA	NA	0,15	
37	Checks off patient in PowerChart																		
Time for 1 Cycle		5,5	8,3	7,3	15,8	12,2	8,1	8,1	8,1	7,0	8,1	6,5	9,0	10,0	12,0	12,0	20,0	13,2	10,1

ECHO registration

No.	Component Task	1	2	3	4	5	6	7	8	9	10	Average (seconds)
1	Patient arrives	10	3	15	5	10	15	11	13	8	12	14,7
2	Asks if the patient had an ECHO before											
3	Seeks for requisition or get a new one			5								
4	Asks patient for OHIP and MSH card											
5	Checks OHIP card				4							
6	MSH card into the stamping machine											
7	MSH card into the stamping machine											
8	Stamps requisition	5	4			3	4	5	6	4	5	
9	Gives back MSH card and tells patient to wait											
10	*Fills in the new requisition	0	0	0	65	45	33	15	0	0	41	19,9
11	*Checks and prints previous report	0	0	0	0	37	45	41	0	0	0	12,3
12	*Stickers file	0	12	0	0	0	0	0	14	0	0	2,6
13	*Writes remaining digits	0	4	0	0	0	0	0	5	0	0	0,9
14	Puts the requisition in the technicians box	1	1	2	3	4	2	4	2	1	2	2,2
15	Changes the status of patient to "Completed"	2	3	4	2	2	3	2	4	3	2	2,7
16	Register patient in PM Launch	45	24	36	32	40	38	42	29	35	30	35,1
Time for 1 Cycle		63	51	62	111	141	140	120	73	51	92	90,4

Stress ECHO registration

No.	Component Task	1	2	3	4	5	6	7	8	9	10	Average (seconds)
1	Patient arrives	7	3	8	50	12	10	9	45	3	4	15,1
2	Checks which test the patient is having											
3	Seeks for requisition											
4	Asks patient for OHIP and MSH card											
5	Checks OHIP card											
6	Gets a new requisition if needed, blank papers, folder, consent, treadmill	16	10	11	10	12	12	13	15	13	12	12,4
7	MSH card into the stamping machine	16	19	15	17	21	20	16	14	16	18	17,2
8	Stamps req, blank papers, folder, consent, treadmill											
9	Gives back MSH card and tells patient to wait											
10	Fills in the billing form ECG	8	10	11	7	9	7	9	8	10	12	9,1
11	*Fills in the new requisition if needed	0	0	0	0	0	0	0	0	0	0	0
12	Stickers file	6	15	12	13	9	17	8	15	13	6	11,4
13	Writes remaining digits	5	4	5	6	6	4	5	4	4	5	4,8
11	*Checks and prints previous report	0	0	0	0	35	0	0	0	0	0	3,5
14	Attaches all documents and puts file on the ECHO administration desk	2	2	3	2	3	2	2	2	3	2	2,3
15	Changes the status of patient to "Completed"	3	2	2	3	2	2	4	1	3	2	2,4
16	Register patient in PM Launch	31	28	38	35	26	41	31	29	37	38	33,4
Time for 1 Cycle		94	93	105	143	135	115	97	133	102	99	111,6

Outpatient ECHO investigation

No.	Component Task	1	2	3	4	5	Average (minutes)
1	Transforming the ECHO exam room, if necessary	?	0	0	0	0	
2	Checks for new requisition	5	2	?	2	1	
3	*(Sonographer 1)* Goes back to ECHO room and reads description or previous report			NA	NA	NA	
4	*(Sonographer 1)* Enters demographics into ECHO machine		1	NA	NA	NA	
5	Walks to the patient		3	?	^	^	
6	Walks with patient to ECHO exam room and introduces to the patient						
7	Explains the investigation, if necessary		0				
8	Asks patient to get undressed		1				
9	Closes curtain						
10	*(Sonographer 2)*Reads description or previous report	NA	NA		2	1	
11	Walks to the shared computer in sonographer room	3	2				
12	Writes in black book						
13	Fills in the billing form						
14	Puts billing form into a pile of billing forms						
15	Goes back to ECHO exam room						
16	Waits for patient to get undressed	2	0				
17	*(Sonographer 1) Adjust stickers*		1				

	to the patient						
18	*(Sonographer 2) Enters patient demographics into the ECHO machine*						
19	Asks height and weight of patient				3	2	
20	Enters height and weight into the ECHO machine			1			
21	*(Sonographer 2)* Adjust stickers tot the patient						
22	Turns the lights off				2	1	
23	Puts gloves on			1			
24	Asks patient to lie down in the correct way						
25	Performs ECHO investigation	19	13	14	21	18	
26	Gets stickers off the chest of patient						
27	Gives a towel to the patient						
28	Turns the lights on	1	2	2	2	3	
29	Waits for patient to get dressed						
30	Throws used gloves away						
31	Tells patient to go						
32	*(Sonographer 1) Cleans probe with dirty linen*			NA	NA	NA	
33	Gets rid of dirty linen						
34	Puts new linen on the bed	2	1	1	1	3	
35	Cleans probe with spray						

36	Cleans wires with tissues						
37	Generates preliminary report	9	12	14	12	8	
38	Fills in the referring doctor						
39	Prints the preliminary report	2	4	4	4	2	
40	Gets preliminary report(s) from printer						
41	Attaches preliminary report to order and possible previous report						
42	Puts documents in box of reading cardiologist						
43	Gives preliminary report to the ECHO receptionist, if necessary		0				
Time for 1 Cycle		43	42	37	49	39	42

Inpatient ECHO investigation

No.	Component Task	1	2	3	4	Average (minutes)
1	Transforming the ECHO exam room, if necessary	0	2	0	0	
2	Checks for new requisition	2	2	2	2	
3	*(Sonographer 1)* Goes back to ECHO room and reads description or previous report					
4	*(Sonographer 1)* Enters demographics into ECHO machine	1	1			
5	Transforming the ECHO exam room to fit in a stretcher, if necessary	4	2			
6	Walks to the patient					
7	Walks with patient to ECHO exam					

	room and introduces to the patient					
8	Explains the investigation, if necessary	1				
9	Closes curtain	2				
10	Helps patient with opening the gown, if necessary					
11	*(Sonographer 2)*Reads description or previous report	NA	NA			
12	*(Sonographer 1) Puts stickers on the patient*	2	2	NA	NA	
13	*(Sonographer 2) Enters patient demographics into the ECHO machine*	NA	NA	4	2	
14	Asks height and weight of patient	^	^			
15	Enters height and weight into the ECHO machine					
16	*(Sonographer 2) Puts stickers on the patient*	NA	NA		1	
17	Turns the lights off	^	^			
18	Puts gloves on					
19	Asks patient to lie down in the correct way					
20	Performs ECHO investigation	20	12	14	42	
21	Gets stickers off the chest of patient	1	2	2	4	
22	Gives a towel to the patient					
23	Turns the lights on					
24	Helps patient with closing the gown, if necessary					
25	Throws used gloves away					

26	Brings patient back to hallway	3				
27	Transforming the ECHO exam room back to normal, if necessary	1	0	0	0	
28	Walks to the shared computer in sonographer room	4	2	2	8	
29	Writes in black book					
30	Fills in the billing form					
31	Puts billing form into a pile of billing forms					
32	Goes back to ECHO exam room					
33	*(Sonographer 1) Cleans probe with dirty linen*	1	1	3	2	
34	Gets rid of dirty linen					
35	Puts new linen on the bed					
36	*(Sonographer 2) Cleans probe with spray*					
37	Cleans wires with tissues					
38	Generates preliminary report	12	10	11	10	
39	Fills in the referring doctor					
40	Prints the preliminary report	1	1	1	1	
41	Gets preliminary report(s) from printer					
42	Attaches preliminary report to order and possible previous report					
43	Puts documents in box of reading cardiologist					
Time for 1 Cycle		55	37	39	72	43,67

Stress ECHO investigation

No.	Component Task (ECG technician)	Component Task (Sonographer)	1 (ECG technician)	1 (Sonographer)	2 (ECG technician)	2 (Sonographer)	3 (ECG technician)	3 (Sonographer)	Average (minutes)
1	Checks for requisition		1	-	?	-	4	-	
2	Walks to patient								
3	Tells patient to get undressed *and signs consent form*		2						
4	Enters demographics into the ECG machine	Sonographer enters demograpics into ECHO machine		1	3	1	˅*	2	
5	Scrubs skin of patient		1	-	?	-	3	-	
5	Puts electrodes on the body of the patient								
6	Asks patient about medication for blood		1				1		
7	Attaches wires to the electrodes with tape		2				^		
8	*Patient reads and signs consent form*				0		NA		
9	Asks patient to lie on the bed		2		^		2*	˅	
10	Asks for weight and height							-	
11	Enters height and weight into the ECG machine								

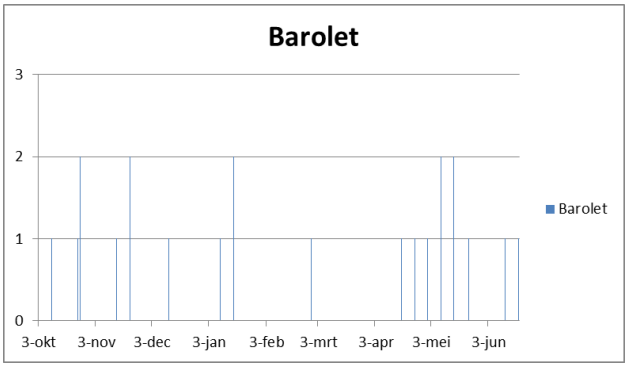
12	Attaches oxygen meter to the finger of the patient		0		2		1	11	
13	Measures oxygen grade								
14	Writes down the oxygen grade								
15	Takes off the oxygen meter								
16	Enters details into the computer	Performs the ECHO investigation	^	10		10			
17	Checks if next patient is already registered		10		5		10		
18	Sonographer tells ECG technician that the ECHO is finished		2		0		-		
19	Asks patient to step on the treadmill		^	-	^	-	2	-	
20	*Patient reads and signs consent form*		0		0				
21	Puts blood pressure meter on		1	-	1	-			
22	Measures blood pressure								
23	Performs the treadmill ECG	Writes diagnoses of the patient in black book	10	2	14	2	10	2	
24	Takes blood pressure meter off			-	1	-		-	
25	Asks patient to lie on bed immediately								
26	Enters data into the	Performs second ECHO	2	3		2	1	2	

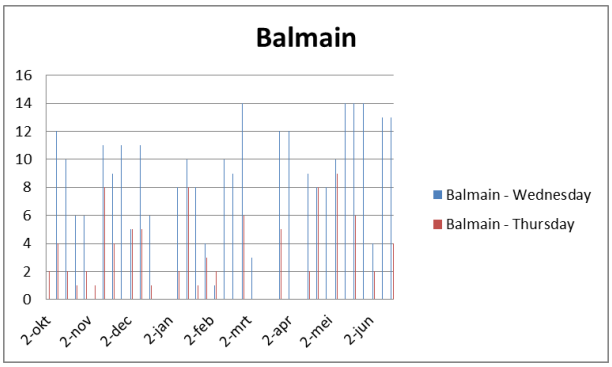
	computer	investigation						
27	Attaches oxygen meter to the finger of the patient							
28	Measures oxygen grade				1			
29	Writes down the oxygen grade							
30	Takes off the oxygen meter			-		-	-	
31	Puts blood pressure meter on							
32	Measures the blood pressure		1		1			
33	Takes blood pressure meter off							
34	Removes stickers and wires from the patient				1			
35	*Tells patient towels are on the bed in the change room*				1		1	
36	Tells patient to get dressed and leave the dressing room		2					
37	Removes dirty linen			13		16		14
38	Puts new linen on the bed						0,5	
38	Cleans hands	Picking images			1			
39	Puts gloves on	Writes down his/her findings in the black book	1				2	
40	Cleans treadmill and ECG machine							

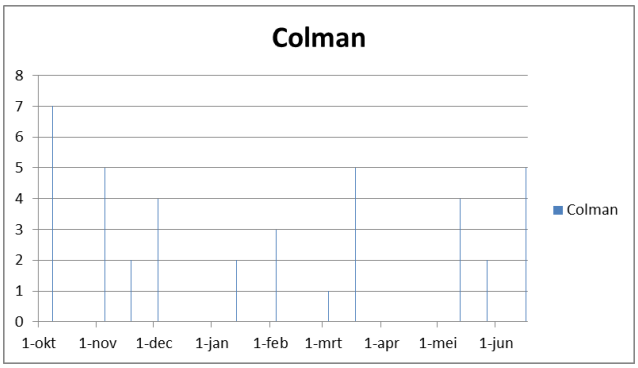
	with Virox								
41	Cleans blood pressure meter with alcohol								
42	Takes used gloves off		2						
43	Generates report		3						
43	Prints report								
43	Attaches all documents		1		2		1		
43	Puts documents in the box for the cardiologist to read								
43	Fills in the billing form								
Time for 1 Cycle			48	29	44	31	46	31	46

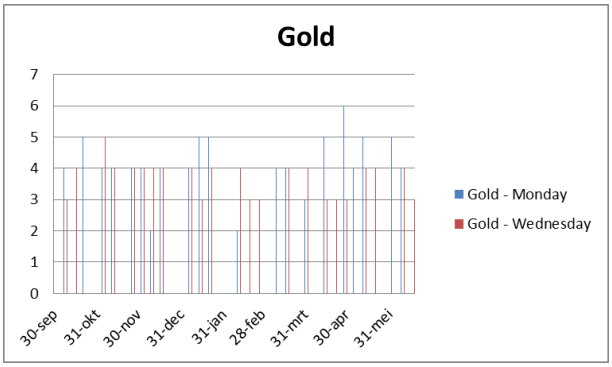
Appendix V – Actual used time slots per cardiologist

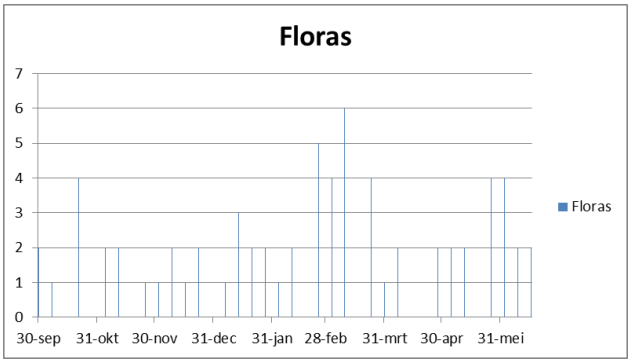
Over the period from September 30, 2013 until June 22, 2014

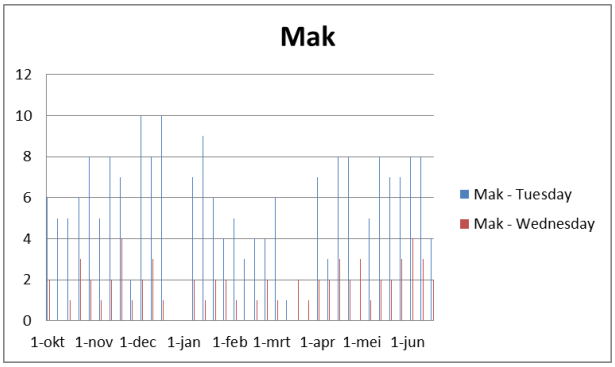


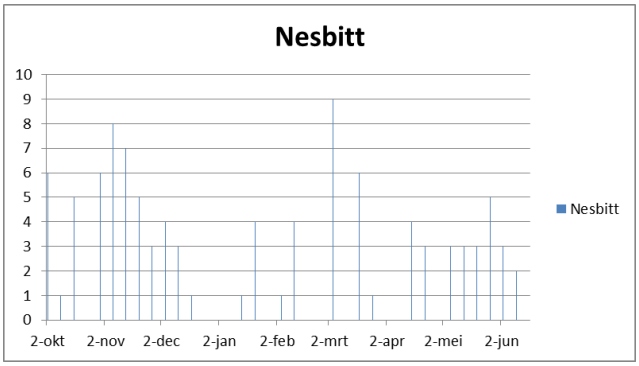








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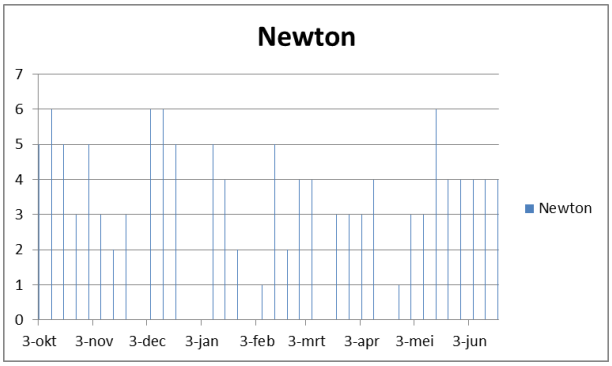
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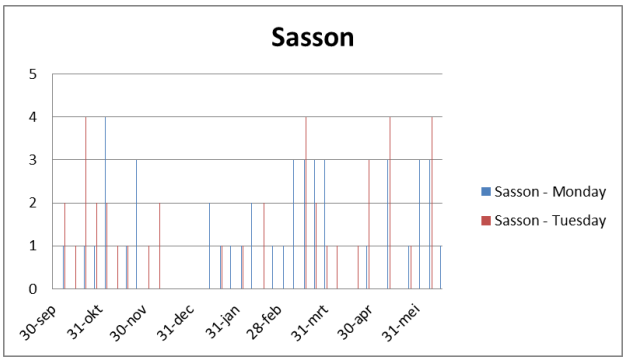
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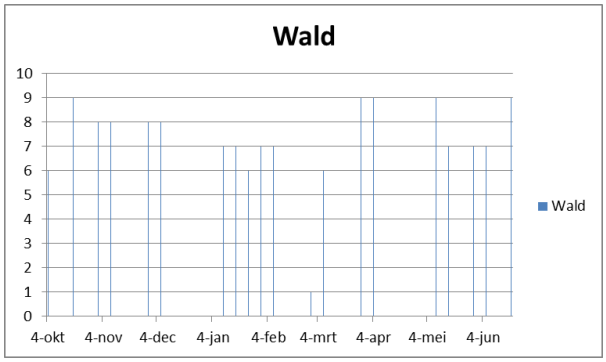
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Appendix VI – Customer value and goals per improvement

	Quality of care	Timely appointments and results for patients	Waiting time upon arrival	Confidentiality	Accuracy of information/result	Clean and comfortable environment	Movement	Achieve the 2014/2015 volume targets	Increased utilization of resources	Cost savings	Reduced paper
Short term											
A		X						X	X		
B		X							X		
C		X						X	X		
D			X						X		
E		X						X	X		
F		X									
G		X						X	X		
H		X					X			X	
I			X								
J		X							X		
K					X					X	X
L		X						X	X	X	
M		X									
N	X										
O											X
P											X
Q										X	
R					X					X	X
S					X						X
T		X	X						X		
U		X	X								
V	X		X								
W			X			X					
X								X	X		
Y			X								
Z			X								X
AA		X									
BB		X									
CC		X								X	
DD			X								

EE		X			X					X	
FF	X		X								
GG		X									X
HH	X	X	X			X					
II			X								X
JJ			X						X		
KK	X										
LL			X								
MM	X		X								
NN	X		X								
OO				X							
Long term											
A		X						X	X		
B		X									X
C		X									X
D					X					X	X
E			X								X
F		X									X
G		X									X
H			X		X						
I	X		X	X							X
J			X								
K			X								
L				X	X						X