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LEAN METHODS AND DIGITAL TECHNOLOGIES IN HEALTHCARE

Supervisor: Janne Huiskonen

ABSTRACT

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Lean Methods and Digital Technologies in Healthcare

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106 Pages, 17 figures, 8 tables, 6 appendices

Supervisor: Professor Janne Huiskonen

Key words: healthcare processes, service businesses, lean management, lean tools, digital technologies, elimination of waste, industrialization of services, telehealth.

This thesis concerns two different approaches – lean management and use of digital technologies – to address healthcare challenges. The purpose of the research is to make an assumption which of the methods may resolve appearing challenges, such as high costs of care, relatively low quality, focus on the customer or communication, and if a combination of both can bring positive outcomes.

The experiences of several healthcare organizations were considered to distinguish the most frequently used lean tools, the success and failure factors, and the obstacles that may appear while implementing lean. As a result, two approaches to "go lean" were defined, and analyzed from the prospective of the applicability to healthcare processes. Industrialization of healthcare was studied, and the most promising digital technology tools to improve healthcare process were highlighted.

Finally, the analysis of healthcare challenges and feasible ways to address them was conducted and presented as the main result of this work. The possible ways of implementation of the findings and limitations were described in the conclusion.

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Bigaeva Aleksandra

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LIST OF SYMBOLS AND ABBREVATIONS

CT – Cycle Time

ED – Emergency Department

EHR – Electronic Healthcare Records

HRI – Healthcare Research Institute

LOS – Length of Stay

NVA – Non Value Added Activities

OR – Operation Room

PACU – Post Anesthesia Care Unit

SPM – Service Process Matrix

TBE – Task Based Education

TPS – Toyota Production System

TT – Takt Time

VA – Value Added Activities

VMMC – Virginia Mason Medical Center

VMPS – Virginia Mason Production System

VSM – Value Stream Mapping

1. INTRODUCTION

1.1 Background

Due to the increasing cost of medical care, the rising demand for high quality and prompt services, healthcare organizations around the world are under a strong pressure to improve. Society is aging, which causes an extra demand for healthcare services. However, the financial conditions for healthcare organizations are not improving but even worsening, along with a rising competition. (Poksinska, 2010, p.3). In these days healthcare providers are challenged to be as affordable, accessible, safe and efficient as possible.

Today customers of healthcare organizations seek out treatment and provider options and they choose the ones that offer the most value. Quality information is getting available and understandable. Therefore, healthcare organizations are struggling to meet an increasing competitive pressure by using process improvement techniques. They have to offer customer value, yielding high quality and a high service at low cost.

Many of healthcare organizations consider lean as a tool that can improve their position and performance. One of the factors that push them to consider this approach is the opportunity to eliminate waste, and, thus costs, and to enhance performance. Lean approach seeks improvements within the framework of an already existing organization structure. It can provide healthcare organizations with an alternative methodology for achieving better results without high investments. It can bring the benefits as a faster respond time, higher quality and creativity, lower costs, reduce drudgery and frustration and even bring employees greater job satisfaction (Staats et al. 2011, p.2). Lean thinking is about working more efficiently and faster while minimizing waste. Originally, this methodology has expanded from the shop floor techniques to all manufacturing functions through involving the whole organization (Kollberg et al. 2006, p.16). However, though several decades it has spread significantly and, today it has been considered as a solution to address challenges in service organizations.

The sustainable way for healthcare organization to succeed, according to the appearing issues mentioned above, is to reduce costs, in other words to provide the best services in as little space as possible, with the least amount of inventory, with the fewest number of people, and the least number of errors (Protzman et al. 2011, p.34). A capability to delight the customers

with the lowest cost will guarantee the companies survival in the upcoming decade of increased global competition. Achieving success in reducing costs and setting predictable delivery systems in place that can meet or even exceed customer expectations provides healthcare organization with an opportunity to grow their businesses.

In addition, industrialization of the services, and healthcare particularly, takes place in the modern world. Digital technologies affect services businesses at all levels, they are ubiquitous and social. Thus, it is drastically important to consider various digital technologies, such as Internet-based solutions, informatics methods and the opportunities they provides to analyze data, simplify search and storing of records, in the frames of healthcare processes, and how these technologies may be used to improve the performance of healthcare companies.

This work studies how healthcare challenges may be resolved with the two mentioned approaches – lean methodology and digital technologies, in order to increase patients and staff's satisfaction and work efficiency.

1.2 Problem statement and research methods

The goal of this work is to analyze possible way to address healthcare challenges with lean tools and digital technologies, or combination of both. Current healthcare issues should be analyzed and classified, lean tools may be considered from the healthcare perspectives and application of digital technologies to healthcare environment should be described. To achieve this goal it is necessary to solve the following tasks:

- Define which types of services are there in healthcare, and classify them;
- Identify main current challenges in healthcare;
- Distinguish Lean tools that may be applicable to healthcare process;
- Explore and compare practices of Lean implementation in healthcare organizations and define "success factors";
- Identify how industrialization of services influence service sector, and especially healthcare;
- Pinpoint which digital tools and upcoming trends may be applicable to improve healthcare process;
- Analyze the possibility of using studied tools and methods for addressing healthcare challenges.

Basically, by the end of the study the viable solutions for present healthcare challenges will be defined, and, it will be shown, which of the two considered methods - either lean, or digital technologies, may be used to resolve the issues, or, if combination of both appears to be feasible and bring even better results.

Thus, the research questions for this work are:

1. *In which types of healthcare processes lean methods (and which particular tools) can work best?*
2. *How can healthcare processes be improved by digital technologies? Can Lean approach and digital technologies be elaborated together in order to provide excellence performance in healthcare processes?*

The research methods of this study consist of literature review and case study. The data for literature review was gathered from the textbooks and articles of the field, with the usage of various databases, libraries, theses and online resources. Search was principally done by using the following terms: "service typologies", "lean in service sector", "lean tools", "lean in healthcare", "industrialization of services", "digital technologies" and etc. The textbooks provide basic and profound principles of the field, solid information about the fundamental concepts of the study. The articles bring more specific and updated information on the field. Various theses and researches describe the background of the field and show what has already been studied about this topic. The information from the interview and proceedings from the conferences proposes ongoing and upcoming trends in the field and latest concepts, which can be used to forecast the potential of the work.

Case study part was conducted by using the open for public information from the big healthcare companies that have been already successfully implementing lean for over years. Experiences of several different companies were studied and analyzed in order to conclude which tools and methods are more suitable in healthcare, what are the success factors and main obstacles of lean implementation.

The purpose of the study was to elaborate the recommendations for addressing healthcare challenges either with use of lean tools or digital technologies, or even with combination of both of these.

1.3 Organization of the study

This thesis consists of seven chapters.

The first part of this thesis has introduction character and presents the background of the study, the research goal and methodology of the work.

The second chapter provides an overview on service typologies, which place healthcare services take there, which challenges managers do face, and why lean approach can be suitable in optimizing healthcare processes

In **the third chapter** basic lean concepts, tools and challenges for service industry are introduced. Lean methodology is considered from the perspective of healthcare environment.

Several cases of the world leading healthcare organizations which have been successfully implementing lean, are considered in **the forth chapter**. As a result of the conducted comparison, two different approaches to apply lean to healthcare organizations were distinguished.

The influence of industrialization of services and use of digital services in healthcare sphere are described in **the fifth chapter** of the work. Thus, current and even future digital trends were highlighted and considered as possible solutions to address healthcare challenges.

Chapter six presents the overall results that have been achieved in this study. It answers the research questions and in which kind of process in healthcare lean tools can work best of all, which process can be improved by the use of the digital technologies and how these two approaches (lean and digital) can be elaborated together in order to provide an excellence performance.

The last **sevenths chapter** summarized all that have been done in this work.

2. HEALTHCARE AS A SERVICE

Healthcare is a very sophisticated system, which is relatively hard to describe and determine. Healthcare organizations are the ones that are established to meet the health need of target populations. *The future of healthcare businesses is the future of the overall economy as the dominant share of services is conventionally defined.*

According to the definition of the World Health Organizations (WHO), a well-functioning healthcare system requires a robust financing mechanism, a well trained and adequately paid workforce, reliable information for decision-making processes, well-maintained health facilities, logistics to deliver quality medicines and technologies.

Healthcare system consists of hospital activities, medical and dental practices and a complex group of other human health activities under the supervision of nurses, midwives, physiotherapists, scientific or diagnostic laboratories, pathology clinics, and various allied health professionals. The variety of different types of services in healthcare is enormous – from oncology up to general practice, mental and physical care, hospital and home health services, and etc. Moreover, the distinctive characteristic of majority of healthcare processes is the huge role of human labor, which makes it harder to specify and systematize these types of processes.

The purpose of this work is to develop recommendations in which particular groups (types) of healthcare processes it can be suitable to use lean tools, in which – digital technologies, and, finally, which processes can be improved with both of these approaches.

Thus, in order to propose the best way of optimization service processes in healthcare, it is essential to structure them. Nowadays, there are plenty of various theories that try to systemize service businesses in different groups, and for this work Schmenner Matrix was chosen as a basic framework.

2.1 Service typologies

To start with, it might be said that services are considered as extremely heterogeneous and often intangible processes, which most often involve and depend on specialized human labor. In fact, specific challenges and best practices of managing so-called "knowledge-intensive services" have received increasing interest (Ritala et al. 2014, p.38). Over the last decades the service sector has shown a significant increase in importance, and it has become the dominant driver of economic growth in many economies over the last decades (Ritala et al. 2014, p.37).

Considering service businesses typology, it is vital to understand that the degree of the contact with the customer plays an important role. Thus, the less direct contact the customer has with the service system, the greater the potential of the system to operate at peak efficiency (Maglio et al. 2010, p.11). And, in an opposite way, where the direct customer contact is high, the less potential exists to achieve high levels of efficiency. As a result, it follows that *service systems with high customer contact are more difficult to control and more difficult to rationalize than those with low customer contact*. In high-contact systems, the customer can affect the time of demand, the exact nature of the service, and the quality of service since the customer tends to become involved in the process itself. In low-contact systems, by definition, customer interaction with the system is infrequent or of short duration and hence has little impact on the system during the production process (Maglio et al. 2010, p.12).

One of the structured ways to classify various services depending upon customer interaction is by using the Service Process Matrix. The Service Process Matrix (SPM), developed by Schmenner (1986), classifies various service businesses into four quadrants of a matrix. The four quadrants represent different operations and are labeled as Service Factory, Mass Service, Service Shop and Professional Services (Figure 1).
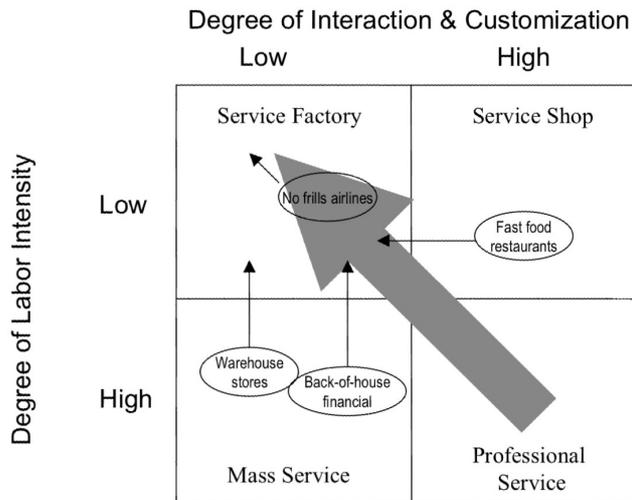
Figure 1. SPM Matrix, 1986 (Schmenner, 2004)

The horizontal axis of the matrix (X-axis) represents the degree of customer interaction and customization and the vertical (Y-axis) – the degree of labor intensity, being the ratio of cost of labor to plant and equipment (Emrouznejad et al. 2014, p. 99). For instance, a service with a high level of interaction is the one in which the customer can actively intervene in the service process and it will work to satisfy an individual's particular preferences. Hence, here are the definitions of the SPM quadrats depending on the level of labor intensity and customization.

The Service Factory is the service type that is characterized by low labor intensity and a low degree of interaction and customization. Much of the transportation industry (airlines, trucking companies), hotels and fast-food establishments can be classified as Service Factories because of low customer contact, customizations and low labor intensity. **The Service Shop** is the service with low labor intensity but high customer interaction. This type can provide various types of customized services for their customers. Hospitals, auto and other repair services are excellent examples of Service Shops. **The Mass Service** has low customer contact in combination with high labor intensity. The following services can be distinguished as this type: retail companies, wholesaling and schools. **The Professional Service** is characterized by both high customization and high degree of labor intensity. Services provided by lawyers, doctors, accountants and architects all have a very high labor costs due to the large amount of education associated with professions. Furthermore, these services tend to be highly customized according to their particular need of each customer (Boyer et al. 2000, p.10).

This matrix was first presented over two decades ago, and since then some shifts have occurred in service businesses. Schmenner states that many of the moves that have been made in the service sector involved moves toward a diagonal, and, indeed, up that diagonal (Schmenner, 2004, p.342). For instance, some of these trends are: deregulation of banking, airlines and trucking, introduction of paralegals in law firms and changes in hospitals, restaurants and retailing. In the mentioned examples, companies have decreased labor intensity and have reduced their customer interaction and customizations. These actions have allowed companies to obtain more control and rationalize their businesses. It is distant that control in service is significantly more difficult than in a factory or manufacture situations. Thus, much of the movement toward and up the diagonal can be explained by the desire of companies to gain more control of their processes (Schmenner, 2004, p.343).

Reworking the SPM from 1986, Schnemmer has come to a decision that "toward and up trend" is nothing but swift, even flow. Thus, in 2004 Schmenner has presented a modernized matrix, where the degree of interaction and customization has been re-titled as *variation* and, the degree of labor intensity – *to speed of flow* (Figure 2) (Schmenner, 2004, p.338). According to Schmenner, the Theory of Swift, Even Flow states that productivity increases as the speed of materials (or information) increases and variability decreases (Schmenner, 2004, p.341). Swift, Even Flow assists to unify well-established laws of variability, bottlenecks, scientific methods, quality, and factory focus, and it shows how these laws work.
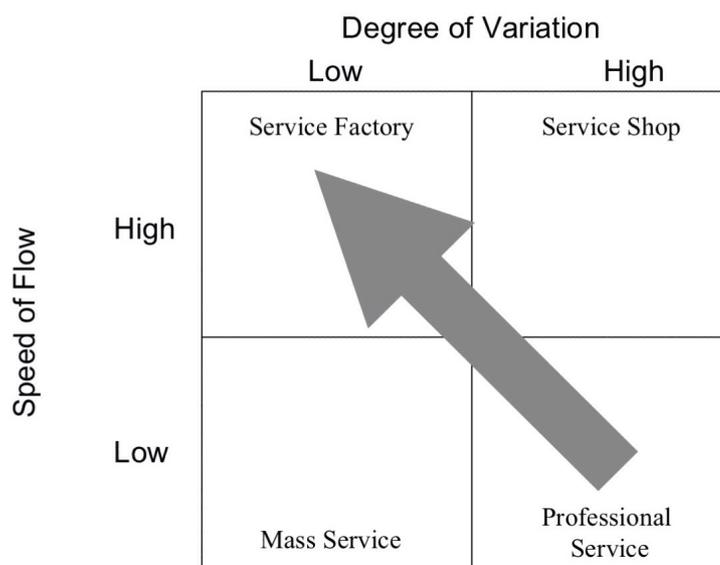
Figure 2. Updated SPM Matrix, 2004 (Schmenner, 2004)

Schmenner (2004) defines that this "manufacture" theory can be applied equally well to the service sector. To prove this, the following are some examples of the service companies that have exploited swift flows with less variability than their competitors and have increased service productivity at a better rate than others. American retail giant **Wal-Mart** has been recognized by its legendary logistics and information system, which communicates each store each day via satellite and triggers a supply chain that can re-supply each store promptly. Hence, relatively little inventory is kept and inventory turns are high. Accordingly, the flow of goods and information is swift and its regularity from day-to-day allows keeping productivity and profits high (Mohr et al. 2010). Another example is a world largest fast food company, **McDonald's,** which prospers due to it swift even flow operations. Variation is kept low as the menu is pretty limited, but, the coordination of the kitchen and counter keeps food orders flowing rapidly from grill and fryer, especially at peak times and rush hours, when the company makes the majority of its profit. The swift, even flow of the processes makes for the convenience and low price that are appreciated worldwide. These companies turned out to be the most profitable an admired firms in the service sector (Mohr et al. 2010).

The described above examples of Wal-Mart and McDonalds present the examples of services that have been reshaped for speed and less variations, either by the design of the service itself or by the refashioned processes that deliver the service. Thus, these companies tend to or have already become a **Service Factory.** According to the SPM, Service Factory is the type of service with the most control. This model is the lure for many services, and hence inspires their strategic moves toward and up the diagonal (Schmnenner, 2004, p.343). One good example of Service Factory – amusement park Sea World in San Diego. The principal factors, which characterize it, are: mass production and high volumes (which tends to increase), high level of standardization of the operations, low level of flexibility, focus on reducing costs, constant quality conforming to consumer expectations, high level of dependability, low variability of the process output, and great attention to selecting the process input, in particular in terms of consumer expectations and characteristics (Baglieri et al. 2014, p.19).

However, it is crucial to mention that there are some limitations to the SPM Model. First, the measures of low and high, which are relatively broad, do not describe the plot of the organizations operations on the matrix sufficiently. Moreover, service organizations commonly have multiple operating models rather than one fixed mode; therefore it is challenging to operationalize the model (Emrouznejad et al. 2014, p.100). Thus, majority of

service businesses tend to change their infrastructure and redesign process as these leaders, and healthcare organizations are not exception.

In the context of this study, Service Factory, where people flow is well organized, can be considered as a perfect "quadrant" (type of service) for hospitals and various clinics that form healthcare infrastructure. In that case, each employee knows how and where to move, which services to attend (with the visual tools help: colors, lines and other visual objects can facilitate this), what exactly to do in the particular moment and etc. Patients also can use visual techniques in order to find the right department, route and rooms. Moreover, various tools can distract their attention: extra TVs in the waiting rooms, information brochures or even some education digital machines (for instance, to teach how to make injections at home, take care about older people, or etc.) in order to decrease the negative impact of waiting time and other wastes. This can allow reducing variability and making the process more stable. In addition, hospitals can organize learning seminars that can teach people how to do simple procedures at home instead of visiting hospital or preparing for surgeries. In the long-term plan that can reduce the workload of the healthcare organization and eliminate some waste. However, such sophisticated healthcare processes as surgery or emergency are unlikely to fall within the definition of Service Factory. On the contrary, they are closer to the Service shop or even Professional Service. Thus, it can be stated that various healthcare processes can be found in various quadrants of the SPM. Because of it, optimization of healthcare processes requires usage of different tools and methods, depending upon the degree of variability and flow speed. And for this, it is essential to distinguish which types of services form healthcare model, and, if it is possible or not to systemize them in order to build "swift, even flow" operations.

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2.2 Types of services in Healthcare

From the written above, it is clear that there are a large number of services in healthcare industry, which can be classified and in different groups according to various characteristics. For instance, the following types of services can be found in the hospital: *surgical services, nutritional services, pharmacy, emergence services, laboratories, radiology, inpatient floors, primary care, and etc.*

To systemize various healthcare processes in the frames of SPM, it is drastically important to focus on the levels of customization and labor intensity, or, adjusting it to the modernized matrix – variability and speed flow. Healthcare has all features of **a customer intensive physical service**. Therefore, one important characteristic of it is that the customer is present in some part of the service creation and delivery process, and may also participate in varying degrees. As a result, customer experience and satisfaction with that experience become an important part of service outcomes. And secondly, the presence and participation of the customer in the service process can significantly affect productivity, cost and quality. Moreover, customer intensive service is typically geographically distributed, and, thus, scale economies are often not present. It is possible to use standardization and replication of equipment and processes in order to to get some economies of scale. Narrowing and specializing the service can sometimes increase labor efficiency, and designing processes with narrower highly scripted tasks that require lower levels of skill. Self-service may be feasible as a way of reducing labor costs (Baglieri et al. 2014, p.29). Hence, classification of healthcare services on the basis of degree of variation (customization) and flow speed (labor intensity) can be introduced in the following way (Figure 3):
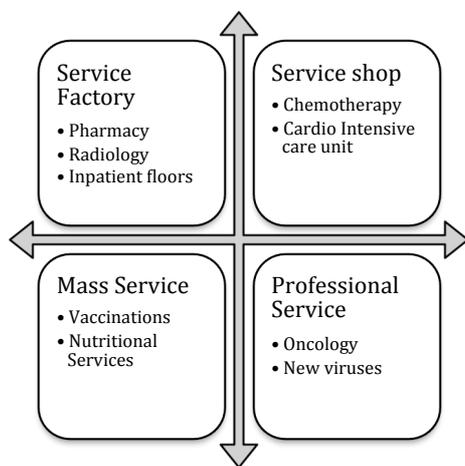
Figure 3. Healthcare services in SPM Matrix

In the Figure 3 it is presented, that highly customized processes, which require high degree of labor intensity, such as oncology, or particularly diagnose definition and developing treatment, are located in the "Professional service" quadrant. Every patient in these types of services needs personal attention and specified treatment of healthcare professional, and it is hardly possible to standardize it. On the contrary, types of services that are mentioned in the "Service Factory" – pharmacy, radiology and etc., have much in common with various

manufacture process, and somehow can be considered as assembly line. They have very low degree of variation, which makes them more predictable and they can be improved with manufacture tools. When talking about Service Factory, it is obvious that it is impossible to redesign all healthcare processes so that they will match this type of service business. However, many operations in healthcare can be simplified and standardized in order to make the whole system more lean (Baglieri et al. 2014, p.63). For example, operations like booking an appointment or receiving the results of your clinical analysis can be done with little (and even no) human interaction. Customers can book an appointment, choose the date and time, avoiding long queues in the hospitals or call-centers, using various channels: online booking, touch screen in the healthcare organizations or, and old-fashioned "concierge desk".

As mentioned in the chapter above (Chapter 2.1 Service typologies), there is an upward trend in service companies to redesign their processes so that they fit "Service Factory" quadrant. Basically, it means that variation declines and flow speed increases, what has a positive impact on the productivity. Low level of variation, such as little number of peak hours, unscheduled patients, relatively controlled people flow, standardized processes, and well organized access to the resource, provides an opportunity to extend the productivity, as the system becomes more organized. On the contrary, the increase of speed of flow allows serving more customers, which, then, improves the financial performance of the organization. It could be a perfect state if all processes in healthcare will be located in the Service Factory type, but in the real life it is hardly possible.

2.3 Which challenges do managers meet in Healthcare processes?

Nowadays healthcare organizations feel the strong pressure to improve their performances and face plenty of various challenges: financial, technological, social and etc. According to the statistics, in the first years of the 20th century plenty of lives claimed yearly in the developed countries (USA, European countries) by fatal medical errors (Spear, 2005, p.83). Other problem is that waiting time for patients is nevertheless getting loner. Moreover, due to the issues economies of developed countries are facing, governments are turning towards budgeting actions with sharp efficiency cuts (Rosmulder, 2011, p.1). Nonetheless, healthcare organizations are expected to deliver more and better quality patient care with the same means.

Based on the summary of various sources, the following groups of challenges can be indicated in healthcare system: *industrial, economic, insurance, staffing,* and etc. **Industry challenge.** Healthcare systems of developed countries have access to very advanced technologies and capabilities, but in many respects instead of providing *efficient service* it delivers un-exceptional outcomes, even though it consumes a big share of private and governmental resources (Husby, 2012, p.4). Moreover, U.S. Healthcare system, for instance, face a phenomenon called "*healthcare tourism*", with patients travelling to locations like India or Cuba to receive a treatment with equivalent outcomes at the price as little as just 25% (including travel expenses) of the price of the same treatment in the U.S. (Protzman et al. 2011, p.35). Consequently, it means that the inefficiencies of the U.S. or many of developed European countries seem to be driving international competition. Another one is an **economic challenge.** Many factors influence the financial stability of healthcare systems in the developed countries. One of the studies, conducted by Geyman J. in 2007, states that the recent economic downturn has resulted in a significant decline in the percentage of population in the U.S. who use health insurance as well as their financial resources to pay for the service delivery (Geyman, 2007, p.342). Apparently, the same trend can be noticed in Europe and other developed countries in the last years. Husby demonstrates in his study (Husby, 2012, p.28) that the most common reason of bankruptcy in the U.S is healthcare costs. Moreover, it is critical to mention that there is another rising trend: plenty of patients avoid seeking care due to their financial situations before their conditions become severe. Hence, if the costs on the health care services keep on increasing, many people would not have *access to medical care* and would not be able to afford proper treatment. **Insurance** companies are one of the stakeholders in health care service delivery. The sophisticated rules and variety of health insurance plans that are presented by majority of insurance companies nowadays have reinforced people to seek care there, and even, to pay extra on their own (Husby, 2012, p.7). As a result, it makes treatment *less affordable* for population. Likewise, the other interested party – **employees** are under threat. **Staff challenge** is the one that caused by the problem of high staff turnover due to the staffing shortages (in order to cut the expenses). **Aging population** is another complicated issue to be solved. Being one of the main demographic challenges of developed countries, it is characterized by high proportion of people suffering from diabetes and hypertension that add extra complexity and work to patient treatment. Research on developing new **medications and medical technologies** require huge amount of money. However, the results of this work are under the doubt as many studies have shown

that there are plenty of cases which outcomes appear to be negative and result in little or even negative ROI (Kumar, 2011, p.372). Some organizations are investing in continuous improvement but the sustainability of these efforts has been minimal in the most of them.

According to the recently published article by Mark Hagland, there is plenty of work for engineers in healthcare sphere nowadays. Thus, based on the survey that was conducted among 323 quality professionals in healthcare, the most crucial things to be improved in healthcare are reducing the hospital readmissions, increasing patient throughput through creating more efficiency along with involving patient coordinators in participation. The results of the whole survey are presented in the figure below (Figure 4).
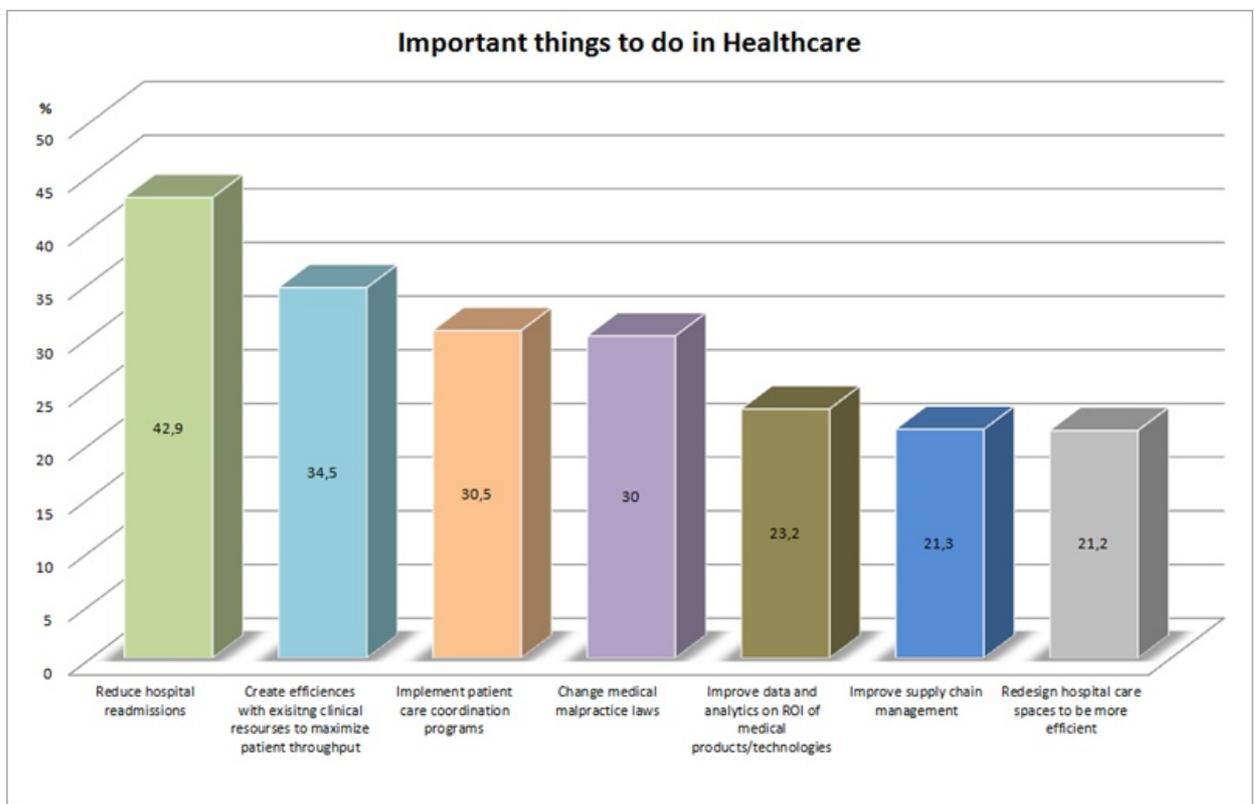
Figure 4. Important things to be improved in Healthcare (based on Hagland Mark, 2014)

Analysis of this data provides evidence that these organizations need to look for new and more efficient ways of providing care. It is crucial to understand that it is impossible to find a single solution onto all problems. Top management in healthcare needs to look outside of the traditional healthcare environments for solutions: for instance, to manufactures and other fields in order to find solid, proven solutions that can be adjusted to healthcare.

Here is the list of most promising actions, which, according to the vision of healthcare quality professionals, can help to improve the existing systems:

- Involve quality and process engineers in healthcare system;
- Focus on Lean management principles;
- Implement mandatory process improvement training for healthcare professionals;
- Create financial incentives to deliver more efficient care;
- Expand the use of medical technology (Hagland Mark 2014).

From the written above it is clear that healthcare system has many problems to be resolved. All these challenges and examples mentioned above can be also classified from the perspective of possible ways to address them, and thus, could be *focused on: patient, costs reducing, quality and healthcare professionals.* In the frames of this work, two approaches are considered to find possible solutions: lean methodology and digital technologies. Lean approach seems to be promising, especially according to the technical nature of some services in healthcare, such as pharmacy or nutritional services, which can be compared to assembly line. Digital technologies, which spread their influence in different service industries nowadays, cannot be ignored and allow optimizing some processes, releasing healthcare employees from routine tasks and increasing the productivity of the system as a whole.

2.4 Why Lean and digital technologies might be suitable?

Applying lean methodology and digital technologies to healthcare process appears to be a promising and advantageous solution for resolving challenges presented above. Even though these two approaches are different – one is manual, another – technological solution, there is a opportunity that each of them, and, probably, a combination, can affect healthcare in a positive way.

For more than a decade in order to keep customers satisfied healthcare organizations have been adopting lean ideas to increase the service quality reduce costs and raise the profitability. Lean approach allows them to analyze the flow of activities, make improvements through process mapping techniques and identify and reduce waste (Piercy et al. 2009, p. 1478). However, given that services are extremely heterogeneous, it is difficult to formulate general management guidelines or best practices for service management. **Womack, lean guru, declares that lean is applicable to any organization since its goal is to create value to the**

customer (Womack et al. 1996, p.78). One good example of using lean in healthcare can prove that is can be beneficially. Thus, the French National Healthcare system has applied a unique approach to Emergency Care. Emergency calls were screened by a physician who decided whether to respond and what type of team to respond, or to tell the patient to come into emergency room. Ten percent of calls to which they respond are handled by a full team, including a physician to diagnose the problem and stabilize the patient on the scene, then take the patient to the hospital that specializes in their needed care (Protzman et al. 2011, p.35-36). This example shows how simple solution can help organizations benefit by applying lean principles. **The goal of lean implementation is to supply the best value to the customer, at the right time, with highest quality at the lowest cost**. It means to create a culture of continuous improvement where each member of the organization takes part in eliminating waste and streamlining processes in order to provide the best value to the customer. Lean in healthcare can improve its operations and outcomes, lower cost, and increase satisfaction among patients and staff (Miller et al. 2005, p.6). It may be beneficial for various stakeholders (Figure 5).

For the patient	**For the worker/stuff**	**For the organization/ hospital/clinic**
• Decreased length of stay; •Increased satisfaction; •Decreased wait time; •Increased quality and safety; •Fewer errors; •More time for direct contact wuth care professional; •Improved patient flow.	•Waste elimination; •Reduction in overtime worked; •Workload reduction; •Increased satisfaction; •Reduction iin walking distance; •Well organized work environment.	•Reduction in inventory levels; •More patients served; •Waste elimination; •Cost reduction; •Improved patient flow.

Figure 5. Potential benefits for various stakeholders from lean implementing in healthcare

Lean methodology can be applied successfully to the healthcare industry. However, it is necessary to remember that lean approach is not a quite fix. When implementing, it is crucial to be open-minded to look at things differently, not to expect instantaneous results and be able to value and embrace principles like lean in order to provide patients with the safest, highest-quality, and most efficient care.

Another solution to address healthcare challenges is to turn to digital technologies. The spread of Internet and internet enable devices have increased tremendously during the last decades, and nowadays almost every aging class in developed countries has at least one: smartphone, laptop, tablet and so on. Vast advantage that this trend provides is an opportunity to integrate these technologies into distinct service areas, such as healthcare, retails, tourism, in order to address raising challenges. New technologies and mobile communications have intensified the service potential experience for customers as majority of them browse the web, share files and updates with peers in social medias, consume videos and etc. on the daily basis.

Observing how digital technologies affect healthcare environment, it may be notices, that many hospitals have been already adopting them for some period of time, to conduct business online by interactive tools: finding a physician, paying bills, using an interactive map, and accessing medical records online. Diverse "future technologies", such as humanoid robots, who can perform like caring nurse, or "smart houses", where plenty of healthcare measures are constantly monitored, are rapidly developing to optimize health industry. In addition, "telehealth", relatively new term, appears to be a very promising solution to address challenges like aging society, lack of staff, high cost and etc.

However, the critical problem of digital healthcare is high investments that are required. Thus, these digitalization may be successful if the company ahs big assets, or if supported by government and huge companies. In Finland, for instance, nowadays (May 2015), supported by Tekes and GE Healthcare, new program "Bits of Health" was launched to facilitate the growth of Finnish companies operating in the health and well being sector by making use of the business opportunities created by digitalization and IT method to reform through the utilization of the growing healthcare market.

To sum up, it may be useful to consider two approaches presented above to solve issues in healthcare. The lean methodology provides the tools to address the frustrations patients and doctors experience in healthcare setting. Lean tools would seem to be applicable and can bring benefits in healthcare organizations if those dedicate resources, disciple and long-term focus in their efforts. Digital technologies enable health organizations establish relationships and communication between the hospital and the patient, educate and empower the user via interactive programs and apps, and deliver more and better health care (even on the distance). Thus, the next chapters are focused on these approaches and their applicability to healtchare.

3. LEAN APPROACH TO SERVICES

This chapter is related to the usage of lean methodology in the frames of services. The most frequently used in healthcare lean tools are described in more details in the first part of this chapter. As a result of this review it can be said clearly, which particular challenges can be resolved by the methods described below. The second part of the chapter considers the obstacles one can meet while implementing lean, such as defining seven wastes or overcoming resistance to apply the method. In addition, the role of leadership and its importance are highlighted, as this is an essential part of any lean project.

3.1 Lean tools in Healthcare

There are many theories about what is Lean. Initially, it takes its roots at the TPS Toyota Production System, first description of which has appeared in the late 1970s. Later in 1990 Womack and Jones presented a book "The Machine That Changed the World" which has first popularized Lean production approach all over the world. Later on, these authors were among the first to propose that Lean techniques can be applied to services and specifically to healthcare. Presently, lean methodology is applied in various types of organizations all around the world. Lean seeks to "flush out" and fight waste in every process. (Womack et al. 1996, p.28) Lean first and foremost strives to obtain a perfect balance between capacity and workload. **Solve problems when they occur without postponing them** (Womack et al. 1990, p.114) is one of the basic principles of Lean.

Applying lean in service sector is essential to add value to customers by providing services with higher quality and speed by using fewer resources. Its focus is to identify the root of the problem so that it will not happen again. Lean services represent the idea of eliminating waste from service processes in order to increase the efficiency. However, the waste in services can be tangible and intangible. Thus, the main challenge is to manage the intangibility of the waste, as it is hard to identify it.

The world of medicine, which is in the focus of this study, is set in a fragile, human, and emotional environment – the place most unlike an automotive assembly line. Thus, not all lean methods can suit to improve healthcare processes. The observation study, conducted in 2010 by B. Poksinska, shows, which lean tools and approaches are most commonly used in Healthcare. The analysis was organized by the frequency of appearance this tools in a

number of papers, which discussed the specific Lean principle, method or tool in the context of healthcare (Poksinska et al. 2010, p.323). The summarized results of this are presented in the figure below (Figure 6).
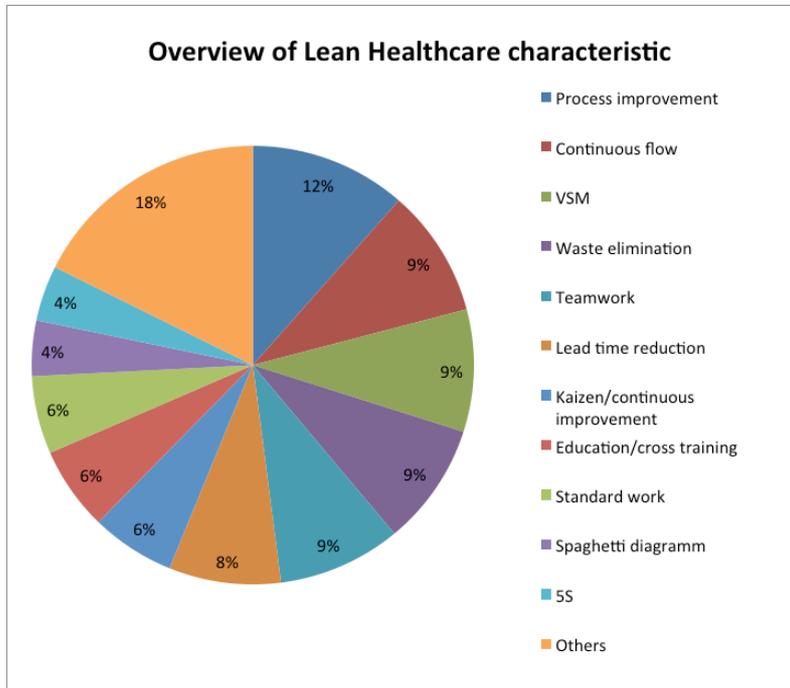
Figure 6. The most frequently used Lean tools in Healthcare

The diagram shows that the most frequently used lean tool in healthcare is a process improvement approach. VSM Value Stream Mapping, Continuous flow, Waste Elimination and Team Work follow it and approximately have the same share of popularity in terms of lean approach. The outcomes of this study were used to narrow the scope for considering various lean tools particularly for this work and choosing the most spread ones. Those tools are described in a more detailed way below.

3.1.1 VSM

According to the research, conducted by Poksinska (Poksinska, 2010, p.322), Value Stream Mapping (VSM) is one of the most frequently used lean tools in healthcare business that provides a system view on the all process steps (Furterer et al. 2014, p.187). It helps organization to find out what is required to be changed, build a long-term vision for the entire organization, communicate the benefits that will result from implementation of the Future State, provide clear understanding of the road blocks. Thus, everyone in the organization can

support these changes and, therefore, make them achievable and sustainable. VSM helps to map, visualize and understand the flow of patients, materials, and information. The key characteristic of the described tool is focus on time between different steps of the process, and future opportunities that appear in order to eliminate this time without reducing value-added time. VSM shows the requirements for each function, delays, wastes and opportunities for process improvements.

To start with, it is essential to note some definitions used while applying VSM. Thus, from lean point of view, all activities can be divided into value-added VA and non-value added NVA. In healthcare, among the activities without value added (NVA) there are activities such as *checks, inspections, tests, loading and unloading machines and data, to mention a few, that companies, out of habit, do not consider to be waste (Suneja et al. 2010, p.7)*. Furthermore, there are also mandatory activities such as *risk management, financial audit and many others unfortunately unpaid and not considered value added by the customers*. And, finally, only about 10% of everything that happens in organization may be called value-added activities (VA).

According to Womack (Womack, et al. 1990, p. 26), in the process the shares of all activities are spread in the following way:

- *10% - value added;*
    - o Transforms patient, material, information, decisions, or risks;
    - o The customer wants it and wills to pay for it;
    - o It is done right the first time (or as right as possible);
- *15% - mandatory non-value-added activities;*
    - o It does not create value but cannot be eliminated based on current state of process, technology, policy or thinking;
    - o Team coordination, corporate reporting, required record-keeping, and etc.;
- *75% - non-value-added activities;*
    - o Consumes resources but creates no value to the customer;
    - o Pure waste – the process can continue if this activity is removed;
    - o Waiting, Inventory, Movement, Excessive/defective processing.

The VSM outlines the process and categorizes what is actually process time and storage (waiting) time for the healthcare customer as they go through the process. It also shows the information flow, materials flow, and a timeline with a results box that shows the overall

process vs storage time. The value stream lends clarity to the process, helping to reveal process steps that impede throughput and highlight where waste and non-value activities are prevalent. VSM is the first and most important managing method used to identify what needs to be changed when striving to apply Lean and it can be divided as follows (examples of Current and Future States VSM are presented in Appendices 2 and 3): Current state VSM (as is); and Future state VSM (as should be).

There are several steps that should be done in order to implement VSM in the organization (Figure 7).
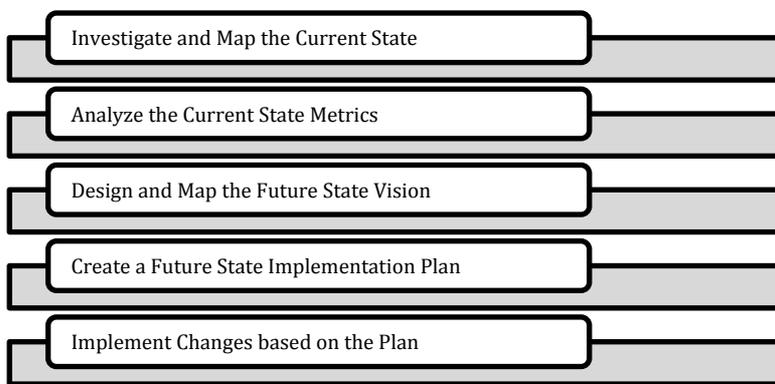
Figure 7. VSM steps

First thing to do is mapping the current state of the process. Thus, it is critically important to collect data about the process. Lean is about being able **to manage by fact and understanding all the data related to the current process and what it can deliver** (Protzman et al. 2011, p.71). In order to manage by fact, it is crucial to analyze the current state metrics and forecast their future value. The following metrics play important roles in healthcare (example of VSM is presented in Appendix 1). The most important data includes: *customer demand, available time, takt time, peak demand, cycle time and throughput time.*

Customer demand. Understanding customer demand influences what hours we need to be open and the number of staff required. In the hospital environment the best or most accurate demand numbers are based on current (actual) and future (projected) forecasted demand. Therefore, it is important to understand demand at the lowest possible level, especially if there are wide swings in demand cycles, such as in the laboratory "morning run" (Protzman et al. 2011, p.78). *For instance, it would be inaccurate to schedule nurses in the emergency room only based how many nurses we need on a daily (24h) basis instead of understanding trends in demand by shifts, or, preferably, in hours. Or, if staff is scheduled equally though the day,*

it is easy to find that hospital is overstaffed on nights and understaffed on days. Hence*,* it is critically important to understand and monitor demand regularly and precisely.

Available time. It equals the total shift time as staff and managers' cover breaks. Actually, the available time is the working time available for the unit or department.

Takt time TT allows looking at a process or a group of activities and determine, based on customer demand and available time, how a process needs to run related to time. Takt time is equal to available time to produce a product or service divided by the customer demand required during the available time. *Takt time = Available time/Customer demand*

Peak Demand happens certain times. For example, in Surgery Department it can be the period of time just from 7am to 4pm, or seasonally – in some months – "snow bird in January-March" (Protzman et al. 2011, p.79).

Cycle time CT provides an understanding of the current state. There are several ways to calculate it: (1) The amount of time each person actually spends completing their part of operation if the work is evenly distributed. (2) The daily or hourly available time divided by the daily or hourly demand of the process (different from Takt Time). (3) Dividing total labor time by the number of people in process, again assuming it is evenly distributed. (4) Timed to the actual individual output of the process, ex. The length of time between the discharges of each individual patient; CT provides a baseline of the process, can be used as an in-process metric (Protzman et al. 2011, p.78-79).

Sometimes Takt Time and Cycle Time can be confusing to understand and calculate. However, TT is a calculation that is based strictly on customer demand, where CT is based on area's demand for that day or hour and the time that actually takes to make an activity. The goal in the Future State is to match CT and TT. For instance, in hospital CT would be based on demand at which we choose to staff or assign resources to perform activities in the area. Despite what is imagined, demand in the hospitals is surprisingly predictable (Protzman et al. 2011, p.79). However, in hospitals, due to scheduling limitations, based on hours one can work and jobs one can perform, it can be difficult to balance CT and TT. In order to "design" a process leveraging CT info to TT, the following steps can be taken: adding or taking away shift (employees) or rooms, running the rooms fewer days per week or fewer hours per days, combining or separating services in a work area and etc. In the operation room (OR), for

example, addition or better equipment can be purchased to facilitate flow, work standards can be invoked, roles and responsibilities among staff – clarified, new rooms – opened, and etc. In addition to all the metrics mentioned above, it is important to include balance of activities in the Future State Map. Add or balance the activities of the resources to a particular task leads to a decrease in "the patient in" to "the next patient in" cycle time (Protzman et al. 2011, p.79-80).

Throughput time (Length of Stay, LOS). And, finally, the last significant metrics is throughput, which is, equals to the length of stay LOS in healthcare environment. It includes both value and non-value added activities. The longer LOS is, the more complex and frustrating the process is. The key goal is to reduce LOS, as the longer it is, the following things happen (Protzman et al. 2011, p.81): the greater the danger to the patient contracting a hospital or nosocomial infection, the expenses to host the patient are higher, more supplies and labor are required during the stay, more space and rooms are occupied to serve more patients, and etc. On the contrary, if LOS shortens, the costs go down, patient safety increases, patient satisfaction increases, staff is able to deliver on time and meet the schedule, and extra capacity generates more revenue.

When all metrics are collected and the Future State Plan is elaborated, it is time to start its implementation. It is crucial to manage by facts and understand data clearly, as human interpretation of the data is critical. VSM is a scrupulous tool that requires lot of dedication from top management and staff, but at the end it can bring huge benefits, reduce wastes, costs and add extra capacity to the process.

VSM has been implemented successfully in many healthcare organizations, one of the most interesting of which is Virginia Mason Medical Centre (its success in lean implementation is studied in Chapter 4, part 1). The examples of The Current State and The Future State VSM maps are presented in the Appendixes 1 and 2 respectively (Bohmer et al. 2008, p.17-18).

To sum up, VSM can help healthcare organization to benefit in the following ways:

- *Visually identify process and storage steps;*
- *Identify which steps can be eliminated, rearranged, combined, or simplified;*
- *Facilitate opportunities to improve flow;*

- *Enable opportunities to see where information systems should be able to talk to each other;*
- *Creates a management roadmap to track the elimination of waste and improvements (Protzman et al. 2011, p.84).*

Updating value stream maps is a great way to keep track of the achieved progress over time and sustain excellent performance. Its main goal, as the majority of lean tools, is to make patients' experience better.

3.1.2. 5S

5S is a simple and helpful tool to create Lean culture within an organization. It is commonly knows that Healthcare organizations face plenty of challenges with storage and management of supplies, instruments, and equipment in different department. The goal of 5S to create a better workplace by reducing workload of employees and errors in processes, neatness to create healthier atmosphere and providing training and education to employees to enhance their quality and productivity. Basically, 5S-workers evaluate their own works areas and make changes, creating optimal workspace; super important, lots of good examples in healthcare (Suneja et al. 2010, p.92). For example, in OR it happens very often that hallways are cluttered with supplies, beds are waiting for patients to come out of surgeries, and trash bags is being staged while rooms are cleaned. These challenges result in the need for improving the OR location and organization of equipment, furniture, instruments, and supplies (Furterer et al. 2014, p.145).

5S is a method of creating a self-sustaining culture that perpetuates a neat, clean and efficient workplace (Protzman et al. 2011, p.366). It consists of the following Japanese acronyms (Figure 8) (Black et al. 2008, p.54).

Seiri/Sort	Seiton/Straighten	Seiso/Shine	Seiketsu/Standardize	Shitsuke/Sustain
• Separate necessary from unnecessary	• Create "a place for everything and everything in its place"	• Control the work area visually and physically	• Document agreements made during the previous steps	• Follow through on all 5S agreements
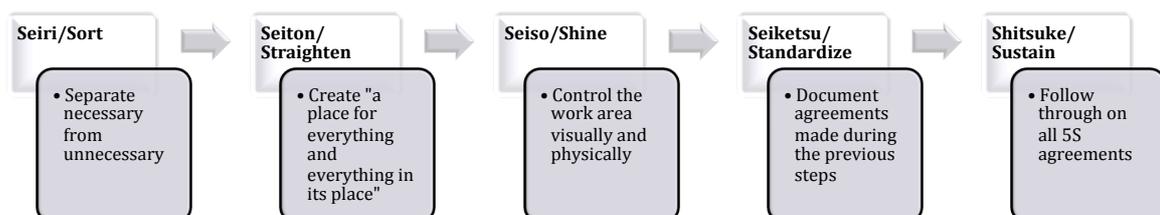
Figure 8. 5S steps

The first step is *Sort*. It distinguishes between what is necessary and what is unnecessary, disposing of the unnecessary. One of the useful methods can be separating everything into 3 containers (one container is for useless objects, one is for useful objects and the last one is for objects shared with other areas that can be stored in the warehouse) or labeling with 3 different colors stickers (red tags for useless objects, yellow – use sometimes and green – useful) (Womack et al. 1990, p.88). The second step requires reorganization of the area. It is important to organize the necessary items so they can be used and returned easily. Third one, *shine,* fixes the root cause of the dirt or disorganization. *Standardize* maintains and improves the standards of the first three S', so that everything that has been done in the previous steps becomes a part of daily routine. Procedures and routines should be defined, especially regarding responsibilities, daily activity checklists, times that cannot be exceeded, checks and inspections and so on; easy and quick to interpret document with photos and drawings (Womack et al. 1990, p.88). And, finally, the last step is the hardest and the most challenging one – to *Sustain.*

Implementation of 5S allows changing employees' behavior and contributing to productivity, quality and safety. One of the ways to implement 5S is to use the Lean Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) problem solving methodology. In the first, Define Phase, it is important, to organize the area to enable the staff to locate, store, and manage equipment, furniture, supplies, and instruments that are used on a daily basis for surgical cases. For this purpose **"Project charter"** can be created, *where the problem statement, goal and stakeholders of the project, scope statement and critical for satisfaction moments* are defined. In the process of of implementing 5S in OR department, for instance, the main goals are to get more space that is available and freed up due to better organization, and reduction of unneeded items, to reduce the time for searching the equipment, supplies, instruments and other necessary things, reduce the quantity of equipment by eliminating the unneeded one, and etc. Patients, OR physicians, nurses, and technicians could be stakeholders of this project. The scope of the project may include implementing 5S in the operating Room central Core storage area, operating rooms, OR storage areas, Pre-op areas and Recovery room, remote storage areas. Finally, the critical satisfaction factors are available space, time to find equipment, supplies, OR turnaround time, and reduced preventive maintenance time for OR Bio-med equipment (Furterer et al. 2014, p.148).

In the table below (Table 1) is shown the example of DMAIC plan for applying 5S tools, on the example of Operating Room (Furterer et al. 2014, p.151).

Table 1. DMAIC and 5S activities mapping

DMAIC Phase	5S Phase	5S Activities
Define		
Measure	**Sort**	1. Identify rooms and areas to be sorted. 2. Identify roles and responsibilities of team members. 3. Define time frames of sorting activities. 4. Set up sorting area. 5. Create OR standard furniture and equipment set-ups. 6. Establish criteria to separate needed/unneeded items. 7. Separate needed from unneeded items. 8. Red tag unneeded hold items. 9. Remove excess items from working areas.
Analyze	**Straighten**	1. Decide where things belong. 1. Decide how they will be put away. 2. Make it as easy as possible to obey the put away rules. 3. Color-coding areas for supplies, type of equipment. 4. Same category of equipment/supplies in close areas (unless posed safety issue). 5. All items that are used in conjunction placed close together. 6. Outline aisles, places where items are kept. 7. Standardize height, size of shelves if necessary.
Analyze	**Shine**	1. Find root causes for things get disorganized. 2. Find abnormalities. 3. Engage Environmental Services and Engineering to repair root causes.
Improve	**Standardize**	1. Create visual management so that abnormal state can be easily identified. 2. Color-coding and labeling, shadow boards, indicators of where things should be put.
Control	**Sustain**	1. Create 5S committee. 2. Create audit plan and schedule. 3. Periodic spring-cleaning schedule. 4. Assess improvement.

The last step (Sustain), as it was mentioned before, is the hardest one to apply. Thus, it is critically important to Create Audit Control Plan and Schedule, organize periodic cleaning schedules **in order to** continue the removal of unneeded equipment, and furniture.

In summary, 5S project implementation can be very successful in organizing the areas of healthcare organizations. *5S is relatively easy tool to implement in the organizations.*

However, it can bring plenty of benefits. For instance, OR Department, considered above, states that due to the 5S implementation nearly 400 square feet of outdated and unneeded equipment were eliminated. OR hallways were organized better, and it turned out to be easier to navigate the patients on beds to the OR. The equipment and furniture were painted, so that it became easy to return back to the correct OR when it is moved (Furterer et al. 2014, p.158). Examples of 5S transformations of the areas are presented in the Appendix 4.

3.1.3 Standardization

In the frames of healthcare business, standardization causes plenty of arguments as for many professionals it is seen hardly possible to standardize work focused on people'. Charles Protzman, in "Leveraging Lean in Healthcare", provides a good example that clearly explains what is actually standard work. He compares it to an orchestra. There is a huge difference between the play of a fifth grade orchestra and symphony orchestra. The same happens to a standardized work. The author concludes, that there are three main components of standard work. First one is a *sequence of operations or steps*. In orchestra every note must be played in the exact order and the right note to be played. If each member of the symphony orchestra did what a lot of healthcare employees do and decided to play the notes in the order they want to play them, or believed that they had a better way to play the music, or paid no attention to the conductor (supervisor), or never practiced, that would lead to a chaos. Thus, it is crucial to follow the order of steps. The second component of standard work is *Cycle Time.* Cycle time in orchestra example is represented by the length of each note and the need to play the note for exactly the correct amount of time. Standard work should be based on Cycle Time because to run to Takt Time may not always be feasible. For instance, Takt Time may dictate that the line or area in some of departments should be run with 1.5 people, which is actually impossible in reality - to run with half of a person. Therefore, two people are required for this work, which means it is necessary to recalculate the time using two people, which is going to turn into a Cycle Time that will run faster than Takt time. That would lead to overproduction unless the "line" will be stopped when the required output is achieved or some other tasks for the half a person appear to do each cycle. In the healthcare environment, this is further driven by the difference in skill sets and the need to have additional people (not just fractional) to run the area. Moreover, since variation appears in some cases dependent on how particular patient care must be deliver, it can lead to a various range of cycle times in the standard work (Protzman et al. 2011, p.135). The last. Third component is *Standard Work in Process SWIP.*

In orchestra example SWIP can be viewed as the instrument the musician is playing. In certain situations, a musician may have more than one instrument in the inventory due to the demands of the musical score. The key difference between professional and the fifth grade orchestra is that the second does always hit the right notes, get the timing right, may not have exactly the right instruments. Protzman goes on to say that like a symphony, standard work first has to be created. After it takes training and education and lots of practice and dedication to hit the notes correctly and follow the beat.

In healthcare, standard work has been actively implemented to improve quality. For instance, in can be useful for the process in administrating blood products, Situation Background Assessment Recommendation SBAR, or handoff communication. A clearly defined process provides an efficient and effective job. **A well-defined job for everyone, and everyone is improving their job** (Suneja et al. 2010, p.81). In order to have standard work implemented smoothly in the organization, it is necessary not to overburden the staff. Once the waste is eliminated, the goal is to work at a normal pace and create an environment where employees are able to take on additional tasks and become multi-skilled and multi-process-capable (Protzman et al. 2011, p.129). Productivity increases and employees become more valuable without working harder. **Standard work is a document** developed by individual staff members, which captures the particular steps and activities that the healthcare professional completes to provide patient care. It describes one person and one job. A standard work document includes:

- Main process steps (work elements);
- Key points to ensure safety and quality of the task, reminders, and tips for success under those steps;
- Sequence/order of steps;
- Supplies of forms needs to complete the job;
- The time it takes to complete each step;
- A layout diagram of where each step is completed (Suneja et al. 2010, p.81).

Standard work should be derived from the work analysis. It is essential first to document operator steps, key points, search for the possibility to reduce waste and time – organize brainstorming of the process with a purpose to eliminate, redesign, and simplify the process (Protzman et al. 2011, p.137). Those steps, which cannot be improved or omitted become the

basis of standard job. The standard work form is constructed at a higher level than the full work analysis. Example of Standard Work form is presented in Appendix 5. It is used to show the operator walk patterns, denote safety items, WIP storage, number of operators needed for the process, quality checks, and pipe location. These types of forms can be developed to various healthcare areas and process. However, it is crucial to understand that standardized work can be only applied to the areas with constant repeatable operations with low degree of variations, where all tools, materials, supplies, and equipment, are ready in their proper locations and in the right amounts necessary and on hand exactly where they will be needed. On the contrary, it is not simple as there is a big challenge for healthcare as the customers (the patients) arrive at different time and require different treatments. For instance, in the emergency room, some patients can only need a prescription for an antibiotic while others need a full workup of diagnostic tests and x-rays. The other example – in the clinic setting, elderly or immobile patients take longer time to process. Thus, in many cases sequence of operations, SWIP, and/or cycle time may vary.

Having looked back at the classification of the services in the frames of SPM matrix, presented in the second chapter, it can be said that different healthcare processes vary regardless of the degree of labor intensity and customization. Thus, not to all of them can be applied the same lean tools, as each group or even each certain process require specific tools or method appropriate for that area. Standardized work may be seen as a suitable solution for the process with low degree of variations - "Mass Service" and "Service Shops" processes: for instance, vaccinations, radiology or nutritional services, where the sequence of the steps can be defined precisely. Finally, standardization of the work can be considered as a basis for the future semi-automate tasks. This concept is simply developing nowadays as society believes that people should not do mundane, repetitive, boring jobs all day long if the machine can do it. Apparently, there are some examples how jobs can be semi-automated: using a power screwdriver vs. a manual screwdriver (Protzman et al. 2011, p.142). However, it is just the developing trend to mistake-proofing operations.

Summarizing, the concept of standard work should be spread around the overall system. This means employees up to the CEO have standard work as a basis for their jobs. In the long-term perspective, it will turn out that majority of workers will start intuitively see the need for standard operations in order to balance the process. Standard work is the foundation for continuous line improvement, line flexibility, and quality improvements. Each staff member

must be trained and must execute the steps in each operation the same way every time. Here is the list of benefits from standard work:

- Helps provide consistent patient service;
- Removes interpersonal barriers by clarifying staff roles;
- Allows staff to anticipate and prevent potential error.
- Makes it easier to schedule the right patients in the right clinics.
- Ensures that new people are trained on the same page and everyone has the same understanding of the process;
- Ensures that high quality is built into the processes and expected by everyone.
- Allows both staff and administration to agree on the right resource levels.
- And, finally, eliminates the seven wastes of Lean (Suneja et al. 2010, p.86).

3.1.4 Spaghetti diagram

Spaghetti diagram is another simple Lean tool, which presents a map that tracks movement in the course of doing a job and creates a visual picture of the process. The goal of Spaghetti diagram is to organize the workspace so that the lines on the map are shortened or eliminated and establish the optimum layout for a department. Implementing Spaghetti diagram in Healthcare environment provides the efficiency in job, healthy ergonomics and a focus on relentless improvement of the care processes. Aneesh Suneja in "Lean Doctors" states that it is crucial to create Spaghetti map for the entire practice (Suneja et al. 2010, p.101). It captures interactions among staff members to highlight where questions, clarifications, or instructions add to patient wait times as physicians, nurses, and other staff cross and re-cross the clinic for needed information. Thus, the physical barriers to effective communications become clear:

- Long hallways of exam rooms that prevent staff from seeing each other or the patient status board;
- Supporting departments that are located at the far end of the clinic and isolate staff members who need to interface with clinic staff;
- And workstations set up by job titles that prevent staff of the clinic from acting like a coordinated team.

Spaghetti diagram is used to visually represent the physical flow of work for a process. In order to create a Spaghetti diagram, it is necessary to do the following steps:

(1) Create a diagram of the workspace;

(2) Note the physical location of the employee at the beginning and end of the process;

(3) Trace the actual steps taken by employee during the entire process;

(4) Draw lines that follow the path which the employee takes as he complete the process (lines could be numbered in order to reflect the steps o the process map);

(5) Note all the stops with sequential numbers and mark the time for each stop;

(6) Mark all inherent interruptions in the path;

(7) Note the certain trips to get extra supplies, documents, information, signature, and etc.

As all these actions are done, the visualization of the process will be completed (Figure 9).
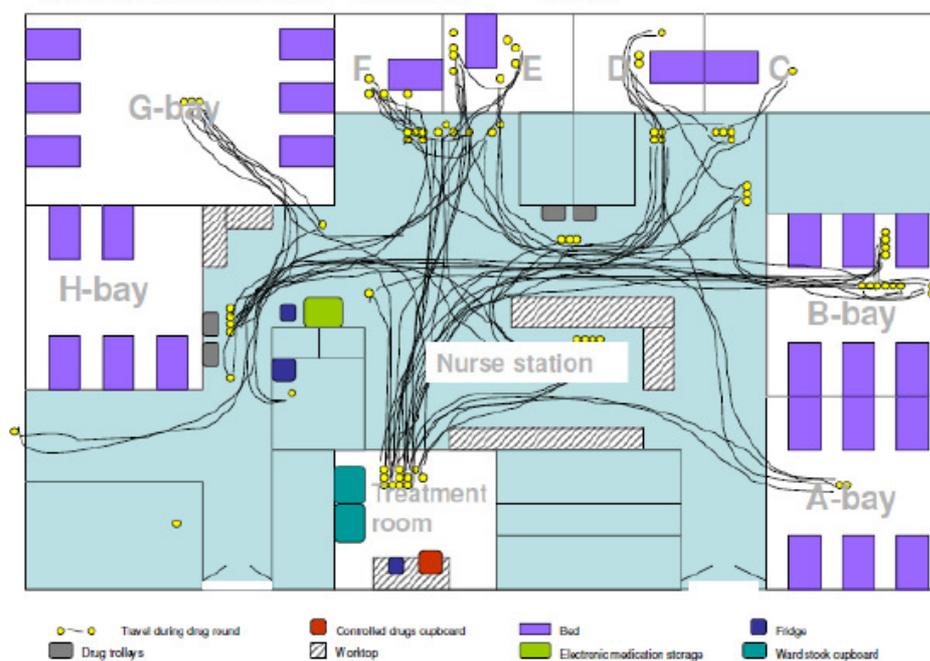
Figure 9. Spaghetti diagram. Nurse path of travel during one drug administration round (McLeod MC, Barber N, Franklin BD, 2013)

Spaghetti diagram allows identifying some sources of problems and defining the waste in the process. Once spaghetti diagram is created, the staff members use its knowledge of Lean Principles to organize the workstations, clear out the clutter, and make sure the necessary supplies are exactly where they are needed (Suneja et al. 2010, p.97). As seen from the figure above, some routes can be inefficient, and as a result, employees loose time, and the

productivity decreases. However, Spaghetti diagram allows seeing the opportunities to make changes in the layout of the department to improve efficiency of the department flows.

The key advantage of this tool, as well as majority of Lean tools, it can be considered as quite manual and low-tech solution, which is relatively easy to implement. According to Aneesh Suneja, it can be very beneficial to use 5S tool after creating Spaghetti diagram to eliminate waste and prepare the area for layout redesigning. For example, implementing Spaghetti diagram in the Orthopedic clinics at Children's Hospital Of Wisconsin brought three new elements to the department layout: an extra door to each exam room (on-stage, off-stage), a special are to organize a common work are for all the clinic staff, including physicians, and a co-located radiology department (Suneja et al. 2010, p.103).

3.1.5 Problem-solving techniques: A3, Fishbone, PDCA and so on

Lean methodology consists of numerous tools. Some of them appear to be more applicable, others – less. In addition to the methods described in this chapter above, it is necessary to point out several problem-solving techniques that are frequently used to optimize healthcare processes. As lean is basically known as a continuous problem solving, then it is important that everyone understands and implements correct tools for resolving issues.

There are various problem-solving approaches in Lean: A3 sheets, Fishbone diagram, PDCA, 8D, and etc. These tools can be sorted regardless on the following characteristics: the size of the problem (small, medium, large), if the solution is unknown or not, and if the issue is to resolve single problem or it is a strategy for a continuous improvement process (Liesener 2013). Here is a table with comparison analysis of all this tools (Table 2):

Table 2. Lean problem-solving approaches

PDCA	DMAIC	A3	8D/PSD
Plan	Define	Clarify the Problem	1. Create Team & collect Information
	Measure	Break down the Problem	2. Describe the Problem
		Set a Target	3. Define Containment Actions
	Analyze	Analyze the Root Cause	4. Analyze the Root Cause
		Develop Countermeasures	5. Define possible corrective Actions
Do	Improve	See Countermeasures	6. Implement corrective Actions
Check	Control	Evaluate Results & Processes	7. Define Actions to avoid Recurrence
Act		Standardize success	8. Congratulate your Team

PDCA cycle, also know as Deming or Schewhart cycle, is principally used for medium-sized problems and the Act step of this approach means that PDCA cycle should be repeated again from time to time to follow a continuous improvement process. A3 strategy, for example, is a great tool for root cause analysis is the tool Toyota uses called the A3 document. Actually, it is a collaborative and visual tool, which consists of 8-step PDCA that should fit on A3 sheet of paper. Usually, this tool is used to solve medium sized-problems, which can be resolved in a week, or less. It is a way to get all your information in one place on one shot of paper (Protzman et al. 2011, p.94). DMAIC, however, takes its roots in Six Sigma world and presents a 5-step analysis for large problems where huge amount of data takes place. Often this tool is related with statistics tools and requires more than months time, dependent on the complexity of the problem and process to be improved.

Another useful problems solving tool that allows discovering the roots of the problem is **Fishbone diagram** developed by Kaoru Ishikawa. Today, it is known as one of the basic Total Quality tools and is very applicable in hospitals. The fishbone works by putting the problem at the head of the fishbone, then brainstorming and categorizing all the reasons for the problems. The first layer of problems, which are placed on the main branches of the fish, simply presents the symptoms of the problems. Then it is necessary to ask "why?" for each major branch, which create sub-branches, and continue doing it until the bottom branch or root cause is defined (Protzman et al. 2011, p.94). This tool provides a way to see all the problems in an area at a glance and is perfect for collecting, categorizing, and root-causing feedback from staff.

Summarizing, it is important to leverage tools to gain an understanding of the root cause of the problem. Identifying root causes allows for the correction of defects and is essential to prevent problems from reoccurring, which ultimately improves the overall process and quality of the result.

3.2 Lean Application

Implementing lean, it is necessary to be open-minded to look at things distinctly, not to expect instantaneous results and be able to value and embrace principles in order to provide patients with the safest, highest-quality, and most efficient care. Top management in healthcare needs to look outside of the traditional healthcare environments for solutions: for instance, to manufactures and other field in order to find solid, proven solutions that can be adjusted to healthcare. **Common goal is to** improve the quality and value of health care.   In Lean Organization the definition of value added is slightly more precise; value added must be created: *At the lowest cost possible, maximizing the value the customer recognizes to that particular output*. (Womack et al. 1990, p.27). Thus, the purpose of eliminating waste may be defined as: every activity that adds costs but non-value-added for the customer. The detailed description of the types of wastes and their examples in healthcare is provided below. In addition, considering that lean is not a quite fix and requires significant efforts, it is necessary to accept and make attempts to resolve the challenges that appear while applying this methodology in healthcare, such as staff resistance, deficiency of professionals and experience, and etc.

3.2.1 The Seven types of waste in Healthcare

Nowadays in the age of high competitiveness, healthcare organizations should focus on value added activities from customers' perspective and strive to eliminate the waste, as the customers are not willing to pay for that (Womack et al. 1990, p.31). There are different types and levels of waste we can find in the organizations. The first level waste is sometimes called *"low-hanging fruit"*. For example, it can be long waiting line, things located out of place, people walking to a printer (instead of shortening the distance), schedules not posted, charge nurses reviewing all the charts. This waste is simple to recognize. The 5S wastes are also among the easiest wastes to see. These types of wastes have to do with housekeeping: things not labeled, trash not picked up, areas need to be clean. The other group of wastes has it roots in the TPS (Table 3). Those wastes were initially developed for manufacturing, but, also can be found in service businesses, and, particularly, in healthcare. Protzman in "Leveraging Lean in Healthcare" proposes, that in healthcare organizations the hardest wastes to distinguish are:

"Boiled frog waste", "tribal waste" and the hidden unseen waste. The first one is an old waste that is hard to notice as employees get used to it, pass by it every day and do not realize that is actually waste. Second one, which is also called *"sacred cow", is* the waste in the organization culture and systems. And, finally, the last type of waste is the one that is typically not seen, and employees really have to hunt for it (Protzman et al. 2011, p.52).

These types or wastes are highly present in service businesses, and, particularly, in healthcare organizations. Nowadays the most spread waste typology, developed in Toyota, describes seven (or eight, including employee potential) types of waste: overproduction, inventory, motion, defectiveness, transportation, over processing, and waiting (Womack et al. 1990, p.54). The following table (Figure 10) was developed to illustrate and provide definitions of the seven types of wastes, based on the various authors' viewpoints.

Overproduction	The excess production of service (organization produces more services than customer requires), which causes extra inventory, and, thus, other problems in the process.
Inventory	Usage of excess inventory instead of what is actually required to provide service to the customer. **(!excessive inventory hides the problems but does not solve them)**
Motion	Additional time and extra movements of employees (hard to measure in service).
Defectiveness	Reworking services, redoing activities.
Transportation	Movement of materials and information that should be reduced for the non add value activities; can be related to occurrence of waiting time and queues that dissatisfy customers.
Over processing	It includes excess costs with attempt to add more value to service that is needed to satisfy customers.
Waiting	A delay in one activity that impact another activity (thus, increasing the total waiting time).

Figure 10. 7 types of waste in Healthcare

In healthcare there are plenty of examples of these types of wastes. For instance, *inventory* is presented by the number of emails sent by customers, requests, or by the number of patients waiting for chemotherapy (physician, X-rays, etc.). Waste of time – *waiting* – is easy to find in healthcare environment: patients waiting in the long queues, waiting for the clients who are showing up later than scheduled, doctors waiting for the reports from another departments – all these factors cause irritation and loss of time of staff. Extra *motion* can be characterized as the necessity to search for people and equipment, which are placed in a long distance or in the wrong place). Many sources also recommend taking into account an 8th waste – human

potential, which means not using employees ideas and skills. It happens when organizations do not engage employees, do not listen to their needs or do not support their careers.

The important issue is how to find the waste. For this, according to Protzman, it is crucial not to get too attached to the existing solutions and encourage employees from different departments to tour others areas (not the one where they work) to provide a feedback. It could be a list of good things and bad things they witnessed (Protzman et al. 2011, p.78). Continuous improvement requires the organization culture where every employee wills to go and search for waste. The table presented below provides very interesting examples where waste can be hidden in healthcare environment, based on the studies of several authors (Petersson, Bicheno, George, Protzman, Suneja).

Table 3. Examples of 8 wastes in Healthcare (Petersson, Bicheno, George, Protzman, Suneja)

Type of Waste	Examples
Overproduction	• Unbalanced staff scheduling; • Unbalanced material flow; • Having more than needed of anything: supplies, beds etc; • Not notifying food service of diet changes and discharges; • Extra floor space utilized; • Backups between departments, for example, ED to in-patient admit; • 25% of surgical supplies picked and returned to the shelf; • Picking and opening OR instruments but not using them so they must be re-sterilized; • Scrap and wasted food.
Waiting	• Idly watching equipment operate; • Idle people or machines; • Outpatient lab draw results take 1.5 hrs; • Surgeons waiting in between surgeries; • Unbalanced scheduling/workload; • Numerous and large waiting rooms; • Reduced productivity (visible); • Patients wait between multiple appointments; • Techs move patients from PACU.

Transportation	• Having multiple information systems; • Inappropriate bed assignments on admission; • Placing multiples calls to transport; • Excess patient transfer/movement; • PACU or OR backed up; • Temporary warehouses and multiple storage locations; • Walking intermittent samples to lab or going to get prescriptions multiple times; • Staff copies patient chart for transfer between facilities; • Finished patient chart walked to financial counselor
Over processing	• Asking the patient the same questions multiple times; • Placing OR scheduling information in multiple systems; • Excessive duplication in OR, pharmacy, nursing units; • Multiple signature requirements; • Performing services patient does not require, for example, lab work; • Manual distribution of numerous report copies; • Sorting, testing, and inspection; • Duplicating physical assessment at triage and in treatment area; • Punching holes in paper to place in the patient chart.
Inventory	• Complex tracking systems; • Multiple forms, multiple copies, multiple weeks' supplies; • No standardization of supplies; • Long turnaround times on floor beds; • Unused appointment slots; • Empty beds; • Duplication of supplies in temporary storage areas, patient rooms, closets, and so on; • One surgical services cart alone had $250k of sutures.
Motions	• Inconsistent work methods; • Long walk distances; • Centralized printers/copiers/Fax locations; • Searching for anything, for example, equipment; • Multiple patient handoffs; • Poor workplace layout for patient services.
Defectiveness	• Mistakes made in-patient care; • Patient returns (OR, readmit); • Frequent rescheduling of office appointments; • High infection rates and falls; • High incidence of bill rejects; • Inappropriate communication of patient transfer mode with order entry; • Pharmacy refilling "multiple dose" medications.
Waste of Talent	• Staff not tapped for ideas; • Staff not developed by their boss; • Lack of discipline; • Staff waits to be told what to do; • Staff does same job over and over; • Poor morale; • Staff not included in decision-making or financials.

Analysis of the Table shows that when studied precisely, waste in the processes can be facile to spot and can be eliminated using variant lean tools. This simple manual tool allows eliminating waste in short terms and with low expenses. The tools like 5S, Fishbone diagrams, A3 analysis are very applicable in the hospitals and used a lot for waste reducing (more is written in Chapter 3.1.5). Many lean professional recommend involving outsiders (from other departments, for example) to search for waste as they can see the wastes that insiders, who get accustomed to the system, cannot. It is important to observe the following elements of the system:

- People. What are they doing (or not doing)? Are their brains tapped? Is there an idea board in the area?

- Equipment. What is equipment doing or not doing? How smart is the equipment? Where is high-volume equipment, like chemistry or hematology in a core laboratory, located? Is it batch or flow equipment?

- Communication – how do we know if there is a problem? Is the area on plan or on schedule? The area should talk to you.

- Visual Controls – Is the area 5S's? Is the area neat and organized? Are there visual controls in place? Are there any metrics posted? Is standard work posted?

- Leadership – What behaviors does the leadership drives? Is it obvious in the area? Are there audits in place? Did you ask people what are they measured on? Are people afraid of their leaders

To sum up, waste – equivalent to NVA, according to the theory, constitutes around 75% of activities in organization processes, and healthcare environment is not an exception. When considered close, it may be simple notify and recognized, and this is, actually, the first step to improve and optimize all the process.

3.2.2 Challenges of Lean Implementation

Lean implementation can be very challenging for service organization, particularly healthcare, as culture and organization environments have not progressed to where many manufacture companies like Toyota and Volkswagen, where everybody is looking to eliminate waste.

Therefore, lean implementation may meet some obstacles on the way while being applied to healthcare organizations.

Firstly, healthcare, due to it specific characteristics, has a **reluctance to accept advice from industrialists** and apply manufacture theories. Skeptics of lean healthcare (mainly experts in healthcare sector) claim that patients are not like cars and, thus, cannot be treated as such. Moreover, patients and illnesses require a customized approach – opposite of standardization, that lean cannot provide. Healthcare experts suppose that their processes are too unique and sophisticated to be solved with manufacture methods (Poksinska, 2010, p.324). It is hard to persuade workers in the organization to change their mindset to focus on customer value and waste identification, because they might be resistant to new engineering tool as Lean. When considering lean implementation into healthcare processes, it is crucial to take into account that clinicians can be especially resistant to perform the improvements as it is hard to measure (see) how lean increases quality. Additionally, healthcare experts doubt that lean can improve efficiency and productivity (Rosenbaum, 2013, p.36). Lean requires collaboration, teamwork, and communications (Womack et al. 1990, p.123). Meanwhile, healthcare system has a **hierarchal structure** where physicians are considered as main decision makers. As a result of this, there is no proper collaboration between physicians (high qualified workers) and low level of organizations (nurses, assistants) (Suneja et al. 2010, p.16). Consequently, it leads to misunderstanding and embarrasses organization lean journey. Thirdly, another challenge is a **deficiency of training** and experience in **process improvement methodology** in healthcare (Hagland Mark 2014). Furthermore, nowadays, there are few consultants who have both healthcare background and experience in real-life lean implementation (Poksinska, 2010, p.327). In addition, there is the **lack of standardized processes** within healthcare industry. Employees should be aware that working by standardized processes will give them more freedom and empowerment, as well as they will receive information about change managements. But on the other hand, healthcare staff has concerns that standardization and structure in their work can have a negative impact on their skills. Finally, majority of healthcare business staff has a wrong impression about Lean and associate it or becoming lean with cutting costs and eliminating staff. In order to make lean implementation truly successful it is necessary to have a written management commitment not to lay anyone off as a result of continuous improvement otherwise people will not work to eliminate their jobs (Protzman et al. 2011, p.28). Therefore, it is drastically important to dedicate time and efforts to adopt lean

by the whole company.

To sum up, organization that want to start lean implementation, should be determined enough to overcome all the mentioned above challenges. Therefore, it is important to have a solid foundation when building a Lean system. Organization that considers Lean implementation should be ready to change. In the book "Leveraging Lean in Healthcare" Protzman discusses the importance of *change managements*. Lean consists of people and tools. 50% percent of Lean is implementing Lean tools. The other 50% of Lean is "people" piece or what others call ***change management.*** There must be a balance between these two pieces. The people piece includes getting people to accept Lean, to embrace and sustain changes, which is a very difficult culture to create. Nevertheless, nowadays there is a special change equation, originally developed by Gleicher, Beckard, and Harris, and later was slightly modified by Protzman, Mayzell and Kepcher, that shows if organization is ready to change and apple lean transformation or no. Over many years the listed authors have found it very useful while talking about lean implementation and resistance it meets. The change equation is

$C×V×N×S>R_{change}$, *where C = compelling need to change, V = vision, N = next step, S = sustain, R_{change}= resistance to change (Protzman et al. 2011, p.43).*

To be successful with Lean, organization needs more than dissatisfaction. Either it should be an actual "crisis" or business case that, without change, the organization will not survive. The crisis dictates a true **compelling need to change**. The other way is to invent a crisis or to set very high goals for the organization, which could not be achieved by doing it the way it has always been done. This creates a healthy "fear" or paranoia that keeps the organization improving. While this can be done at a department level, it is most successful when started at the senior executive level. **Vision** is important in the change equation because if people understand the vision and the change that is required supports the vision, then this is easier to become accepted. *N* stands for next steps. Once a compelling need was discovered, the next steps need to be determined to get to the vision. These steps come from assessing the current position of organization relative to the vision, and can be done with many Lean tools that help with this letter of the equation. **Sustaining** is the true test of whether there was a compelling enough reason to change and a sign if the other letters were implemented properly. The leadership must be unwavering and totally committed to sustain and continually foster the compelling need to change and ongoing improvement. In the change equation, there is a

multiplication sign between each letter. This is because if any of the letters are zero or are not addressed, it is impossible to overcome the R_{change}, which stands for resistance to change, thus effective change will *not* occur. In addition, each step needs to be followed in order.

Concluding, change is difficult and one must be persistent in order to overcome the resistance to change. To overcome resistance to change, there must be both a compelling need to change and some advantage for staff members if they are to accept it. Lean is tough to implement and very difficult to sustain, and it depends a lot on top management's attitude as leadership must walk the walk. Considering all mentioned above, it is important first to build a solid foundation before implementing lean in healthcare. All the challenges – resistance to change and accept manufacturing tools, hierarchical culture, variety, and others – can be overcome with a proper built culture, and the last one depends on the Leadership.

3.2.3. Role of the Leadership (building Lean Culture)

Lean is a journey and should be considered as a whole-system strategy. It is crucial for leadership to understand that no "silver bullet" solution, such as a new computer or automated equipment exists, which can increase the efficiency of the processes. Moreover, efforts of only middle managers or frontline workers are not sufficient for success. The role of the leader and his attitude to the project defines if lean journey succeed or not. To overcome all the challenges presented above, every organization transformation requires a leader with, according to Suneja (p.121) consumption (who has long and successful experience in lean) following competencies (Figure 11):
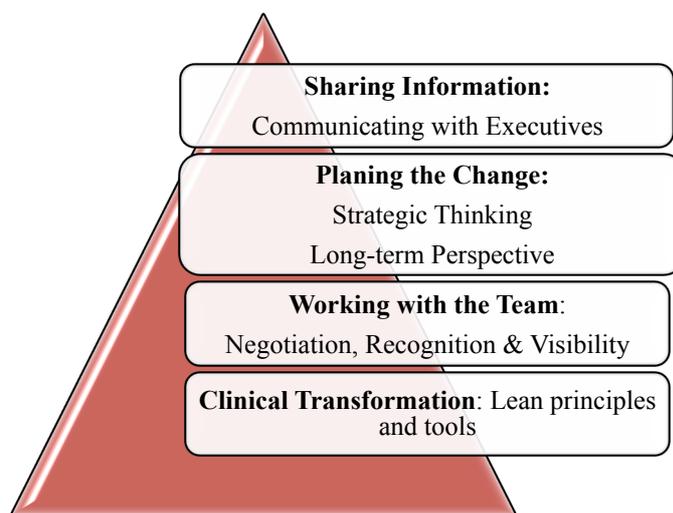
Figure 11. Lean Leader Competency

As seen on the figure above, lean leader has considerable number of skills required. Leader should intervene and require people to behave distinctly, encouraging them to experience a better set of results. Once Lean is implemented, the project leader has to accept that any problem that shows up, even if the organization has had it for the last 30 years, will now get blamed on Lean (Protzman et al. 2011, p.85). It is critical to supply initial and ongoing training on how to manage in Lean environment and provide opportunities to train new managers and employees in Lean thinking. The senior leadership team must drive accountability to sustain Lean implementations through their line organization and continue to coach and develop the process owners. Lean guru Womack believes that to deliver a superior order of performance, leaders should lead from the workplace, the "gemba" to use the lean term (it means real place, real products, real people) and not from the boardroom. "Gemba" leadership turns this idea on its head, asserting that superior results will be achieved if leaders spend all their time encouraging small-step continuous improvement at the workplace ("kaizen") and learn about their strategies and processes from working with their people rather than thinking in their stead.

In the article "Lead With Respect", M. Balle (Balle 2014) makes an attempt to take a closer look at "gemba" management skills and to give them a broader context in terms of company performance. Based on his consumption, the following "gemba competences" and behavior are required to lead with respect.

(1) **Go and see for you -** to see the facts firsthand rather than read reports. By looking at specific cases at the patients' or at the workplace, leaders can better understand context and values. Furthermore, the key to sustainable continuous improvement is to get people to agree on the problem before they start arguing about solutions – go and see is a foundational political as well as technical skill.

(2) **Challenge is** the energy that fuels the continuous improvement engine. Challenging means demanding that visual control should always more be more precise and better owned by operators, that problem solving be more rigorous and seeking root causes, that process improvement deliver more results and more customer oriented.

(3) **Listening** - looking out, at the workplace, for the specific obstacles that get in the way of employees doing their job well, whether thankless tasks, poorly performing equipment or suppliers, asking them to do things beyond their competence level or personal difficulties.

(4) **Teaching** problem-solving skills and improvement skills. The trick is to focus on problem

solving and improvement efforts, which enable leaders to delve quickly into technical issues even though they do always master the ins and outs (on the other hand, managers do have the larger context).

(5) **Support.** It means saying "go ahead" to people when they come up with new, untested ideas, especially when it goes against the grain of organizational habits. The skill lies in learning to listen and discuss well enough to avoid having to say no to hare-brained schemes and encourage instead very small risk-free steps.

(6) **Teamwork** means being able to solve problems across functional boundaries, as it is the key to successful process improvement. In order to establish the right grounds for process improvement, leaders must constantly develop teamwork by teaching individuals to work with their colleagues across functional silos.

(7) **Learn. Finally,** as the leader gain in experience with "gemba" walks, he learns along with staff members. By involving oneself deeply in problem solving and employee initiatives, leaders discover that their mental maps are not always framed in the right, fit-to-fact manner. As people on the ground learn, you learn, which is probably the most profound discovery (and message) of lean leadership.

Implementing lean thinking requires major change management throughout an entire organization, which can be traumatic and difficult. Therefore, strong commitment and inspiring leadership from senior leaders is essential to the success of an effort this challenging. The CEO must be a vocal, visible champion of lean management, create an environment where it is permissible to fail, set stretch goals, and encourage the staff. Well-aligned senior management team with profound lean understanding is crucial for successful lean implementation (Miller et al. 2005, p.6).

4. CASE STUDY ANALYSIS

Lean has been successfully implementing during the last decades by many healthcare organizations. However, not all of them have achieved success. This chapter observes several successful examples of using Lean approach by famous healthcare organizations: Virginia Mason Medical Canter, Orthopedic Center of Children's Hospital of Wisconsin and ThedaCare. The choice was done based on the availability of information about implementation cases in the open access, and the high rate of citation these organization in the resources with the topic as "Lean Healthcare" and etc.

4.1 Virginia Mason Medical Center

*Virginia Mason Medical Center in Seattle, Washington, has been using lean management principles since 2002 (*Virginia Mason Institute*). Virginia Mason has created more capacity in existing programs and practices by eliminating waste, so that planned expansions were scrapped, saving significant capital expenses: $1 million for an additional hyperbaric chamber that was no longer needed; $1 to $3 million for endoscopy suites that no longer needed to be relocated; $6 million for new surgery suites that were no longer necessary* (Miller et al. 2005, p.16-17*). Using lean principles, staff, providers and patients have continuously improved or redesigned processes to eliminate waste, requiring fewer staff members and less rework, and resulting in better quality. Consequently, as employees retire or leave for other reasons, improved productivity allows for them not to be replaced. The results of the first two years of this lean imitative are presented in the table below (Table 4).*

Table 4. Results of 175 Rapid Process Improvement Weeks at Virginia Mason Medical Center
(Source: Virginia Mason Medical Center)

Category	2004 Results (after 2 years of "lean")	Metric	Change from 2002
Inventory	$1,350,000	Dollars	Down 53%
Productivity	158	FTEs	36% redeployed to other open positions
Floor Space	22,324	Sq. Ft.	Down 41%
Lead Time	23,082	Hours	Down 65%
People Distance	Traveled 267,793	Feet	Down 44%
Product Distance	Traveled 272,262	Feet	Down 72%
Setup Time	7,744	Hours	Down 82%

Analysis of the table shows that in a period from 2002 to 2004 the staff walking distance within the medical center reduced by 44%, and the travel distance of parts by a whopping 77%. Inventory was cut in half. Lead-time within the medical center decreased by 53% over two years. There was a 36% gain in productivity, which is the equivalent of 158 full-time employees redeployed within the medical center.

The idea of Lean implementation has come out of the need, critical need to change organization. In the beginning of the millennium Virginia Mason medical center faced significant challenges – it was loosing money, staff morale was declining, other hospitals from the area were presenting ardent competition. In addition to these negative factors, there was a safety challenge raised as the Institute of Medicine had reported about the huge number of people dying because of medical errors that occur in hospitals. Thus, the new CEO Kaplan decided to change the strategy and railed the organization around a new strategic direction towards becoming the quality leader in healthcare industry (Bohmer et al. 2008, p.2). He put a huge emphasis on the role of leadership and dedicated plenteous amount of time and efforts to change the organization. The CEO has studied TPS production precisely, and came to a decision that *"It seemed perfect at every level"* (Bohmer et al. 2008, p.3-4). TPS appeared to be the method the medical center had been seeking to implement its strategic plan. Thus, the leader of Virginia Mason designated a special committee, which consisted primarily of physicians and administrative employees, to create an explicit physician compact. After twelve months of work, the compact with new goals and patient focus was created (Appendix 6). The next step was to develop a strategic plan that put the patient first and created a new vision – to become the industry quality leader. VMSP was presented as a Pyramid (Figure 12):
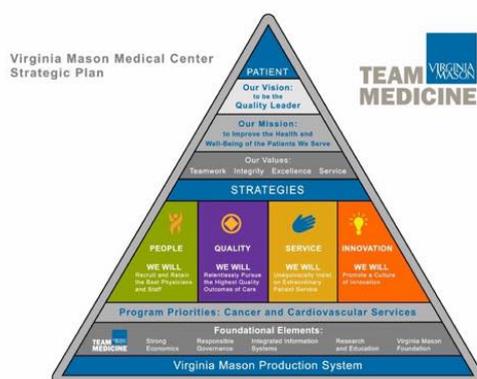
Figure 12. Virginia Mason Medical Center Strategic Plan

As seen from the table above, VPS's primary customer, the patient, is at the top, supported equally by four "pillars": people (recruiting and retaining the best staff), quality (a focus on achieving best outcomes), service (to internal and external "customers"), and innovation (supported by the culture). **The goal at Virginia Mason was to design the system and its processes around the patients' needs.**

Implementation of lean was not effortless. At first, Going Lean in Virginia Mason faced some challenges – mainly, resistance from board and employees. As one of the strategic goals was to increase the staff morale, **No Layoffs Policy** was established, in order to engender full commitment from the VMMC workforce, which has caused several problems. It required rigor around attrition and hiring. Labor costs amount 78% of total hospital costs (Bohmer et al. 2008, p.4), and the wish to reduce them was high. However, company has investigated another solution - to accomplish lower labor costs is not to hire replacements when people leave, and redeploy others. For instance, one good example of redeployment happened in the audiology department: after the workshop it was discovered that there were two and a half too many audiologists, who are highly trained professionals with advanced degrees. The organization ended up redeploying one of our best audiologists to a project manager in the operating room, with equal pay, and she was very satisfied (Bohmer et al. 2008, p.5). The other challenge was staff resistance to apply manufacture methodology in healthcare. Many physicians and nurses issued that "they do not make cars but treat patients". They were skeptical about the benefits of Lean management, insisted that lean tools, such as standardization, threatened their ability to perform such core competencies as diagnosis and treatment selection, stifle their autonomy and clinical creativity. As a result of this resistance, 10 physicians left the medical center – sometimes it is necessary to let "naysayers" go instead of trying to convince them in the rightness of implementation.

In the chapter 3 it was highlighted that Lean implementation and transformation of organization requires a profound **infrastructure.** In VMPS to support the massive undertaking of implementing a special infrastructure was designed around VMPS operations and *kaizen* promotion offices (KPOs), which was responsible for overseeing, leading, and coaching units through RPIWs, as well as facilitating everyday lean. Later, as VMPS evolved, the infrastructure has expanded as well. Hence, in 2005 the medical center had three KPOs: corporate, hospital, and clinic, with each with six full-time staffers. This expansion resulted in RPIW goals that were better aligned with organizational goals, the creation and tracking of

explicit measurable targets, and accountability for implementation and sustained results. Every of 5,000 Virginia Mason employees was trained and educated by VMPS specialist: an introduction to VMPS and everyday lean and "how-to" courses on value-stream mapping and mistake proofing, data collection and analyses, and etc. (Miller et al. 2005, p.14). Furthermore, twice per year VMMC employees, from senior executives to physicians to nurses made trips to Toyota's head office and factories in Japan to observes and work the shop floor at Hitachi in a *Gemba Kaizen* (continuous improvement workshop).

Overall, VMMC dedicated 20 full-time employees ((who were redeployed from their previous roles within the medical center) to the planning, implementation, and maintenance of VMPS. The financial commitment to VMPS was large, but administrators justified the expense as "avoided costs." - felt that financial gains through improved efficiency outweighed the labor expense. Well-organized infrastructure yielded higher efficiency improvement and showed the human capital was a worthwhile investment (Bohmer et al. 2008, p. 3).

In Virginia Mason Medical Center the following lean strategies were used: VSM, RPIW, 5S, 3P, Everyday Lean, Patient Alert System, Bundles, and etc. Some of them are described below in more details to show an example of their implementation in healthcare organization.

Value-stream mapping (chapter 3.1.1.) is a simple flow chart with associated medical-center metrics. Kaplan saw the value-stream map as the foundation of VMPS. In Virginia Mason early value-stream mapping encompassed patient check-in and visits, flow of equipment, and inventory (Appendix 1). During lean transformation all the departments within the medical center had engaged in value-stream mapping. An example of the evolution of value-stream mapping can be demonstrated on the oncology unit: after value-stream mapping such activities as patient check-in and laboratory processes, the oncology unit decided to track a patient with breast cancer from the point of diagnosis through to the completion of treatment. The resulting value-stream map (Appendix 2) followed the patient from the moment a provider revealed a positive biopsy through the various departments available to each patient, cancer conferences during which specialists discussed the diagnosis and treatment selection possibilities, and treatment options available. In the Future State (Appendix 3), the oncology unit was expecting to include standard work around patient follow-up, so that patients were able to choose which provider they wished to follow up with

their primary-care physician or oncologist, with the knowledge that their follow-up process would not differ between providers (Bohmer et al. 2008, p.8).

RPIW is another important component of VMPS. Rapid process improvement workshop (RPIW) is a five-day event designed to eliminate waste, improve processes, and increase both efficiency and productivity in the participating unit. RPIW teams defined the existing process and set targets for the new process before spending over two days observing, measuring, and brainstorming on the existing process. On the fourth day, the team established new or improved existing standard work and on the fifth day "reported out" to the organization. RPIWs measured specific targets such as staff walking distance, inventory turns, and quality for specific tasks, such as ambulatory specialty scheduling, inpatient incomplete chart processing, or rehab medicine patient flow. Target progress report was utilized to track the metrics. Initially, RPIW was focused on designing mainly standardized processes and to tackle "low-hanging fruit", but with time it was tailored to align with organizational goals.

5S is a simple tool (Chapter 3.1.2) that enables organization of physical space. It was used as a visual system for organizing the workplace, stood for sort, simplify, sweep, standardize, and self-discipline. In VMPS, a clean and orderly space enhanced quality and productivity because less time was wasted searching for tools and problems were more salient (Appendix 4).

3P - production, preparation, process, was an improvement strategy used to radically redesign space according to flow. By utilizing 3P, unit providers and staffers examined ways to improve service delivery, introduce new services, and complement process design changes. 3Ps throughout the medical center resulted in over 10 million of saved capital budgeted dollars (Bohmer et al. 2008, p.9).

Everyday lean is yet another VMPS tool that encouraged all employees, at every level within the organization, to creatively change the approach to their jobs in order to reduce waste and add value for patients. Embracing the concept of *kaizen*, employees were encouraged to identify areas for improvement, innovate solutions, test solutions on a small scale, and measure the effects. The everyday lean idea form standardized the process of submitting proposals and implementing successful solutions. Virginia Mason held monthly contests to recognize the top three employee ideas based on applicability, ease of implementation, and

how well the standard process was followed. Between June and September 2005, employees suggested 87 lean ideas, 80% of which were implemented (Bohmer et al. 2008, p.9).

Patient safety alert system PSA was a direct result of a factory visit to Japan and seeing the *andon* cord in action. The PSA process was a commitment by all employees to "pull the cord" when any safety hazard or mistake was identified. The process notified senior leaders, who immediately addressed the root cause of the problem on-site. For instance, in the dermatology unit, a medical assistant prepared two syringes for a surgical patient. When the physician injected the first syringe, the patient reported discomfort and a lack of numbness in the surgical site. The physician, suspecting that the medication mix in the syringe was incorrect, aborted the procedure, informed the patient of the error, called the pharmacy for advice, and sent the patient to observation. Later on, VMPS instituted a medical emergency team (MET), composed of a hospitalist, critical-care nurse, and respiratory therapist, who responded to calls on any hospital floor and assisted in the evaluation, assessment, and management of patients in an effort to improve patients' status, reduce critical-care unit admissions, support and educate floor staff in real time, and prevent emergency situations.

Bundles In 2004, VMMC consulted best practices from medical literature and publications by the Institute for Health-care Improvement (IHI) and instituted "bundles" into VMPS. Bundles at VMMC included specific steps to prevent ventilator-acquired pneumonia, surgical-site infection, and central-line infection and to improve myocardial infarction care. The bundles came out from best practices, or evidence-based interventions, were discovered through robust scientific experimentation and widely agreed to be the preferred method. A great example of bundles eliminating risk factor occurred with reducing ventilator-acquired pneumonia (VAP). According to the IHI (Miller et al. 2005, p.17), the four practices known to dramatically reduce incidences of VAP were elevation of the head of the bed between 30 and 45 degrees, daily sedation and assessment of readiness to extubate, peptic ulcer disease prophylaxis, and deep venous thrombosis prophylaxis. In the critical care unit at VMMC, nurses employed standard work such as checklists to ensure that each patient received the appropriate bundled care by using the principles of VMPS to reliably get evidence-based bundles to every patient. Overall, using bundles provided a significant decline in total cost to medical center for VAP cases from $500,000 to $15,000 in the period of 3 year (2002-2005) (Bohmer et al. 2008, p.10).

Another important goal of Lean (and TPS, originally) is "mistake-proofing" standard processes, or investigating the root cause of mistakes and immediately instituting countermeasures to avoid repeating those mistakes. Thus, during lean transformation, Virginia Mason set a goal to achieve zero defects.

Summarizing, the following six areas of focus brought VMPS success:

- Patient First as the driver for all processes;
- The creation of an environment where people feel safe and free to engage in improvement, including the adoption of a "No-Layoff Policy";
- Implementation of a company-wide defect alert system called "The Patient Safety Alert System";
- Encouragement of innovation and "trystorming" (beyond brainstorming, trystorming involves quickly trying new ideas or models of new ideas);
- Creating a prosperous economic organization primarily by eliminating waste;
- Accountable leadership headed by Kaplan (Miller et al. 2005, p.15).

Concluding, VMPS has resulted in significant improvements within the medical center. Implementing Lean was a successful cost-saving and quality-improving effort. Word of VMMC's success spread, and had a positive impact on many other healthcare organizations to start lean initiatives.

4.2 Orthopedic Center of Children's Hospital of Wisconsin (Lean Doctors)

The transformation in the Wisconsin Hospital has resulted in a book "Lean Doctors" and complementary workbook by Aneesh and Carolyn Suneja, and was held in a very different way from VMPS. As a result of this Lean journey, the Orthopedic Center increased its "fractures patient volume" (the number of patients seen with bone fractures) by 25%, in the same amount of time, with the same umber of staff – and using 25% fewer exam rooms. The important healthcare measure of "time to next appointment" has been reduced by more than 33% (from 3 weeks to less than 2 weeks). Weekly access for new fracture patients has increased by 20%. And the clinic has reduced patient wait times by ore than 70%. The summary of these results presented in the table below (Table 5):

Table 5. Clinic results (Source: Suneja, p.11)

Category	Before	After	Metric	Change, %
Patient Volumes (4-hour clinic)	40	50	Number of Patients	Up 25
Space	6	4.5	Number of Exam Rooms	Down 25
Space Utilization* (PA clinic created)	0	6	Number of Patients	Up 100
Patient Wait Times	38	11	Minutes from Door to Provider	Down 71

The main challenge on the way of Lean implementation in this case was the same, as in Virginia Mason Organization - resistance of the physicians, as they are highly educated professionals who spend years gaining the knowledge and experience and do not believe in the success of manufacture methods in healthcare organization. In addition, it is known that in the hospital environment (as were mentioned before in Chapter 3.2.2) physicians have a certain area of authority that creates distance between them and rest of the stuff – as a result, the rest of the staff learns to work around the physician. Thus, majority of quality improvements focus on the roles of nurses, physician assistants, clinic assistants and others play – in isolation from the physician.

The key idea of the chosen approach - one doctor at a time, one department at a time, is to transform one area before moving on to another – to make true and deep changes that take hold and then allow the changes to migrate naturally as world of their success spreads (Suneja et al. 2010, p.16). Thus, the author of "Lean Doctors", carrying out this Lean journey, decided to focus on one physician and his team. The chosen team was forced to improve its communication and dynamics. As a result of these efforts, with time the culture of the team has changed so that the members (employees) started to include quick and brief experiments to solve occurring problems in the real time, focusing on performance goals rather than interpersonal dramas, and continually discussing ways to make the process more efficient and more effective.

Suneja's method requires a motivated manager and committed physician. Starting point of this lean implementation was to choose the leader who is interested and capable to create the atmosphere where all the team members are open to trying new things and looking for ways to improve (Suneja et al. 2010, p.22). Thus, a "willing victim", that was chosen, was a well-

respected by his team physician, who has established an open communication among the nurses, nurse practitioners, was open to trying new ideas and learning more about business leadership skills and quality improvement. This healthcare professional is the critical element in healthcare delivering process, was sincerely willingness to be a part of the work and eager to try something different (flexible but with strong enough personality).

One of the key focus features in Wisconsin Clinic transformation was focus on **wait times**, which is an important metric in healthcare. Waiting time is but one aspect of health care that patients' value, and its centrality to patients' assessment of their primary care visit compared to other aspects of the health care experience is uncertain. Between vast amount of data in healthcare, such as patient satisfaction surveys, rate of medical errors and so on, wait time is fairly easy to understand as it has a direct connection to the efficiency of the organization and can be directly influenced by the staff. It is highly visible indicator of organization performance. Wait times provide a framework to develop a Lean Mindset, focused on evaluating and improving (Suneja et al. 2010, p.37). It is crucial to understand that wait times do not influence the actual interaction between the patient and the doctor. And, as an added benefit, wait times provide a simple source of happiness to the staff – the ability to leave work on time or even earlier. The focus for lean team was simply on organizing patient meeting with the doctor as quickly as possible, meanwhile reducing the wait time for test results or antibiotics administration. However, it is necessary to take into consideration that patients can still be satisfied even if they have to wait, as their ultimate goal is to get quality time with their doctor. They are accustomed to it. (p.31) In the article "Willing to wait", the authors have concluded that longer waiting times are associated with lower patient satisfaction, but the time spend with physician is the strongest predictor of patient satisfaction. Thus, the decrement in satisfaction associated with long waiting times is substantially reduced with increased time spent with the physician (5 minutes or more). Importantly, the combination of long waiting time to see the doctor and having a short doctor visit is associated with very low overall patient satisfaction. These results suggest that shortening patient waiting times at the expense of time spent with the patient to improve patient satisfaction scores would be counter-productive. (Anderson et al. 2007)

Ideal situation is to reduce waiting times without rushing the physicians from patient to patient. This can be achieved by reducing the many and varied sources of waste from the care delivery process. Thus, the first step is to collect all the possible data about one physician

practice, which can turn into "eye-opening" moment as it is seen that patient may have spent 60 minutes at the clinic but only received 2 or 3 minutes of the value-added time. This direct observation can be simply done with pencil and note, while collecting statistics data about the patients – how long they spend at check-in, in waiting room, exam room, with follow-up care providers, visit the physician (Suneja et al. 2010, p.35). Various Lean tools described before (Chapter 3.1) can be used to reach this goal.

In Orthopedic Center **lean transformation was made in six steps.** The approach chosen by Suneja was a combination of: "one physician at a time" plus "patient waiting time", and it consisted of six following steps (Figure 13) (Suneja et al. 2010, p.9):

1. Create physician flow
2. Support physician value-added time
3. Visually communicate patient status
4. Standardize everyone's work
5. Layout the clinic for minimal motion
6. Change the care delivery model
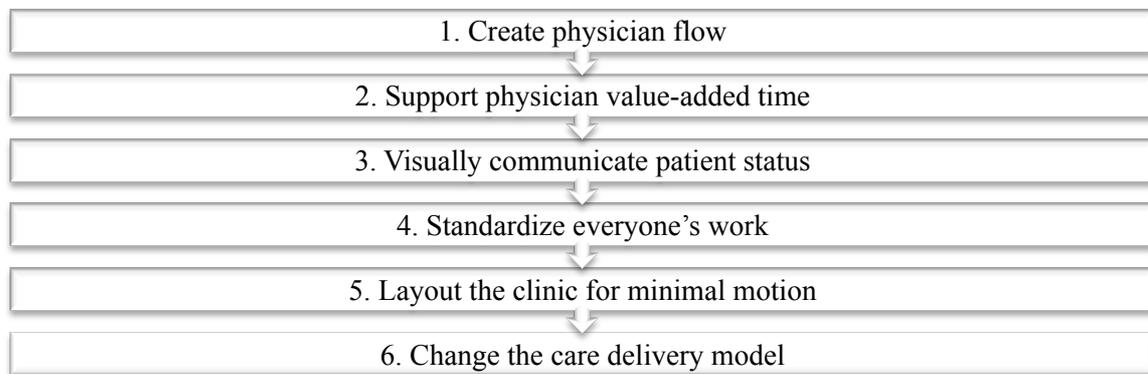
Figure 13. Six steps of Lean Implementation

The first one was to create a physician flow. It meant to create a process that allows the doctor to move from one patient to another in an efficient manner, with the necessary information in hand and clear direction (Suneja et al. 2010, p.45). In healthcare environment the physician is always the driver of the patient care process, and the quality interaction with the physician is one of the primary determiners of patient satisfaction (Anderson et al. 2007). Thus, it is crucial for healthcare organization to make sure that each physician has enough time to meet patient's expectations, and that is the reason for the chose approach. Moreover, it can be useful to take responsibilities for all paper work or file dictations from the physician as it will enable him to have more time available, or, in lean terms, will increase physicians' capacity, and, therefore, throughput.

Flow in healthcare can be defined as an ideal state in which the person going through a process and never stops moving from the beginning to the end. It means that the patient comes into the clinic, is immediately checked in and roomed, has any diagnostics tests or z-

rays performed, is seen by the physician, receives a diagnosis and care plan, and leaves (Suneja et al. 2010, p.49). However, the following factors can influence negatively on the flow (interrupt it): patients scheduled in the wrong clinic or for the wrong amount of time, emergencies that are squeezed onto an already full schedule, administrative tasks that are expected to be filled in between the patients or the doctor not having necessary information or which patient is next. Chosen approach considers the physician as a centerpiece of the process, thus, the goal is to make him (physician) flow from patient to the next without interruption. Physician is a *machine* through which all of the patients must flow. The goal in Orthopedic Center of Children's Hospital of Wisconsin was to eliminate *changeover time* between patients for the physician. Changeover, in the considering healthcare approach, begins when physician finishes one patient's consultation and end when he walks into the exam room to see the next patient. Thus, to reduce this time it is important that by the time physician leaves one patient the next one is prepared for the interaction with physician: ready in the next exam room, complete with paperwork, radiology films and all necessary information' (Suneja et al. 2010, p.51).

Focus on changeover has resulted in timesaving of several minutes per patient, and multiplying those minutes per 40 patients a day –into hours (Suneja et al. 2010, p.51). As organizations reduced non-patient facing physician times in a clinic to the minimum, it began end on time, and, in addition, opened up opportunities for the physician to increase patients' volume or consultation time to form deeper doctor-patient relationship. Decrease of waiting time was achieved in Wisconsin Hospital by the use of the VSM that was focused on particular staff members' workflow or other processes. It showed the detailed steps of the process, had data about critical metrics about the time each step takes and how often that step is done right at the first time, and the picture of communication among different roles in the clinic at each step (more about VSM tool in Chapter 3.1.1, examples – Appendices 1,2,3). Created VSM provided immediate opportunities for change – showed the areas to conduct quick experiment to make improvements. For example, after building VSM of physician process, the lean implementation team found out that the physician was often frustrated with the seemingly disorganized patient information from the nurses: too much information was irritating and had a negative impact on his productivity and morale. Thus, the team, consisting of physician and nurse agreed about 3-4 things the physician actually needs during his work, made this process standardize and, as a result, quickly solved a problem.

The second step of lean transformation of Orthopedic Clinic was to support physician value-added time. In Suneja's approach, physician is considered as a shared resource, and, ideally, should do only value-added work, while the staff in perfect synchronization does changeover tasks. Thus, special **team leader** position was created: an employee (not physician) that coordinates staff schedules and scheduling templates, keeping track of where patients are and where the doctor is, and resolving the issues that interrupt patient flow (Suneja et al. 2010, p.58). This enabled physician to better concentrate on patient consultation and diagnosis. The **team leader** is pivotal to a lean transformation, as due to his presence, the clinic ran much more smoothly and staff appreciated that someone was coordinating their patient schedule and workday. According to Suneja's and lean team members' experience, *"creating the team leader position was a key"* and brought such benefits as feeling that someone is "driving the bus" in the team, clarity in the roles and responsibilities, removed the feeling of chaos from a busy clinic, influenced the ability of clinics to stay on schedule and end on time (increase patient and staff satisfaction), and, was a key to move Lean transformation (Protzman et al. 2011, p.44). In Wisconsin Hospital a nurse with extra level of responsibility was chosen as a team leader. It is important that team leader knows clinic's demands and process inside and out, and has been working with one doctor to learn and supply his preferences and individual style. Team leader is not a supervisor, but he/she ensures patient and physician flow, tracks data on a glass wall, identifies and solves problems, engages staff and cross-trains and develops leadership skills. In the considering example, team leader was responsible for maintaining the lean system and driving it forward by the following activities: *clinic preparation, monitoring and measurement*. Thus, *clinic preparation* required leveling the schedule at the shared resource (physician) – to examine the scheduling template to be sure that the mix of patient types and the length of appointment slots will help create the flow, rather than bottlenecks. In addition, team leader supported the front line workers by removing potential problems before they disrupt the clinic flow. As a result –preventable problems and sources of waste are taken out of the system. *Clinic monitoring* means that tem leader should solve bottlenecks, such as too many patients waiting at x-ray, making sure all the patients are "ready" for physician examination to support value-added time. Team leader also conducted *clinic measurement* by maintaining the glass wall of metrics. Glass wall is bulletin board where graphs of key metrics are posted, for example clinic errors (missing radiology films), patient volume by injury type or complexity, patient/staff satisfaction, physician volumes, nurse line calls, staff hours worked, time to next

appointment, etc.. It is vital to collect data honestly and present concrete numbers (Suneja et al. 2010, p.64).

The thirds step was to build a visual patient communication status – so called "crystal ball". The Lean concept of ***visual communication*** uses markers, signals, and sign to create a system of autonomous control that requires at the least possible supervision. This system communicates the status of a given process to the entire working team so everyone can tell what is in progress, what is working, and where the problems are (Jeney, 2009, p.32). The goal of this system is to transform important information as quickly as possible, by the experts performing the work. Using visual communication tools provided essential information and performance feedback to all team members in order to encourage problem solving, process improvement and decision-making activities. In the healthcare organization, clinic status board was established to tell the staff where in the clinic each patient is located. As the patient moves through the care process, the team leader moves the magnet into the appropriate column. Thus, all the staff knows where is the patient, where are bottlenecks and etc. (Figure 14) (Suneja et al. 2010, p.71). It is always monitored and updated by the team leader.

Figure 14. Status Board in Use (Source: Suneja, p.71)

This board can be added with details, different colors magnets can be used to show new or follow-up patients and etc. The key idea is to keep physician up to date, or keep the people telling physician what to do next.

In addition, other visual communication tools can be used to let the physician know where to go next: the flags outside the door (a red flag mean go here next), the names on the board in the MD column, the countdown number on the board, and the team leader directing traffic.

The next step was to standardize everyone's work. Standard work tool has been already described fairly precisely in the Chapter 3.1.3. A good example of standard work form, developed during this Lean journey, is presented in the Appendix 5. When staff clearly understands how something functions, it makes him/her more aware, and provides and opportunity to job better. The advantage of standard work is an opportunity to look at things differently, notice wastes, error. Moreover, it allows to capture best practices, make improvements, discover unbalance and correct it, work smoothly, and know how many resources are needed at any time of the process (Suneja et al. 2010, p.84). Developing standard work clarified roles and expectations of the staff, provided a forum for discussions about methods and improvement, and enabled to removes the root causes of many kinds of workplace conflict. Furthermore, standard work makes training new employees easier.

After the first steps were done, the fifth was to **change the clinic layout for minimal motion**. Lean approach states that work environment affects work's performance. Thus, several tools – 5S, waste reduction, and Spaghetti diagram were used to improve the layout in the clinic. It has resulted in three new elements that had appeared in the Orthopedic clinics: an extra door to each exam room (on-stage, off-stage), a common work area are for all the clinic staff, including physicians, and a co-located radiology department (Suneja et al. 2010, p.103).

Finally, the last **sixth step - changing the care delivery model.** It means that lean leaders decided to create the process that truly put **the patients at the center** of the healthcare environment. First five steps make the process stable and free of waste and confusion, and then it was necessary to move from traditional separated departments to "mini-factories" or "cells" (Suneja et al. 2010, p.109). Healthcare organizations are often organized in departments that resemble traditional manufacturing, which requires transportation between departments and make the scheduling process complex. The concept of *patient-centered organization* calls for aligning resources around the patient (no need for patient to travel). *Cells model* enable to evaluate patients with similar needs and require similar services (sport or head injure, scoliosis, baby born with a club foot), and then form them into patient families. After that, different patient families are scheduled separately (Sunej et al. 2010,

p114). Providing services in the exam room is the easiest cell-creation step to execute. In this lean implementation process, the director of Orthopedic Center decided that rather than having the patient eave the exam room and move to a casting room where the casting technicians would put on cast, the casting technicians could be roomed to the exam room. It allowed easier communication between physician and casting technicians. Hence, co-location specialist together when needed turns into better communication, and less errors and waste.

One of the crucial factors that made Lean implementation successful in the Orthopedic Clinics was the active participation of the Leaders in the project **(leadership).** Lean is a philosophy that is "pulled" from the bottom up rather than "pushed" from the top down. It is very vital to the success of Lean transformation, as it must be "owned" by the front line workers in any organization, the people who do nitty-gritty day-to-day work (Suneja et al. 2010, p.119). Commitment from the senior leadership is key. There are three important elements: ownership for the whole system, a sense of community and a common language (more detailed Chapter 3.2.3). An example of this leader's involvement occurred when clinic visual board was established in the Orthopedic Clinics. The head of the department spent first three days staying next to the board making sure that everyone uses it consistently (Suneja et al. 2010, p.75). This is important and shows the active leader participation in the process. Lean leaders responsibilities include close collaboration with the team: negotiation, ability to focus on others interests and to consider the other person as a partner in problem-solving, receiving feedback, encouraging and motivating team, strategic thinking, organizational support and etc.

Summarizing all studied above about this lean transformation, it can be noted that this lean implementation has spread through organizations through small and quick changes, which initially took place only in "one physician" team. This model lined provided immediate feedback, opportunity to test new approaches quickly (which turned both into fails and successes), was a so-called "learning lab". As a result, significant improvements that affected patient outcomes, patient satisfaction, and staff satisfaction have been achieved (Suneja et al. 2010, p.27). These studies lean journey resulted in the book "Lean Doctors", which is highly demanded in healthcare community nowadays. Some of the ongoing problems were solved, new more transformative challenges surfaces. The work that started with one team in one department has expanded to other departments.

4.3 ThedaCare Health System

ThedaCare is a health delivery system based in northeast Wisconsin and nationally recognized for its quality performance results. ThedaCare is one of the U.S. "most wired," or computer-savvy, health care institutions. Lean journey was imitated in the organization in 2004 and the leaders set ambitious and specific goals to kindle a culture change. They wanted to improve quality to "world-class" levels (95th percentile or greater), become the health care employer of choice, making the Fortune 100 list of best employers, and, finally, to reduce costs in order to lower the price paid for services, gaining $10 million a year through cost savings and increased productivity (Miller et al. 2005, p.14). In this chapter, lean transformation of ThedaCare is shown briefly, highlighting the result and key tools used, due to the deficiency of the material in the public assess. Visual representation of the goals was made in graphics in order to help all staff visualize them (Figure 15).

Figure 15. The goals of ThedaCare (Source: ThedaCare website)

As it is seen from the figure above, the key focus was on quality and safety of the services, financial stability and people. The patient was considered at the center of these goals. As a result of how the ThedaCare health system transformed their culture by redesigning the system of daily managements appeared a book "Beyond Heroes: A lean Management System for Healthcare".

ThedaCare put an emphasis on the fact that each organization should take benefits from its most important active – the brainpower of its staff (Miller et al. 2005, p.15). On the contracry, if organization does not do it – that is the 8th waste in lean classification. In many cases, the

waste is the result of time the staff spends "putting out fires" and that designing processes that work better reduces waste and enables staff to better meet the needs of patients (types of wastes and how to distinguish them in healthcare organization were studied in details in Chapter 2.2). In ThedaCare, staff participation in at least one Event Week is mandatory for everyone (staff can choose from six different Event Week topics each week). Its goal is to develop their people to solve problems and to improve performance (ThedaCare Website). Teaching through experience is useful as people learn best when they are directly involved. The rapid results of the work - *"What gets designed on Wednesday is implemented on Friday,"* demonstrates for participants the power of their work and helps to build momentum. The three tenets of the ThedaCare Improvement System Event Weeks are:

- Respect for people;
- Teaching/learning through experience;
- Focus on world-class performance.

ThedaCare tracks a range of outcomes related to lean management, including number of Event Weeks, number of employees who have participated in at least one Event Week, significant quality improvements, and financial measures (Miller et al. 2005, p.15).

The following lean tools were used to form the lean management system in the organization (Figure 16):
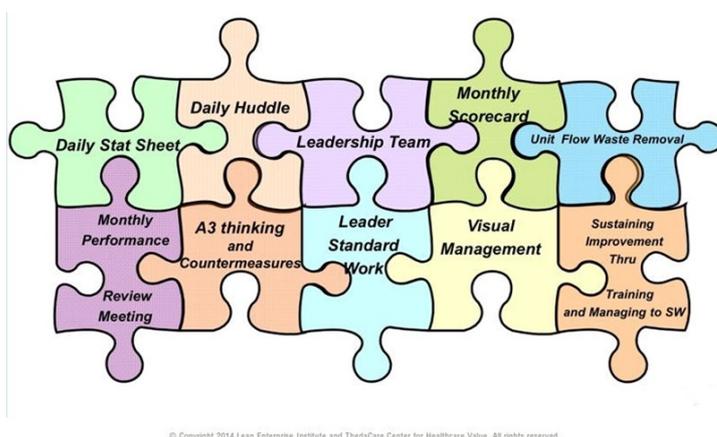
Figure 16. Lean tools implemented in ThedaCare (ThedaCare Website)

Analysis of this figure shows, that the most frequently used methods in the other healthcare organizations are present here as well: Standard Work, Visual Management, Problem-Solving Solutions, and etc.

Summarizing ThedaCare lean experience, it can be stated that focus on such aspects as improving staff moral, quality and productivity leads to the positive results. It is essential for leaders to dedicate significant amount of time transforming organization into lean and maintain "lean activities", for example held Weekly Events.

4.4 Summary

In this chapter three examples of successful Healthcare organizations – Virginia Mason Medical Center, the Orthopedic Department in Wisconsin Hospital and ThedaCare center, were considered in order to understand the nature of their lean transformations, distinguish success factors and mostly used tools and methods.

The key goal for all of them was to *create flow of patients from one to another while scheduling appointments.* These organizations have used various approaches and various scales for conducting their lean journeys. Therefore, the main difference of Suneja's approach in the Orthopedic Department of Wisconsin Hospital from the experience of Virginia Mason Medical Center is that he decided to go small, starting just with one team instead of making attempts to change the whole system at a time. This method has a huge advantage – without requesting vast expenses, the words of team's successful transformation started spreading in the whole organizations, and, consequently, the others also showed their wish to become next lean project. Moreover, another distinctive characteristic of this approach is that it was focused more on people, than on general lean training. On the contrary, the seniors of Virginia Mason decided to go lean in the whole system. After studying TPS, they developed VMPS and the special infrastructure with 20 people, dedicated to lean efforts (while in Suneja's experience the Lean team consisted just of a motivated manager and committed physician). Meanwhile ThedaCare organization focused on people, their transformation and training, and as a result has reached significant success.

Summarizing, it can be said that all healthcare organizations faced the same **challenges**: reluctance of workers, skepticism, and negative attitude to manufacture principles. The only solution for resolving these issues is trying Lean slowly, keeping focus on improving patients care, making true and sustainable changes within a small dynamic and adaptable group. The

cases showed that it is inevitable that in particular situation some healthcare professional deny accepting lean and lean the hospital.

Observation of the used **lean tools** shows that the most useful and important one is VSM, which is followed by "eliminating waste" methods, such as 5S, Spaghetti Diagram, and etc. Implementation of these tools resulted in the healthcare organizations to maximize staff efficiency, flow in patients resulting higher number of patients, ability to allocate more time for operations and reduce walking for staff to complete the job. Aside from this, patients' waiting time was reduced significantly, increasing the number of treated patients.

The paradox is that reaching this truly successful and truly transformative change involves a tremendous amount of leadership. Leaders of these organizations emphasize the importance of creating an organizational culture that is ready and willing to accept lean thinking. Without a receptive culture the principles of lean will fail. It can be said that strong, focused and dedicated Leadership along with creating lean culture in the organization are the key success factors in the whole lean journey. Lean implementation requires the culture change, which often leads to forming smaller, "right-sized" groups of workers or technologies in "cells" rather than large, cumbersome processes. Strong, partly directive leadership ensures success.

Overall, management commitment, employee involvement, training and reward have a positive impact on quality improvement. Top management should give great efforts in encouraging employees for change by introducing the importance of lean concepts (Atkinson, 2004, p.28). Top management commitment is important to give support to low level employees and convey consistent information about Lean (Atkinson, Protzman, Appioti and Bertels). Moreover, it is critical to increase communication between employees, as well as within the management and employees, as clear communication plays important role in keeping strong customer-supplier relationship, where the responsibilities of employees are clear. Finally, strategic focus, where customer is in the center, is the first step to the success.

5. DIGITAL TECHNOLOGIES

This chapter describes the variety of digital technologies in the modern world, their role in the service sector and how they can be adapted to optimize healthcare system. It shows how industrialization of services influences particularly healthcare sector, which digital challenges exist and which technologies appear to be useful in healthcare environment.

5.1 Industrialization of services

Nowadays, industrialization of services, even more than manufacturing, is a complex topic. Services have a number of features that do not exist in majority of manufacture processes. A crucial one is *the lack of tangible output*, which leads to the difficulties while observing the outputs and outcomes of the services (Baglieri et al. 2014, p.23).

The healthcare delivery is in the process of "industrialization" and cannot ignore the undergoing changes in the organization of work in services, which mirror those that began in other industries (mainly manufacture) a century ago. An increasing division of labor, standardization of roles and tasks, the rise of a managerial superstructure, and the de-skilling of work characterize this process. **Industrialization of healthcare systems** has begun with usage IT to process huge amounts of statistical data in the last century, and it has moved to the next wave – full digitization of the enterprise, such as developing digital products, channels, and processes. Nowadays, players in the healthcare industry need to focus on patients and enable them to use digital networks and services, and understand what the customers really wanted. Success in industrialization of healthcare services depends very much on clear understanding of patients' presences. Biesdorf and Niedermann (2014) have interviewed thousands of patients from different age groups, countries (USA, United KingdomGermany, Sinagpore), genders, and incomes, with different levels of digital savvy (Biesdorf et al. 2014) in order to understand how healthcare organizations should begin their digital patient-enablement journey. The results of their study have presented the following five insights about the myth about industrialization of healthcare.

First one is that people do want to use digital services for healthcare. The main reason patients adopt digital healthcare slowly is because existing services do not meet their expectations. Thus, more than 75 percent of respondents would like to use digital healthcare

services, such as Hospital Websites, emails, smartphones apps, and social media, as long as those services meet their needs and provide the level of quality they expect. The second insight is that actually p**eople from all age groups are more than willing to use digital services for healthcare.** Moreover, older patients (those over 50) want digital healthcare services nearly as much as their younger counterparts. More than 70 percent of all older patients in the United Kingdom and Germany want to use digital healthcare services; in Singapore, that number is even higher. However, there is a difference between the kinds of digital channels older and younger patients want to use: older patients prefer traditional digital channels such as websites and e-mail, while younger are more open to newer channels such as social media. Thirdly, it was analyzed that **demand for mobile healthcare is not universal.** Mainly, this demand is stronger among young people: for instance, apps that focus on prenatal health or those that could be classified, as lifestyle apps are highly demanded. Another interesting finding is that **patients do want innovative features and apps.** The key features patients expect from their health system are surprisingly mundane: efficiency, better access to information, integration with other channels, and the availability of a real person if the digital service does not give them what they need, while highly innovative services, better apps, and more social media are far less important to majority of the patients. And, finally, it **is not necessary to have a comprehensive platform of service offerings to creating value.** According to the survey, it is smarter to start small and act fast, instead of building a comprehensive platform with offerings along the entire spectrum of customer services (Biesdorf et al. 2014).

To summarize, the study of Biesdorf and Niedermann has shown, that across the globe, people require the same thing from the healthcare systems. Thus, in order to achieve success, it is crucial to follow these recommendations: to understand what the patients really want and what is the best way to give it to them, to segment the services according to basic criteria such as the amount of investment required, estimated patient demand, and value created through the service, and, finally, to add continually new services to keep patient attention and build value: once patients are familiar with the general idea of digital-service provision, organizations can begin offering more complex, high-value services, such as integrated-care companion apps or mobile health records.

Industrialization strategies can be applied for healthcare businesses but must be carefully designed and implemented, so as not to damage customer experience (Baglieri et al. 2014, p.29). ***Today the health sector faces a daunting new digital challenge:*** *unleashing the power of technology to fundamentally reinvent how care is delivered.* Digitally enabled care is no longer a "nice-to-have" but rather a fundamental business imperative. *Digital technologies bridge time, distance and the expectation gap between consumers and clinicians.* However, the main challenge for healthcare organization is to connect their old systems with new digital technologies and merge the data locked inside them to generate meaningful, actionable insights for caregivers (HRI 2014).

Firstly, it is important to understand which digital health technologies present value for physicians and consumers. As the study by Healthcare Research Institute (2014) shows both are relatively comfortable with using diagnostic testing of conditions such as strep throat, skin rashes, and urinary tract infections at home by patients, and they both recognize the efficacy of using health apps to self-manage chronic diseases. Thus, it is necessary to make patients aware of alternative by providing information and promoting apps. In addition, healthcare organizations should determine when digital interventions make the most sense**.**

Secondly, success and sustainable extension of digital technologies depends on the how well caregivers and consumers are motivated to adopt these tools. Healthcare providers should evidence that digital health technologies save insurers and employers money, to develop a behavior change program, to create patients incentives and to sustain balance between financial and nonfinancial incentives.

Finally, it is crucial to generate meaningful, actionable insights through analytics to yield better, faster results. To achieve this goal healthcare companies must listen to data signals, combine administrative and clinical data into one view, and expand the data web with traditional and non-traditional health companies. Finally, rethinking the workforce and informing workflows will fuel the return on digital health investments.

5.2 Digital technologies used in Healthcare

The previous chapter (5.1) has shown that patients transit from passive healthcare recipients to active value-seeking consumers. Hence, it is time for the healthcare sector to turn to digital tools. Digital technologies are the underpinnings for creating new care models. HRI research from 2014 states that the next five years will be critical in making the significant leap from using these technologies as add-ons to turn them into fully integrated tools, which allow lower cost, care alternatives and enable to create data-rich insights into real-time care delivery. Just as the banking and retail sectors, healthcare sector will start using data and technology to improve efficiency, raise quality, and expand services.

Nowadays, there are following emerging trends in healthcare: social media, EHRs, telehealth and mobile phone applications. Healthcare organizations focus on implementing full-blown e-commerce capabilities, which will include pre-registration, online payment, making appointments online in outpatient services, and making encrypted medical records accessible online (Huang, 2012). Digital technologies enable to provide tools for patients to submit forms, participate in health management care management activities, and help to address the health issues of population. However, it is crucial to remember that advanced e-health implementation does require significant investment in information communication technology.

5.2.1 Interactive Internet-Based Technologies

Interactive technologies represent a new opportunity for service providers to improve the efficiency and the appropriateness of healthcare service considered as the main value gained by the entire healthcare system. Technology enables healthcare systems to turn back to a time when there was a stronger (or maybe closer) physician and patient relationship, but to do it with all the benefits of the modern world. Results of the study by HRI, where 1,000 physicians, nurses, and assistants were surveyed, the following insights on the promise of digital technology were found:

- **It can help caregivers work more as a team:** majority of physicians believe the use of mobile devices can help clinicians better coordinate care;

- **Digital technologies increase patient-clinician interaction**:
- **These tools allow putting diagnostic testing of basic conditions into the hands of patients:** usage at-home test results to prescribe medication;
- **It can promote self-management of chronic disease using health apps:** special apps to help patients manage a chronic disease such as diabetes (HRI 2014).

Edgar Huang, who has been studying the implementation of digital technologies in healthcare and their impact, called digitalization of healthcare services E-Health. According to him, e-health can be is defined as *"the combined use of electronic information and communication technology in the health sector for clinical, educational, research, and administrative purposes, both at the local site and across wide geographic regions" (Huang et al. 2012). E-Health is an* online mechanism that initiates an online transaction between a hospital and a user. Virtual communities, hospital websites and mobile applications are just a few examples of the active integration between the Internet and the healthcare system. This virtual system of relations represents a shift in healthcare model towards an emerging consumerist model where patients have an opportunity to communicate more effectively with the doctors that manage their care (Demiris, 2006, p.181).

Virtual communities are specific social networks formed or facilitated through electronic media that are able to offer significant advantages to healthcare professionals and patients. They allow participants to support each other and enable the sharing of knowledge and experiences. Moreover, special online communities for healthcare professionals simplify the exchange of information, experiences and opinions between providers, which lead to the opportunity to solve cases as a team with participation of all members of the community (Demiris, 2006, p.182). It organizes synergy effect and raises the chance for searching best solution with minimum costs, as healthcare professional can work from all over the world. A customer and professional centered community groups is an alternative means of communication between healthcare provider and patients, which can supplement face-to-face communication. Regardless of the type of the community and its members, various activities enabled by virtual platforms contribute to the common goal of knowledge creation and sharing.

Hospital websites bring together healthcare providers, professionals and patients, enabling them to access a variety of resources, such as medical literature, service platforms, personal

data and etc. (Baglieri et al. 2014, p.194). These websites host support groups to patient, enable interactions with community organizations and become a portal for physician organizations and private medical offices. They provide such opportunities as sharing videos to educate patients with chronic medical conditions, merely to informing patients about service and facilities, making appointment on-line and etc. For example, starting YouTube Video Channel of the healthcare organization and sharing educating videos (for patients with chronic medical conditions) is getting more popular. It provides a highly positive impression and has an impact on users' experiences: healthcare organizations that have been using on-demand or live webcasts on their websites have reported a growth in patient volume (Huang et al. 2012). Furthermore, the potential for knowledge gathering, interactions and services on the hospital websites is increasing, especially as mobile access to networked information gets more accessible.

Another growing trend is usage of **mobile applications.** As smartphone is becoming more and more spread in developed countries, huge numbers of applications, which are being developed for it, transform it into a variety of assistive devices that help people with or without disabilities to improve their quality of life. It provides them an access to the healthcare services all over the world directly from home. Healthcare mobile applications enable patients access to the information, opportunity to consult a doctor through smartphone, make an appointment and have interactions with multiple and diverse actors, enabling them to share their resources collaboratively by adapting their processes to each other.

Huang (2012) found that by the end of 2008, 86% of the U.S. hospitals were in the Internet. The figure presented below was based on study, conducted by Huang and Chang in 2012 on the 712 hospitals (out of the total of 764 hospitals in the sample) that did have a Web site. The researches have developed a list of 21 most useful digital tools and classified them into seven categories. (Table 6):

Table 6. Interactive tools on U.S. Hospital Web sites (Hung and Chang, 2012)

Traditional functional tools	- Online search (66.6%) - Interactive map (60.8%) - Finding a physician (56.7%) - Contact us (46.1%) - Interactive calendar or event finder (42.8%) - Virtual tour (8.6%)

Core e-business tools	• Paying bills online (40.2%) • (Pre)registration online (19.4%) • Making a doctor's appointment or communicating with a doctor online (15.3%) • Accessing health records, medical records, and lab results (10.1%) • Refilling prescriptions online (9.7%)
Patient support tools	• Interactive patient education or health-risk assessment (47.0%) • Patient caring and support through CarePages, blog, or chat room (16.2%)
Visitor-related tools	• E-card or e-mail for a patient (28.2%) • Online nursery for viewing/purchasing baby photos (27.7%) • Online flower/gift shop (9.3%)
Public relations-related tools	• Presence on social media, such as Facebook and Twitter (35.7%) • Online caregiver recognition (3.9%)
Emerging functional tools	• ER wait time (5.6%) • Interactive cost estimator (3.5%) • Site or application for mobile devices (2.0%)
Others	• Online service menu$^{\alpha}$ (11.0%) • Personalized account$^{\alpha}$ (10.7%)

According to the data, presented in the table above, it can be seen that among the traditional functional tools, more than half of the hospital Web sites provide online search, interactive maps, and the tool for finding a physician, which were followed by the "contact us" tool (46.1%) and interactive calendar or event finder (42.8%). On the contrary, the adoption of core e-business tools is lower: only paying bills seem to be widely used with around 40%. Among the patient support tools, interactive patient education, including health encyclopedia, videos, and interactive tools for risk assessments, calculators, quizzes, and symptom checker are seen to be popular. E-card or email for a patient and online nursery that enable patients to view, purchase and print photos of a newborn baby, are two most frequently offered visitor-related tools. Presenting hospitals in social networks, such as Facebook and Twitter, turned out to be a new trend for hospitals in 2009.

According to the study of U.S. Hospital Websites, "Find a physician," "online bill pay," "online search," and "contact us" are seen as the most-used interactive tools for patients on hospital Web site. The most popular tools are the access to lab results and secure emailing with physicians via mySharp. Web site users highly desire core-business tools, especially access to medical records and lab results (Huang, 2012).

Nowadays E-health is recognized as competitive differentiator for getting consumer preference. Based on the interview of healthcare professionals from leading U.S. hospitals, e-health provides the following advantages:

(1) Establishing relationships and communication between the hospital and the patient;

(2) Educating and empowering the user (e-health is an electronic connection between the health system and the patient so the patient gets directly involved in managing his/her own health);

(3) Delivering and enhancing healthcare procedures (scheduling appointments, reviewing selected lab results, paying bills; sending secure messages to the physician's office, reviewing their health profile, and etc.);

(4) Increasing overall satisfaction and market share (Huang, 2012).

However, implementing E-Health on hospital Web sites can meet some barriers, such as a resource shortage, lack of medical practice standardization, poor integration of the information system, and insufficient infrastructure. In order to make e-health feasible, healthcare organization needs to have a sufficient infrastructure and backend systems automated with electronic medical or health record.

Healthcare organizations consider interactive rapidly developing health technologies as dynamic and relational platforms for the future collaborations and proximity relationship with different stakeholders: employees, patients and their families, insurance organizations and etc. In addition, usage of these modern tools has a very positive promotional effect on the reputation of healthcare organizations. To prove this, an example of Mayo Clinic positive results is shown below. Mayo Clinic is a worldwide leader in medical care, have been already successfully implementing main interactive technologies: social and video sharing platforms, blogs, online patient community and mobile apps. Nowadays, it is one of the best healthcare information sites with all these tools integrated into the corporate information portal (Table 7) (Baglieri et al. 2014, p.198).

Table 7. Mayo Clinic interactive health technologies

WEBSITE. The corporate web site is addressed to consumers/patients community, clinicians, medical students and sponsors. It is organized in five sections:
(1) *Patients online service* (access to personal records, management appointments)

(2) *Disease and conditions A-Z, symptom checker, tests and procedure and healthy living* (access to info, improved self-management)

(3) *Online Services for Referring Physicians* (instant access to patient records)

(4) *Medical publications, clinical trials and new medical practices* (learning and knowledge sharing platforms for physicians)

(5) *Medical edge (*collection of professionally produced television, radio and print packages covering medical advances and compelling general health topics*)*

Online community - a social platform, launched on July, 2011, to connect the global Mayo community (patients, their families and friends, Mayo Clinic's employees and students). It includes contents from various Mayo blogs, health and medical videos from Mayo's YouTube channel and links to news articles about Mayo Clinic research and treatment advances. It features a discussion forum where members can share their experiences, information, support and understanding. Discussions are organized around specific topics and collected according their degree of activity, newness (last published) and popularity (most viewed, liked and commented)

Social Media

(1) *YouTube Channel* - about 10K followers, more than 2,416 videos – stories, interviews, latest researches

(2) *Facebook* – links for patients, actioners and educators; responds on helping requests, sharing stoties and etc.

(3) *Twitter* - more than 531,442 followers and more than 10,500 posts (tweets)

(4) *Radio* – international audience

Mobile applications for physicians

(1) *Synthesis mobile* allows the access, at home or on the go, to the same resources provided by the Mayo Clinic web site (patients' electronic medical records, dictate clinical notes, reports, lab results, medications etc.)

(2) *AskMayo Expert* provides a quick access to Mayo-vetted clinical information about conditions and their treatments

(3) *The Quarterly Directory app* enables display paging, search, one-touch calling, texting and e-mail contact information as well as access to the intranet when using Mayo's wireless network

Mobile applications for patients allow the access to the online Mayo community where people can share stories, learn from others' experiences and gain support from thousands of members. *Mayo Clinic patient app* provides many resources, such as updates on health news, access to schedule and management appointments, health recommendations and alerts, information on Mayo educational resourses, classes and sessioan, and etc.

Numerous numbers of apps were launched to support people with specific pathologies, such as, obesity, diabetes, heart disease, etc. They include three sections that helps users:

(1) To understand their conditions through 30 min conversation with Mayo Clinic specialists;

(2) To change their diet to feel better, through a specific training with a Mayo Clinic dietician that follows up users to make meal planning simple; and

(3) To reduce stress through a 40 min session with a yoga instructor.

According to the Mayo Clinic annual report (2011), from the physicians' perspective, the opportunity to connect patients' data through mobile devices enables them to save from 10 to 60 min per day to save costs, and to care for patients in a more efficient way. Capability to connect peers through raises the chances to receive immediate insight on live cases, to share experiences and knowledge as well as to develop professional collaboration. During the first weeks when app for physicians was launched, more than 1,000 physicians have downloaded it across Mayo Clinic and within the first month, more than 700 of them became active users (Mayo Clinic Annual Report 2011). Overall, all these activities shown in the table above contribute to empower doctors, by improving their knowledge, produce positive effects on their way of approaching and caring for patients and, as a result, on the final value they gain.

From the patient's point of view, the belonging to the online community allows the practice of connecting, sharing knowledge, information, experiences and to give and receive back emotional and social support to/from peers, doctors as well as the entire Mayo network (Mayo Clinic Annual Report 2011). The usage of video platforms, such as YouTube, as well as the use of the apps for specific diseases allow the patients training, managing health status, following health instructions, combining complementary therapies, modifying symptoms management, and etc. All these activities contribute to make easier the service delivery.

Summarizing all mentioned above, it can be said that Mayo Clinic experience proves that use of digital technologies has a positive impact on the all the stakeholders: physicians, patients, and so on, and can be a good example of integrating these technologies in the other healthcare organizations.

5.2.2 Electronic Healthcare Records

Electronic Healthcare Records (EHR) is an electronic record of health-related information on an individual that conforms to nationally recognized interoperability standard and that can be created, managed, and consulted by authorized **clinicians and staff** across **more than one organization (**Hoyt et al. 2012, p.28**).** This way of storing data appears to improve data flow within organizations and staff significantly. EHR enables all members of the team to have ready access to the latest information allowing for more coordinated, patient-centered care. Spread of EHR has a positive impact on life-saving, cost-saving, better transitions and motivation. Here is an example of *life-saving* advantage: the information gathered by the primary care provider tell the emergency department clinician about the patient's life threatening allergy, so that care can be adjusted appropriately, even if the patient is unconscious. Sharing access to the data is critical. Access to healthcare information also improves care quality and reduces patient harm. EHR is a perfect solution to save *time* and *costs.* For instance, the lab results run last week are already in the record to tell the specialist what he needs to know without running duplicate tests. **Better transitions** between care settings are information intensive and require excellent interprofessional communication. The clinician's notes from the patients hospital stay can help inform the discharge instructions and follow-up care and enable the patient to move from one care setting to another more smoothly. The last but not the least important benefit from EHR is the **motivation**. Patients' portals that provide access to numerous amounts of data are becoming available in many healthcare organizations. Patients can log on to their own records and see the trend of lab results over the last tear, which can help motivate him to take his medications and keep up with the lifestyle changes that have improved the numbers **(**Hoyt et al. 2012, p.74**)**. Overall, leverage EHR data lead to improving care, generating new knowledge, and addressing population needs.

Nowadays, Mayo Clinic that was mentioned above as one of the first adopters of digital technologies has a Strategic Health IT Advanced Research Project (SHARP). The goal of this project is to create a unified EHR through the secondary use of EHR data to allow the exchange of patients' information among care providers, government agencies, insures and other stakeholders (SHARP website). Traditionally, all the patient's medical information – medical history, exam data, hospital visits and physician notes, are inconsistently stored in

multiple locations, both electronically and non-electronically. SHARP project aims to efficiently leverage EHR data to improve care. It consist of various projects, such as "***Standardize health data elements and ensure data integrity***" to avoid storing the same information by using several different abbreviations, "***Merge and standardize patient data from non-electronic forms with the EHR***" to merge patient information, for example, physician radiology or pathology notes, to the EHR, "***Find processes to make clinical data normalization, NLP and high-throughput phenotyping more efficient using fewer resources***" that focuses on building adequate computing resources and infrastructures to accomplish the previous steps, and others.

Thus, as it was demonstrated, the idea to transform all medical information into EHR appears to be very promising and can be used as a basement for developing various applications, smart devices and other technologies to improve care. However, computerizing health records requires huge investments. In United States of America EHR is a part of strategic plan for improving healthcare, and government invests plenteous amount of money in it. According to the data, in 2009 president Barack Obama spent $25,8 billion for health IT and incentive payments (Wogan, 2012). However, this huge amount of money in capacity opens new opportunities.

Nevertheless, it is critically important to take into consideration some limitations of EHR. Therefore, poor EHR design improper use can cause errors that compromise the safety and security of the information, leading to errors that endanger patient safety or decrease the quality care. People who are involved in EHRs spread around the global or countries highlight that it is drastically important to show "meaningful use" of it. Special assessments, phased in three stages with increasing requirements, exist to check if healthcare providers who receive investments and access to develop EHR are using it meaningfully.

In a long term plan, implementation of EHR globally around the world, considers achieving the following goals:

- To improve the quality, safety, and efficiency of care while reducing disparities;
- To engage patients and families in their care;
- To promote public and population health;
- To improve care coordination.

5.2.3 Telehealth

Spread of informatics in health care has resulted in the new term – **telehealth** – the way of delivering health care via telecommunications technologies. Telehealth can be a simple conversation of two health professionals discussing some case over the phone or a sophisticated robotic surgery between facilities at different ends of the globe **(**Hoyt et al. 2012, p.182**)**. Telehealth presents an integration of medical devices in healthcare.

For instance different machines that tend to miniaturization, communication enablement, and convergence of monitoring function, decreased batter size. Patient-monitoring systems may be a great solution for patients with chronic diseases, such as Asthma, diabetes, or congestive heart failure. This type of self-service machines combines proactive management programs with technology and communication, which leads to better patient outcomes. Use of new technologies that provide continuous **monitoring and communication** may result in better disease management, and fewer hospitalizations or emergency visits. Various apps are developed to connect patients with health professional; any Internet enable device may be used to get access to communication between patient and professional. **(Messages)** Processing continuous stream of data appears to be sophisticated task, which, however, may bring great outcomes. Informatics tools enable to manage remote patient monitoring data in multiple contexts: personal health records, electronic health records, and data repositories. For instance, sometimes diagnostic and analytical tools are used to drive conclusion about patients' health from raw data.

Nowadays, there is a significant number of implementations of Telehealth. It may resolve challenges in *home health care*, such as monitoring, education or support. *Nurse home or ambulatory* care can receive specialty consultation (dermatology, neurological) via telehealth tools. Telehealth allows improving even *prison settings* by providing better and more frequents services within the prison (mental, for example). Moreover, it is a good way to promote health in the society. Nowadays the obesity issue is rising significantly around the global, however, special apps can help people to do a better job by performing some exercises, fitness courses and etc.

Telehealth may be delivered in several methods:

- Real time:
    - o Telephone-based (limited to education, counseling);
    - o Web-consults (two-way audio and video);
        - ▪ With or without peripheral devices;
- Store and forwards – images, audio, video (for example, X-rays can stored in special database and send when needed);
- Combination of two methods.

As it was mentioned before, telehealth varies from email up to sophisticated system for real-time monitoring. Different equipment is used to support telehealth: phone lines, Internet, computers, cell phones, lifelines, sensor technologies and even peripheral devices, such as blood pressure scale, glucose monitoring, or electronic stethoscope. These peripheral devices enable the person on the other end to collect the necessary data locally, and then transmit it, so that the patient feels health professional participation. The great characteristic is that these devices have achieved a high level of quality, and, for example, allow to hear the patient's breath perfectly as if he is next to you.

5.2.4 Forthcoming trends

In addition to all mentioned above, innovations influence the significant number of new digital trends in healthcare environment.

One of the promising trends is to organize **smart environment** for the patients – so-called "Mr Smith's House is Calling". Smart houses allow supporting people to stay safely in the community. Smart houses may be very well equipped with special *caregivers alerts*, *voice prompts* to remind a patient to take medicine (medication management; for example, it may be a special device that calls a doctor in 30 min if the patient has not taken a medicine required), *floor sensors* (mainly can be useful for patients with ambulation problems as an early warning detectors), safety features, smart beds that can notice on early stage if the patient need to go to the bathroom and wake him up), video monitors, medical condition monitoring, humanoid robots and etc. Spreading of Smart Homes face some challenges as slow expansion of use due to the deficiency of technology infrastructure, financial investment

and licensure. However, overcoming these challenges can result in the benefits, such as a positive impact on access of population to health care, financial return, coordination of care (particularly home care), and quality.

Another rising digital technology is use of **gaming and simulations**, which are being developed for real-life situations to teach or to solve some issues. Nowadays, healthcare games research is an emerging science that struggle to learn about the health gaming benefits. Games and simulations create virtual environments to search for real solutions, form experimental learning opportunities and "learning by doing" experience. Simulation represents the real world with existing problems – time pressure, necessity to make quick decisions and etc. As a result, students are having more fun and achieve better educational result, increase mental, physical and emotional resilience and, have an opportunity to find new ways to improve processes at a best price, quality, outcomes and value.

Summary

To sum up, digital technologies may improve the delivery of health care services, patient health outcomes, and population health. Application of digital technologies to health environment enables:

- Better care - more patient-centered, reliable, accessible, and safe;
- Affordable care (reducing the cost of healthcare for individuals and government);
- Healthy people and communities.

6. CONCLUSIONS

This chapter presents the analysis of all the observations regarding lean and digitalization of healthcare services, and how these approaches can be used to address appearing challenges. As it was shown in the previous chapters, healthcare system is very complicated. It faces considerable number of challenges nowadays, and it is impossible to find and apply a single solution onto all of the issues.

To find a solution for the raising problems and make an attempt to resolve them, it is drastically important to understand three following things: stakeholders, existing challenges and possible solving strategies to address them.

The peculiar nature of healthcare services is the improvement of the patients' quality of life. However, in addition to patients there are several others interested parties within the patients' network. Based on the research, conducted in this work, four following groups of participants in healthcare services were distinguished.

1. Patient, family and friends;
2. Healthcare professionals (physicians, doctors, assistants, nurses and so on);
3. Healthcare organization;
4. Government.

It is clear that each of these groups has its particular interest and expectations. Thus, patients' and their surroundings require accessible (especially from financial perspective) treatment, quality and safety service, with little waiting time. Healthcare professionals demand less overwork time, more organized space, simple access to the necessary data, and, as literature review showed, opportunities to develop professional skills within their workplace. The desired goal of the healthcare organization itself is to receive positive feedback to increase the trust and popularity (for more ambitious organizations it can be the goal to become a leader in the particular geographical area, or type of treatment), loyalty and revenues. And, finally, government will benefit from the reduction of charge for each patient's (citizen's) care.

These goals and expectations can be reached by applying two approaches to healthcare processes – lean methodology and digital technologies.

Lean is basically a manual solution, which enables to solve plenty of problems in healthcare. Analysis of different practices of lean implementation in several healthcare organizations, carried on in this research, has shown that there are two opposite approaches to turn healthcare organization Lean. First one is to start initiative from the top (senior management), take a big scale and make an attempt to transform the whole organization, like VMPS (Chapter 4.1). Second, presented in the Chapter 4.2, is to start with one small team and then, due to the success word spread, change the whole organization. Depending upon the size of healthcare organization, its financial assets and goals, both approached can be considered. However, second approach appears to be more suitable and acceptable in majority healthcare organizations, as it does not require huge investments. Thus, with the presence of motivated project manager and committed healthcare professional, lean transformation can be started. The big advantage of Lean methodology that it is fairly simple and manual solution, which can be implemented both in the whole organization at a time or only in some specific departments. Applying lean enables organization to add value to customers by providing services with higher quality and speed by using fewer resources. It focuses on eliminating various types of wastes from the processes, reducing waiting time and throughput time, which, as a result, turns into increasing capacity. Moreover, some of the lean tools considered in this work can be applied within short period of time and show positive results almost immediately, which can prove utility of this tool and promote lean strategy within organization.

Conversely, the second approach – digital technologies, requires more technical support from the organization. The analysis of healthcare organizations and upcoming trends has shown that digital technologies are demanded to support measurable, value-driven care. Consequently, healthcare organizations are required to adopt them in order to keep effectively compete within the industry, to keep pace with changing consumer demands and maintain financial sustainability. Variety of digital technologies addresses different interested groups, from patients to healthcare professional. Great advantage of digital tools is an opportunity to bridge the gap of time and distance between patients and caregivers. Information technologies and automation can help especially when they support self-service, or when they have positive experiential value, as in the provision of information to reduce uncertainty or anxiety. There are substantial numbers of the digital tools that can support healthcare organizations: patient support, core e-business, functional and etc.

However, the key issue is to distinguish which tool or approach can resolve particular challenges in healthcare. For this, it can be useful to consider lean methodology and digital technologies through the frame of Schmenner's SPM described in the second chapter (Chapter 2.2). This matrix provides an opportunity to classify services on the basis of degree of variation (customization) and flow speed (labor intensity). Hence, most sophisticated healthcare services as oncology treatment and defining new viruses are located in the quadrant called "Professional Service", as they require fairly personal approach and the variation level is pretty high there. The less sophisticated, such work of the pharmacy within the hospital, or radiological department, are present in the "Service Factory" types, as they are characterized by low variation level, fairly high flow speed, and can be compared to some industrial processes. It seen on the picture below (Figure 17):
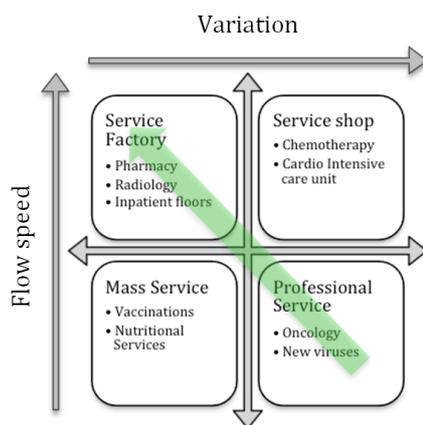
Figure 17. Upward trend to increase productivity in service processes

Nowadays all service industries tend to decrease the variation level and, conversely, increase the flow, as it has a direct impact on the productivity. It is clear that when variation in service processes, and healthcare particularly, declines, it is easier to predict the demand, and thus, to serve it better – with lower waiting times, less over processing which appears from the chaos (when plenteous number of patients arrive at the same time). Moreover, low level of variability allows to standardize processes, and, as a result, eliminate waste in them, reduce number of errors occurs, shorten the time needed for each patient, and etc. Increasing speed of flow, furthermore, raises the capacity of the system. In the frames of healthcare organization it means that healthcare professional can serve more patients at the same amount of time, or, need less time for each patient.

As a result, combination of these two trends – downward for variation and upward for speed of flow has a significant influence on the productivity. Precisely, the productivity of the whole systems raises when process becomes more stable (with low variation) and with bigger number of customers served. This explains the wish of majority of service organizations to transform their organizations so that they match "Service Factory" quadrant, as the most productive one (this trend is shown on the Figure 19). However, it is hardly possible to redesign all healthcare process to "Service Factory" model due to their complicated nature. As the research has shown, basically all Lean tools are focused on moving organization to the "Service Factory" quadrants, and to prove it is enough to mention that one of the key lean principles is to reduce variation. Nevertheless, applying both lean tools and digital technologies, which was considered before, can move numerous healthcare processes towards this desired quadrant. These approaches enable increasing the productivity without adding extra employees or updating the equipment.

To show it in more details, the table below was developed (Table 8). It demonstrates the problem types that exist in healthcare process and were discovered during this study, and possible solutions to resolve them: either it is lean methodology and some particular tools, or applications of digital technologies, or both at the same time. All the challenges are divided into four groups regardless their focus.

Table 8. Managerial challenges in healthcare and possible solutions to address them

Managerial Challenge	Example of the issue in health environment	Approach	What to do?
Focus on the patient as a consumer			
a. More personalized approach	Patients expect health care professional to have an overview on the medical history, dedicate more time during visit, support within the clinic if necessary.	L D	**L:** Eliminating NVA by VSM, 5S, Spaghetti diagram relieves care professional *more time for direct communication* during the visit. **D:** Various telehealth tools and interactive technologies, such as **patient-support apps**, **web- and phone-consultations**, enable communication between patient and health provider. Moreover, **EHR** (plus physician-oriented apps) provides immediate access to the healthcare staff to patient's medical records - patient medical history.

b. Reduce waiting time	The perfect state considers that patient meeting with the doctor should be as quickly as possible, with little wait time for test results or antibiotics administration.	L	**L:** It is essential to reduce as much as possible waste from the processes by implementing various Lean tools. (Described in details in Chapter 4.2) **VSM**, for instance, shows the areas to conduct quick experiment to make improvements, such as frustration of physician by disorganized patient information provided by nurses, too much info and etc. **Standardization** enables to simplify process, exclude all NVA, and, therefore, eliminate the time. **5S:** In OR department (Chapter 3.1.2) equipment and furniture were painted, thus it became easy to return them back when it is moved (less time needed). **Spaghetti diagram.** Redesign layout more efficiently - co-locate, for example, radiology department so that significantly less time need, thus, visit to physician will shorten.
c. Increase access	Due to several reasons – age of the patient (problem of aging society), restriction of physical movement and so one significant number of people have limited physical access to health care. In addition, incredibly high costs of healthcare lead to the issue that plenty of people address health care providers only with absolutely urgent need.	L D	**L:** All lean tools are focused on eliminating waste and NVA, which leads to the increase of capacity for each healthcare professional - opportunity to dedicate more time for each clients and to serve more clients. Thus, the costs of the healthcare services will decrease both for organizations and government, and more patients may afford healthcare support. **Ex. From "This is Lean" (Modig et al.)** Transition from resource efficiency to flow efficiency – flow unit's perspective. Creating organization that are organized around specific need, for ex. "one stop breast clinic". As a result, throughput time decreases from 42 days to 2h. This example of lean implementation also has a positive impact on ***waiting time, customer focus and quality characteristics.*** **D:** Different interactive technologies – **websites with online-consultation option**, **apps** and **social media technologies** (for ex. Facebook) provide an opportunity to the patient to address the need through any Internet enable device, regardless of location. **Telehealth** and **self-services,** especially for people with chronic deceases or seniors,

			allow receiving care within home. *According to HRI report, digital visits, or e-visits, could replace more than 10% of in-office patient visits, while nearly as many consumers meanwhile say that they would be willing to communicate with their caregivers online (HRI, 2014).*
d. Increase communi-cation	Nowadays, patients are active value-seeking consumers, who require communication with healthcare providers, between each other and an opportunity to share experiences.	L D	**L:** VSM, 5S, Spaghetti diagram and other tools are focused on relieving care professional more time for direct communication with a patient during the visit. **D**: Social media, online communities, apps, telehealth – phone and web based consultations.
Focus reducing costs			
a. Reduce costs of treatment for customers, organization and government	According to statistics, provided in this work (Husby, 2012, p.28), health costs is the main reason for bankruptcy in the US, and not everyone can afford it. Government also spends numerous sums to support healthcare environment. Health organizations are seeking for the solutions to reduce high costs.	L D	**L:** VSM, 5S and other methods lead to reduce: inventory (unused tools, duplication of supplies in temporary storage areas, patient rooms and etc), overwork, overprocessing (necessity to repeat some examinations or ask patients the same questions) and etc. (More examples of waste may be found in Chapter 3.2.1). Thus, processes become simpler, take less time and, less costs respectively. ***5S: OR Department*** (Chapter 3.1.2*)* eliminated nearly 400 square feet of outdated and unneeded equipment. Lean (in general): In Virginia Mason, lower labor costs were accomplished by **redeploying staff** to the new tasks instead of hiring new. Ex. After Lean was implemented, 2,5 more audiologists were discovered (highly trained professionals), and they were redeployed to a project manager in the operating room with equal pay. **D**: **EHRs** save all the patient data, thus, any time health professional can refer to it, without necessity to repeat some examinations again. **Telehealth** and spread of **self-services** allow to lower costs, as instead of direct visit patients may receive needed care within the

			home (applicable to standardized process, relatively simple tasks). For instance, peripheral devices allow making examination via phone. **Smart home** is a future of digital technologies. Even though the price is high for smart beds, floors, alert and monitoring systems, in a long term it can be cost-efficient, as the patient saves on regular hospital visit, nurse and nursing homes.
Focus on quality			
a. Reduce number of errors	Unfortunately, nowadays medical errors are responsible for injury od 1 out or every 25 patients, estimated 48-98 thousands patients die from medical errors yearly (data from HRI).	L D	**L:** Lean tools aim to improve the quality by eliminate the root of the problem and excluding NVA. **VSM** allows optimizing the process flow, and thus, to prevent unnecessary steps that can lead to errors. **Standardization** of the process appears to be useful in terms of reducing errors risk, as it makes processes transparent, clear and defined. Ex. Administrating blood products, Situation Background Assessment Recommendation. **5S** create *neatness atmosphere* in the workplace, which has an impact on the reducing the number of errors in process made by health professionals. For ex., in VMPS, a clean and orderly spaced enhanced quality and productivity, as less time was lost searching for tools and problems were more salient. **D**: New trend – **robots performing surgeries** – excluding human factor. **EHR:** allows emergency department, for instance, check patients medical records and, if he has allergy to some medication, prevent using it and future allergy reaction.
Access to the healthcare services, little waiting time and interaction with patients also characterize quality challenge and were presented above.			
Focus on healthcare professionals			
a. Local communication (within organization)	Inefficient communication between healthcare staff transforms into longer waiting time,	L D	**L: 5S** tool shows the opportunities to redesign layout to make interaction between professional, physician teams and etc. easier and more accessible. **Visual communications tools** (for ex.

	NVA activities, repetition of lab tests and etc.		patient status boards) simplify patient "tracking", indirect communication. **Spaghetti Diagram:** redesigning layout inside the clinic. Ex. A special area to organize a common work for all clinic staff. **D**: **Intranet, apps** and **databases** allow the access at home or on the go to the hospital resources - patients' electronic medical records, dictate clinical notes, reports, lab results, medications etc.
b. Global communi-cation	The opportunity for healthcare professional collaborate all over the world may show significant synergy benefits, due to sharing practices, experience and implementing EBP.	D	**D:** **Sharing knowledge platforms**, **videoconferences** and sessions, special apps, online forums. **EHRs** is a very promising record system, nationally recognized, that allow clinicians and staff across more than one organizations (in long-term perspective, county) creating, managing and consulting medical records.
c. Reduce overwork	Bad scheduled appointments, long walking distance, necessity to search for supplies and equipment are the key reasons for long working hours.	L D	**L: VSM and Spaghetti diagrams** may provide an opportunity for eliminating NVA, walking distance, and lead-time. **Standardization** of the processes simplifies them, and, thus, reduces the time. **Balancing schedule** and workload lead to lower overwork. **D**: **Self-service** and various educational programs provide patients with an opportunity to do some procedures at home, such as preparation for appendix surgery, procedures for the chronically ill and etc., thus – saving time for health care providers.
d. Opportunity to obtain new skills within workplace	Researches show that healthcare staff does want to upgrade their skills and competences.	L D	**L:** Event weeks for ex, introduce and teach employees lean principles. **D: Gaming and simulation** show good educations outcomes. Video conferences and opportunity to observe practices and experiences around the global upgrade professional knowledge and competencies.
* L – Lean tools, D – digital technologies			

The table above shows that it can be interesting and promising to combine lean approach with the use of digital technologies to optimize and improve the processes in healthcare organizations. Despite the fact these methods are hard to compare, as one of them is a manual tool, and another requires profound technical infrastructure, combination of two can enable solving some healthcare challenges.

As it can be seen from the analysis, **lean tools** are great solution for plenteous number of issues. Firstly, as mentioned above, it is important to choose lean strategy – either to transform whole organization or just start with some departments. The second option, "go small but fast", is simpler and does require much investment. Basically, to start lean journey organization needs just to form a project team with physician and his (her) surroundings. Despite the fact that Lean cannot be implemented overnight, the first positive results, however, can be seen fairly soon from the starting point. Extra overwork, waiting times, errors (mainly, because of tiredness and deficiency of concentration), and, finally, high costs can be eliminated with simple tools. For instance, applying VSM shows all the inefficient activities in the process, and then, with the tools as 5S or Spaghetti diagram, this inefficiency can be removed. Another small step that can rapidly improve the processes is, for example, separating incoming patients and requests to the urgent ones, those, which can be solved with nurses without physician participation or even at home. This allows physician, who is the main "value creator" in the considered processes, to dedicate more time to activities that add values, such as patients who need it and already ready for receiving (for example, with all checks and tests made before by assistants, all data and records available*). Service standardization,* as a part of lean initiative*,* can provide some scale advantages, and make more services feasible.

Digital technologies also allow healthcare providers to reduce overwork and add some space to their workload. Significant advantage of digital technologies, such as social medias, Youtube channels, websites and apps developed for particular organization, is that they do not require tremendous investments but have a very positive impact on the overall impression of the clinic, its popularity and customers loyalty. Thus, these types of digital solution can resolve challenges such as knowledge sharing, increase interaction between physicians and patients, facilitate such time consuming processes as making appointments, searching for data and etc. Moreover, use of various digital technologies inside healthcare organizations can have a positive impact on the small characteristics that distinguish organizations:

transparency, friendly for using for customers, online access to data and so on. Another interesting finding that was done, patients are fairly tolerant to waiting times. If during this time they can attend some study seminars, use simulation "machine", or just watch YouTube video within waiting area to learn something (how to make injections, self-examination and etc.), it can not only entertain them but build a basement for a following self-service treatment. Digital technology may be also used as a tool to design work processes and protocols that allow all clinicians to practice at the top of their license. Nowadays, there is a curious trend appearing – developments of humanoid robots. Thus, robots do look like human beings and can be programmed so that they walk with people, serve them and substitute a caretaker or a nurse for people, who need permanent assistance and support. Currently, humanoid robots are not spread a lot, but if it proves its reliability, it can be a great solution for healthcare providers.

The findings show that both lean and digital technologies are worth applying in healthcare. Surprisingly, **but combination** of these two approaches appears to be possible and bring huge benefits to healthcare organization. Combining these approaches can be powerful when applied to developing self-service strategies. For example, patients' preparation for appendectomy is a simple process that does not require special skills and can be done at home by the patient himself. The same is with chronic diabetic procedures. Firstly, however, patients have to be taught how to do this. A solution for these issues could be standardization of the procedures, developed by healthcare professionals, and then spread to the patients through educating videos and smartphone apps. As a result, patients can do these procedures at home, allowing decrease labor intensity for the healthcare system. Furthermore, if patients need consultation they can just contact a physician or assistant (regardless on type of request) by web or special app, instead of making appointment. Hence, these small efforts can bring huge benefits for all the stakeholders. Healthcare professionals will be enable to dedicate more time directly to VA activities, exclude their overloads which lead to tiredness (and, apparently, errors), and, serve more patients. Patients' healthcare costs will be cut, as instead of visit they can just watch video and follow the instructions, contact physician through web while staying at home and etc. Organizations will also benefit from developed self-services as it leads to shorter LOS in the hospitals – one of the most important measures for productivity.

However, applying these strategies is not simple and there are some limitations that should be pinpointed. Firstly, as it was discover in this work, lean implementation may face some

resistance while being applied. Moreover, organization will turn lean when it feels the necessity, and cases considered in this work have proved it. As Change Equation states: multiplication of compelling need to change, vision of the next steps and ability to sustain changes should overcome the resistance. In addition, implementing NoLayoff policies and educating professional might solve resistance of staff unaccepting manufacture methods. For example, in Finland, in several medical school lean has been introduced as a new obligatory subject, so that health professionals get used to it and count it as possible and acceptable way of improving care deliver.

The main limitation on digital technologies implementation is their high costs. Digitalization of health requires numerous investments, which hardly may be found within organization. Thus, governmental or huge companies support is required, as it can provide necessary assets and spread digital globally. Presently (May 2015) in Finland, for example, special platform is developing presently (May 2015) – "Digital Health Trac" – for multiple health categories – big data, analytics, personalized medicine, genomics, telemedicine and etc.

Finally, crucial for both approaches as well as their combination is the presence of the leader, the one who dedicates time and is passionate by transforming organization, sustaining and seeking new way to improve the organization.

In conclusion, this research has shown that healthcare challenges appear to be resolved with the use of industrial lean tools and digital technologies. In some cases, lean is more applicable as without special investments it allows optimizing overall performance by eliminating waste, turning the system to be more organized and smoother. Digital technologies address mainly communication and access issues, which is also drastically important nowadays in the edge of competitive economy, when many people struggle to receive healthcare due to many reasons. Finally, the synergy of these two methods, especially, for addressing some challenges as communication, may be very efficient.

7. SUMMARY

The goal of this work was to give an "outsider" consult look on the different lean and digital tools that be used to address healthcare challenges.

Healthcare service and its impact on the society well being are highly recognized by scholars as a global research priority. Nowadays it is one of the fastest growing service markets both in developed and emerging economies and one of the most vital and personal services that costumers buy. Healthcare produces a ubiquitous effect on economies and on the quality of life. Thus, enhancement of the healthcare assess, quality and productivity can be considered as the most relevant challenges for the next decades.

Healthcare services were considered in this research in the frames of SPM by Schmenner, and were distinguished by the level of variety and flow speed into four different types (Service Factory, Professional Service, and so on). This classification allowed to understand better, which tools are more applicable to particular services: lean, digital, or combination of both.

Lean tools were studied from the healthcare perspective. The most frequently used, such as VSM, 5S, Standardization, Spaghetti diagram and several Problem-solving methods, were highlighted and described in terms of their applicability to the healthcare processes, underscoring the potential benefits they can bring. Comprehensive lean application requires understanding the waste, being able to find them and eliminate. Thus, Seven types of wastes, which lie in the core lean idea, were described and supported by the examples from healthcare performances. In addition, it was mentioned that Lean journey have no chances for success unless strong commitment and inspiring leadership takes place.

Cases analysis, presented in this work, investigated experiences of lean implementation in several different healthcare organization, who have reached success in this practice – Virginia Mason Medical Center, the Orthopedic Department in Wisconsin Hospital and ThedaCare center. The goal was to understand the nature of their lean transformations, distinguish success factors and mostly used tools and methods. As a result, two different approaches to go lean were distinguishes. One, presented by VMMC, was to implement lean in the whole organization, building special infrastructure, extra departments and even VMPS (Virginia

Mason Production System). The second on, used in the Orthopedic Department of Wisconsin Hospital, was to go small but smart, starting just with one team instead of making attempts to change the whole system at a time. The key advantage of this method is relatively low investments, as without requesting vast expenses, the words of team's successful transformation started spreading in the whole organizations, and, consequently, the others also showed their wish to become next lean project. Therefore, it can be said that the second approach, focused more on people, than on general lean training, appears to be more promising for organizations, which consider lean application to address their problems but do not have numerous assets and resources.

Considering various options to improve healthcare organizations' performance, the rapidly evolving world of healthcare informatics was taken into account. Organizations who become an early adopter of health information technology have an opportunity focused on improving the quality of practice and population health outcomes through informatics. Thus, potential of digital technologies in healthcare was studied. As a result, several trends – Interactive Internet technologies, such as websites, online communities and social medias, Electronic Healthcare Records, Telehealth and even emerging, such as Smart Homes or Humanoid Robots, were chosen to resolve rising issues in healthcare.

Finally, the last chapter presented an analysis of all the challenges and the ways of their potential solution. It turned out the best way to resolve majority of them is to combine manual lean tools and digital technologies, to optimize the processes and improve the overall performances. However, applying these two methods is not simple, and, thus, limitations were discovered and written above.

To sum up, the healthcare industry, challenges that exist there and possible solutions to resolve them appear to be very interesting and promising research topic. The findings of this work may be useful for small or medium sized healthcare organization to have an overview of the resolving challenges methods, and, it is quite possible that some of them would be applicable to Finland, as a very modern progressive country with well-developed infrastructure.

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APPENDIX 1

Hematology/Oncology Superflow VSM, Virginia Mason Medical Center

Lead Time	298:03
Processing Time	238:00
% Value Added (VA)	79%
% Non-value Added (NVA)	21%

Scheduler

PHARMACY

Scheduler

LAB

Patient Arrival	Rooming Process	RN Admission	Provider Visit	Medication Admin.	Home
Check-in	Vital Signs	-Assessment -Blood draw-ing by RN -(Lab) -Pre-meds	Review of labs, symptoms, records	Administr-ation of Medication	

8:00   1:00   30:00   21:00

:42   7:21   31:00   7:00   192:00

CT :42 %VA 0%	CT 7:21 %VA 0%	CT 31:00 %VA 100%	CT 7:00 %VA 100%	CT 192:00 %VA 100%
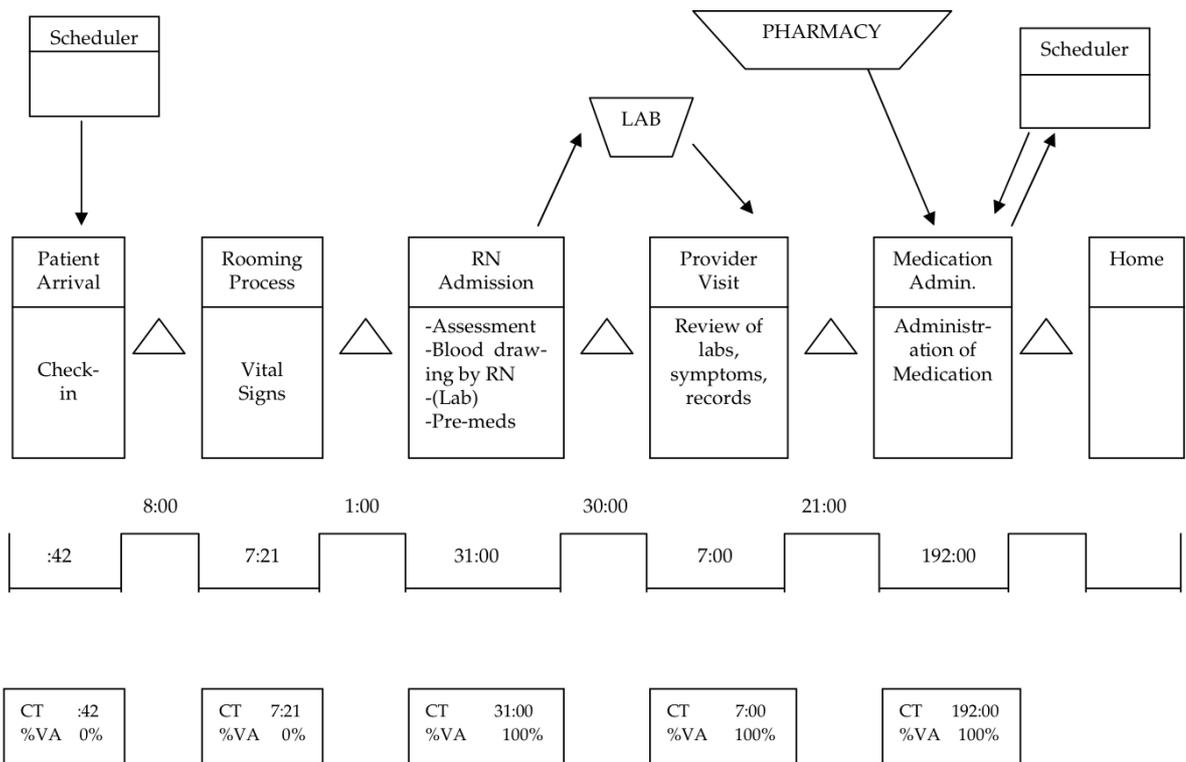
Lead Time: Arrival at reception desk to discharge

CT: Cycle Time

APPENDIX 2

Current State VSM Breast Cancer, Virginia Mason Medical Center

Current State Value-Stream Map Breast Cancer
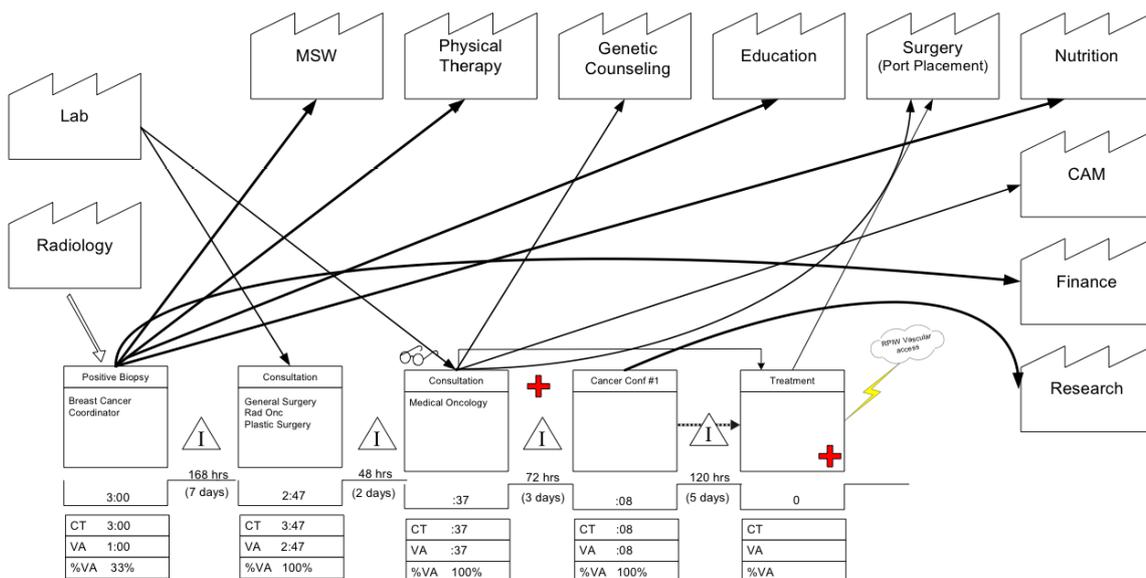
Number of cancer patients per year ÷ 2080 hours = 6.7 hours takt time

Definitions
CT = Cycle Time: Total manual working time for one cycle of the work sequence.
LT = Lead Time: Total elapsed time from positive biopsy to start of treatment. Current = 20 days. Future = 10 days.
PT = Processing Time: The sum of all cycle times.
CO + Change Over: The length of time between the last piece of one run to the production of the first piece of the next run.
VA = Value Added :   Part of the process that changes the form, fit, or function of the product or service; something that the customer *is* willing to pay for.
NVA=Non Value Added: Part of the process that does not change the form, fit or function of the product or service; something that the customer *is not* willing to pay for.

Lead Time	480 hrs (20 days)
Process Time	6.5 hours
Value Added (VA) Time	4.5 hours
Non Value Added (NVA)	476.5 hours
% VA	1%
% NVA	99%

APPENDIX 3

Future State VSM Breast Cancer, Virginia Mason Medical Center

Future State Value-Stream Map Breast Cancer

APPENDIX 4

Example of 5S implementation in Virginia Mason Medical Center

PC Configuration Room Before 5S

PC Configuration After 5S

Anesthesia Shadow Board Before 5S

Anesthesia Shadow Board After 5S
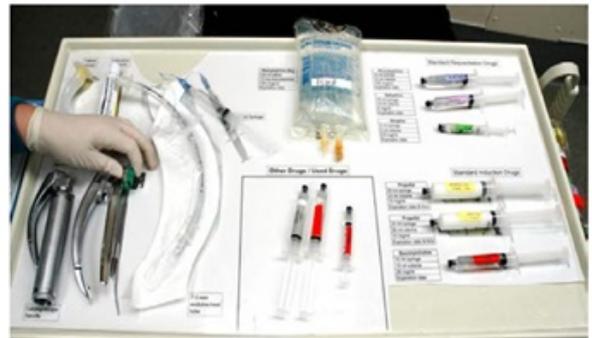
Source: Virginia Mason Medical Center, 2005.

APPENDIX 5
Standard work form (Suneja, p.88)

Step	Activity or Task	Tips for Success (Ideas, Technique, Notes)	Time
	Title: Nurse Team Leader Standard Work		
	Developed By: Lori Peterson		
	Version: Final		
	Approved By: Pam Longo		
1	Before the clinic starts, check patient charts to ensure that the plan, the most recent note, and the flow sheet (if available) are on every chart.	If it seems that the patient might need x-rays, prior to the exam, check in with the doctor or NP.	30 Min
2	During the clinic, if there is a new patient in the exam room, perform an initial assessment to better understand their reason for visiting Orthopedics. Check if x-rays, labs, or other studies have been done.	If the x-rays were not brought along, check with the physician to discuss if he wants x-rays done before seeing the patient.	2 Min/Each
		If CTs, MRIs, or labs were done but not brought along, find out where they were done and call for reports to be faxed to Fax: xxx-xxx-xxxx.	2 Min/Each
3	If there is an FUP patient in the exam room, assess patient status: pain, mobility, ADL issues, school needs, cast/brace issues, emotional concerns and report to MD, Res, or NP prior to the exam.	Report info to MD, Res or NP.	3-5 Min/Each
4	Work with the Clinic Assistant to monitor wait times, clinic flow, and emergent needs of the patients.	Keep MD, Res, & NP informed of the clinic flow and any immediate patient concerns.	Variable
		Ensure that MD, Res, and NP have clear direction on the next patient to be seen by using the whiteboard.	Variable

APPENDIX 6

Virginia Mason Compact (Bohmer)

Virginia Mason Medical Center Physician Compact

Organization's Responsibilities	Physician's Responsibilities
Foster Excellence	**Focus on Patients**
• Recruit and train superior physicians and staff • Support career development and professional satisfaction • Acknowledge contributions to patient care and the organization • Create opportunities to participate in or support research	• Practice state-of-the-art, quality medicine • Encourage patient involvement in care and treatment decisions • Achieve and maintain optimal patient access • Insist on seamless service
Listen and Communicate	**Collaborate on Care Delivery**
• Share information regarding strategic intent, organizational priorities and business decisions • Offer opportunities for constructive dialogue • Provide regular, written evaluation and feedback	• Include staff, physicians, and management on team • Treat all members with respect • Demonstrate the highest levels of ethical and professional conduct • Behave in a manner consistent with group goals • Participate in or support teaching
Educate	**Listen and Communicate**
• Support and facilitate teaching, GME and CME • Provide information and tools necessary to improve practice	• Communicate clinical information in clear, timely manner • Request information, resources needed to provide care consistent with VM goals • Provide and accept feedback
Reward	**Take Ownership**
• Provide clear compensation with internal and market consistency, aligned with organizational goals • Create an environment that supports teams and individuals	• Implement VM-accepted clinical standards of care • Participate in and support group decisions • Focus on the economic aspects of our practice
Lead	**Change**
• Manage and lead organization with integrity and accountability	• Embrace innovation and continuous improvement • Participate in necessary organizational change

Source: Reproduced by casewriters from Virginia Mason Medical Center internal document, 2001.