A3/BUSINESS CASE

Value stream mapping as lean healthcare's tool to see wastes and improvement points: the case of the emergency care of a university hospital

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ABSTRACT

Lean manufacturing emerged as an evolution to traditional production management systems amid the crisis that plagued Japan and then required Japanese companies to dry up their spending and optimize their costs. An initial tool for deploying lean manufacturing in any enterprise is value stream mapping. Based on the great importance and applicability of lean manufacturing with the help of mapping the flow of value in industrial environments, the question of research has arisen: can the application of value stream mapping in hospitals bring positive results as it has brought to the industries? Therefore, the main objective of this research is to analyze the productive environment of a university hospital, as a case study, identify bottlenecks and waste by current value stream mapping, and propose improvements with the aid of future value stream mapping. The expected results after the proposed improvements are implemented are reduction of the total lead time (time spent in the hospital), reduction of waste, better management in sight, and greater commitment of all those involved directly and indirectly in the process. This research, in its methodology, is classified as exploratory, qualitative, and used bibliographic review and case study to validate the content researched and potentiality of application in hospital environments.

Keywords: Lean manufacturing. Value stream mapping. Hospital management. Lean healthcare.

1. INTRODUCTION

Going back to the historical evolution of the productive systems, it is possible to see clear progress in the managerial field of the same, since everything began in an organized way with the scientific administration of Taylor. He brought the sciences into the light of enterprise, counteracting the empiricism of the day, organized working methods, implemented controls, and gave the workforce a burden commensurate with its capabilities. Ford continued to follow this new era of factory management, deploying mass production and creating interchangeable parts, making it its largest contribution to the world's production systems, as an efficient and cost-effective way to standardize parts that they would serve in various car models. (SLACK et al, 2008).

According to Slack et al (2008), lean manufacturing emerged as an evolution of the Fordist management system, with a focus on reducing waste and increasing customer value. It can be divided into three levels: lean manufacturing as a production philosophy; lean manufacturing as a technique for production management; and lean manufacturing as a planning and control method.

2. LEAN MANUFACTURING AND ITS LEVELS

2.1. Lean Manufacturing as a Production Philosophy

According to Slack et al. (2008), the essential reasons for lean manufacturing to be understood as production philosophy are:

a) Eliminate Waste: waste is any and all operation or activity that demands time but does not add value. Toyota has identified and separated seven types of wastes, *muda* (in Japanese), that apply to the reality of any company, be it manufacturing, services or commerce. Are they:

- Waste of overproduction: production greater than the quantity demanded by the next level, being the largest of the sources of waste;
- Waiting time wastage: material waiting time that exists when employees are producing in-process inventory, which is not required at the time;
- Waste of transport: movement of materials inside the factory and excessive movement of inventory in process are activities that do not add value;
- Process waste: operations that exist only because of deviations from projects and/or maintenance errors, and are totally liable to be eliminated;
- Inventory waste: stock does not add value and must be eliminated by eliminating its causes. Stock buffer is the first target. According to Schonberger (1993),

in addition to immobilizing capital, inventories impede feedback on quality, which means more refuse and more rework;

- Waste of movement: employee moving due to failures in the process does not add value and should be eliminated. Shingo (1997) said that it is precisely from this that the costs related to the unnecessary movement in the execution of the activities due to the inefficiency of the operation come;

- Waste of defective products: they are products that are out of specification. Minimizing the impacts of failures and/or sudden stops with the creation of fail-safe devices are the goals of the so-called poka-yokes, much advocated by Shingo and Dillon (1986).

b) All Involvement: The philosophy of lean manufacturing aims to provide guidelines for the inclusion of all employees and all processes in the organization, transforming the company culture, valuing and motivating employees.

c) Continuous Improvement (kaizen): The goals of manufacturing and the lean environment are usually expressed in ideals and goals that can never be achieved. That is why the emphasis must be on how organizations approach the ideal dreamed state, that is, on the path and not the end. However, according to Womack (2007), it is sometimes necessary to employ another principle, more radical, called kaikaku, or revolutionary change.

2.2. Lean manufacturing as a technique for production management

According to Slack et al. (2008), the second level of lean manufacturing is the greatest efforts, among them the following aspects:

a-) Basic Work Practices: they aim to ensure a healthy and productive environment, so that the focus is primarily the factors of production. Slack et al (2008) approach the topic within the following aspects:

- Discipline: work patterns were created to be followed by all the time;

- Flexibility: it should be possible to relax responsibilities to the limit of qualification of the people and give them greater autonomy;

- Equality: unjust and segregating human resource policies should be discarded, and merit should be rewarded;

- Autonomy: It is vital to progressively delegate more responsibilities to employees, where autonomy can include authority to stop the line, isolated aspects of factory programming and data collection in the workplace.

b-) Design for Manufacturing: Slack et al (2008) say that the project demands between 70% and 80% of total costs, where improvements are likely to drastically reduce the cost of the product by reducing the number of components and subassemblies, in addition to improve the use of materials and methods.

c) Focus on Production: According to Womack (2007), the approach that Toyota used focusing first on its management system before focusing on the tools was its great

triumph. As Slack et al (2008) suggests, before using the tools it is vital to learn to treat each factory as a limited and manageable set of products, technologies, volumes, and markets.

d-) Simple Machines: the simpler the machine and its more agile tools will be the exchanges and rearrangements when necessary, increasing the flexibility power of the manufacture.

e) Physical Arrangement and Flow: a good physical arrangement is responsible for increasing the speed in which the product goes through the line or plant (lead time) and influences the good tempo of the work (takt-time).

f) TPM - Total Productive Maintenance: TPM aims to eliminate variability in production processes caused by unplanned breaks. Employees are motivated to take responsibility for their machines and perform routine maintenance and minor repairs.

g-) Setup reduction: setup time does not add value and increases productive lead time, so it should be reduced. Shingo (2000) explains that running parts of the setup while the machine is running (called an external setup) reduces costs because it releases a feature that adds value to add value. In other words, transforming internal setup (machine stopped) into external setup (running machine), reducing machine down time in batch exchange or product, considerably raises the availability of equipment so that they do something really productive.

h-) Total Involvement of People: Danni and Tubino (1996) say that lean manufacturing is a philosophy fully supported by the total involvement of people, and that the system is likely to fail if it is not fully supported by it and not compromised. "The two pillars of the Toyota Production System are just-in-time and automation with a human touch, or autonomy." (OHNO, 1997).

i) Visibility: Slack (2008) shows that visibility is a widely used tool for understanding and analyzing the synchronization of the entire production process, and if correctly exposed, all problems can be better tackled and solved. In lean manufacturing it is used with the name of kanban, referring to the use of cards or andon (signaling numbers).

j) Delivery Lean: In order to improve the efficiency of the supply chain, it is necessary to reduce the amount of buffering between the steps, identifying bottlenecks, balancing capacity and promoting a smooth flow of materials (SCHONBERGER, 1993).

2.3. Lean manufacturing as a planning and control method

Its main points are:

a) Programmed pull: according to Slack et al (2008), the drawn programming aligns the real productive capacity to the demand of the market, that is the need to produce only at the right time, without excesses. Womack (2007) complements that this can not extract time from the customer (deadline), since the pulled schedule creates priorities and prerequisites that end in pulled production, that is, the previous stage

produces the exact amount of the subsequent demand for that extinguishing inventories in process, homogeneously redistributing the productive demand.

b-) Control kanban: Slack et al (2008) says that kanban is a method of efficiently operating the system of production planning and control in a pulled form. To do this, it uses cards for withdrawal, operation or transportation. Also they can be signal numbers coming from the Japanese model andon.

c-) Level programming: heijunka is the Japanese word used for leveling production. Slack et al (2008) states that the main difference between conventional programming and pulled programming lies in the distribution and division of tasks, while conventional programming distributes the tasks individually, by operation point, throughout the process. The pulled schedule distributes the tasks / orders in a constant way. Shingo (1997) provides three basic principles for pull programming: reducing batch size, increasing delivery frequency, and leveling and balancing the flow of delivery.

d) Mixed models: According to Womack (2007) and Slack et al. (2008), to heal the unevenness in programming caused by differences in lead times when scheduling lots of diversified products, it is necessary to maximize the flexibility of the productive process , in order to reduce the natural imbalances caused by this difference of lead times of diffuse lots. One tool that is widely used to assist in this process is the quick tool change, which aims to slow down the setup and increase the time available for production that adds value.

e-) Synchronization: synchronizing the operation means balancing the outputs of the system so that the variations and differences in productivity in the flow are minimized, and the flow occurs more linearly and continuously. (SLACK et al, 2008).

3. Value Stream Mapping

3.1. Starting Value Stream Mapping

First of all it is essential to define value flow. Rother and Shook (2003) say that value flow is every action, whether or not it adds value, that transforms and transports the product across the channel into the hands of the customer. This flow can be macro, going from the raw material source to the final consumer, or micro, from the stock of raw material to the stock of finished product (within the factory environment). It is prudent to start by understanding the internal, micro, door-to-door flow, and then expand to the macro level where the entire supply chain would be treated.

Mapping the value stream is simply that, in a simple way, to design the steps of the process sequentially, identifying wastes for subsequent improvement proposals. Teamwork at the time of mapping is critical to the successful roll out of VSM (Value Stream Mapping). (ROTHER; SHOOK, 2003).

According to Gill (2012), in making a quantitative evaluation in terms of metric assessment and identification, some criteria can be used to determine whether each step of the process is:

- Valuable: if it really creates value from the customer's point of view;
- Capable: the degree to which a result is of good quality (ability level or other relevant performance indicators);
- Available: the degree to which the stage is able to function when necessary (availability of resources and inputs);
- Adequate: the degree to which capacity is placed to respond to customer requests as needed;
- Flexible: the degree to which the process can change quickly and inexpensively from one member of one product family to another.

Rother and Shook (2003) provide in the table below the reasons why the VSM is important to reduce waste.

Table 1. Reasons why VSM is important to reduce waste.

	Why is Value Stream Mapping (VSM) an essential tool?
1	It helps to visualize more than simply the individual processes, for example assembly, welding. etc. You can see the whole flow.
2	Helps identify more than wastes. Mapping helps identify the sources of waste in the value stream.
3	Provides a common language for dealing with manufacturing processes.
4	Make flow decisions visible, so you can discuss them. Otherwise, many details and decisions on your shop floor only happen by default.
5	It joins lean concepts and techniques, which helps you avoid implementing some techniques in isolation.
6	Form the basis of an implementation plan. By helping you to design how door-to-door total flow should operate - a part that is lacking in many lean efforts - value stream maps become reference for lean implementation. Imagine trying to build a house without a plant!
7	Shows the relationship between the information flow and the material flow. No other tool does this.
8	It is much more useful than quantitative tools and layout diagrams that produce a set of steps that do not add value, lead time, distance traveled, inventory quantity, and so on. The value stream map is a qualitative tool with which you describe in detail how your production unit should operate to create the flow. Numbers are good for creating a sense of urgency or as measures and comparisons before / after. The value stream mapping is good for describing what you will actually do to get to those numbers.

Source: Rother e Shook (2003, p. 4).

Gill (2012) further states that the VSM may well be employed in health care services, such as hospitals, clinics, among others. This is because it is a tool that aims first to see the flow of value, then to identify wastes, to attack them and later to draw the map of the future state expected with the proposed improvements. It is a tool that has been successfully applied in the industry for years and is soon being brought to the service sector and all others that have a productive flow, whether tangible or intangible.

Rother and Shook (2003) point out that one must map not only the flow of materials but also of information, and one should also choose a family of products, the most representative in sales for example, to begin with the mapping. They also point out that it is vital to define who will be the most responsible for the mapping, the leader who will be next to the stream raising the information.

Teichgraber and Bucourt (2012) reinforce the importance of VSM nowadays for medical services, which are easily adapted in these environments where it was previously believed that they would not be. They still provide an outline of the steps of the VSM implementation plan, which can be seen in Table 2 below.

Table 2. Outline of the implementation plan of the VSM technique.

Step	*Task*
1	Identify which major product or family of products, taking into account the relevant product families, supplementary materials and services required.
2	Create an VSM current from the current state, which describes the process with current steps, delays, and information flows.
3	Evaluate the VSM of the current state in order to create a lean flow, eliminating waste, waste and especially activities that do not add value.
4	Create a future state VSM with improved flow potential.
5	Implement the future state VSM.

Source: Teichgraber e Bucourt (2012, p. 48).

3.2. The current state map

The current state map is nothing more than a flow x-ray, door-to-door, showing the processes and their wastes. Rother and Shook (2003) point out that for the current state map to be efficient and achieve the expected objectives, it needs to: collect the information itself in the process by moving along the processes and flows of information and materials; start with a quick door-to-door walk for overview, and then return to point to point; start by the final expedition and then in the previous processes,

thus making the path drawn by the consumer through the final processes, which are the ones that really define the rhythm; do not rely on ready data, make the measurements yourself; map yourself, even though your team is also involved; always draw your hand and pencil for probable changes and adjustments to the map.

According to Swallmeh et al. (2014), the value stream mapping, in its present state, aims, among other things, to see the wastes that were not previously seen in the traditional way of drawing. With the VSM the wastes become more evident, and have seen focus of attacks for improvements in the system.

The purpose of this article is not to teach to build the VSM, but to show the importance of it and its steps to apply it in the practical case.

3.3. Characteristics of a lean value stream

Swallmeh et al. (2014) recalls that in the health sector, organizations have increased their concern to improve patient experience and effectiveness and efficiency of the system. This sector is experiencing increasing costs, service demand and service quality expectations only increase. Corresponding to these challenges, managers were forced to think of new flexible ways to reduce waste, improve process control, and improve resource utilization. Lean philosophy is one of the most valuable techniques for achieving these ambitions. Lean is a philosophy-related concept derived from the Toyota production system to create more value with fewer features. The lean process evaluates step-by-step operations to identify waste and inefficiencies, and then creates solutions to improve them and thereby reduce cost. It represents an endless cycle toward perfection, in which services are continually improving and improving.

Peralta and Forcellini (2015) argue that lean thinking has been applied with great success in a wide variety of health-related services. They reinforce the importance of health organizations directly involving management, working in functional divisions, continuing to create value for patients and other clients, and sustaining long-term vision of continuous improvement.

Rother and Shook (2003) provide the procedures for achieving a lean value stream. Are they:

- Produce according to takt time: that is, only produce at the speed demanded by the market. If the demand today is 30 pieces you will make 30 pieces, even the capacity being 40. And takt time is the result of the division of demand by the time available to produce them;

- To develop a continuous flow where it is possible: to produce in continuous flow is to produce without stops, one piece at a time;

- Use supermarkets to control the production where the continuous flow does not extend to the above flow processes: when it is not possible to continuously align the productive flow, because the processes or have very fast processing times or are naturally unbalanced, semi-finished between stages that can not become continuous as an alternative to balance and level productivity.

- Send client programming only to a production process: and this process is called the pull process and is usually the last door-to-door process, the one closest to the client.

- Level the production mix: distribute the production of different products evenly over time in the puller process. The more level the product mix in the handle process, the better you will be to respond to the different wishes of the customers with a small lead time, while maintaining a small stock of finished products. This also allows your next supermarkets to be smaller.

- Level the production volume: create an "initial pull" with the release and withdrawal of only a small and uniform increase of work in the handle process.

- Develop the ability to make every piece every day: this describes how often a process changes to produce variations on a part. The shorter the swap times and smaller batches in previous processes, these processes will be able to respond to process changes more quickly. But they will require even less inventory in supermarkets, which applies to both discrete part manufacturing and process industries.

3.4. The future state map

The central objective of mapping the future state of the value stream is to identify and eliminate waste sources, building a lean and continuous productive flow, producing only what the customer wants. (Rother and Shook, 2003).

Rother and Shook (2003) still bring eight key questions that must be answered for the effective construction of an efficient future value stream mapping. Are they:

a-) What is takt time?

b) Will it be produced for a supermarket of finished products in which customers pull it or directly for shipping?

c-) Where can continuous flow be used?

d) Where will it be necessary to introduce systems pulled with supermarkets in order to control the production of the above / previous processes?

e-) Where will the production pull process, which will receive all the programming?

f) How will the production mix be leveled in the pull process?

g) What increase of work will be uniformly released from the pull process?

i) What process and flow enhancements will be vital to promote fluidity of the flow of value according to the specifications of the future state project?

According to Narayanamurthy and Gurumurthy (2014), it is already evident that the application of lean manufacturing concepts has won several business segments, including health care segments. This sector envisions a new philosophy, once industry specific, now being applied quietly in health, and successfully in several practical cases in the international literature. And it is in this context that the importance of value stream mapping in its future state, planning and designing with a focus on waste elimination, is notorious even if some goals may seem utopian at first sight, they must be pursued in a motivating and I strongly.

3.5. Reaching the future state

In order for the future state map to be reached, Rother and Shook (2003) suggest that an annual value-flow plan be drawn up which will contain exactly what will be done step-by-step, measurable goals, and clear performance evaluation points. They further state that the improvements follow the following sequence:

a-) Create a continuous stream operated based on takt time;

b) Create a pull system to control production;

c) Introduce the leveling between the stages of the process, and between the process and the market demand;

d) Create the routine of practicing kaizen continuously to eliminate waste, reduce batch size, reduce supermarkets and increase the reach of continuous flow.

Ford et al (2012) elucidates the importance of enterprise management in the efficient deployment of future value stream mapping as a revolutionary lean manufacturing tool that is. They also emphasize the great importance of teamwork and the autonomy of employees so that kaizen is actually always executed, with a focus on eliminating waste.

Finally, Rother and Shook (2003) argue that it is vital that management provides support and support tools so that the productive sector can level takt time as necessary. That is, to demand that takt time be fulfilled not only from the factory floor but also from all sectors of support linked directly or indirectly to production. They also point out that it is putting the hand in the dough that the lean manager will make the necessary changes, as well as preparing for the management shocks that all cultural change causes, because the old will give way to a new philosophy of lean management that aims to eliminate everything that does not add value, focusing on eliminating waste and improving company profits.

4. CASE STUDY: MAPPING OF THE VALUE FLOW IN THE EMERGENCY CARE OF A UNIVERSITY HOSPITAL

4.1. Current state value stream map

Health systems are complex. Although a significant part of the budgets of many governments is attributed to health, results are hardly matchable with expectations and many indicators of health system performance have shown limited improvement. Large queues of waiting, overcrowding, and patient dissatisfaction are the major health system problems in several countries. Health managers are challenged by the uncertainty of the demands and outcomes of care in the health system, in addition to high public demand for quality services, high levels of human involvement, both at the patient and resource level (doctors, nurses, etc.). There is also the issue of being always working with limited budget and resources, and having to manage a large number of variables (eg scheduling / staffing, number of beds, etc.). As a result, health managers are continually studying the effectiveness of existing health systems and exploring opportunities for improvement.

As a result, Lean Manufacturing is increasingly being applied to health services, with a unique focus on waste reduction, as well as continuous improvement.

This article focused on the emergency care of a university hospital, more specifically in the specialty of medical clinic, to understand and see the flow, and identify waste.

The following is the figure 1 which shows the current state of the value stream of the medical clinic in the care of the referred hospital.

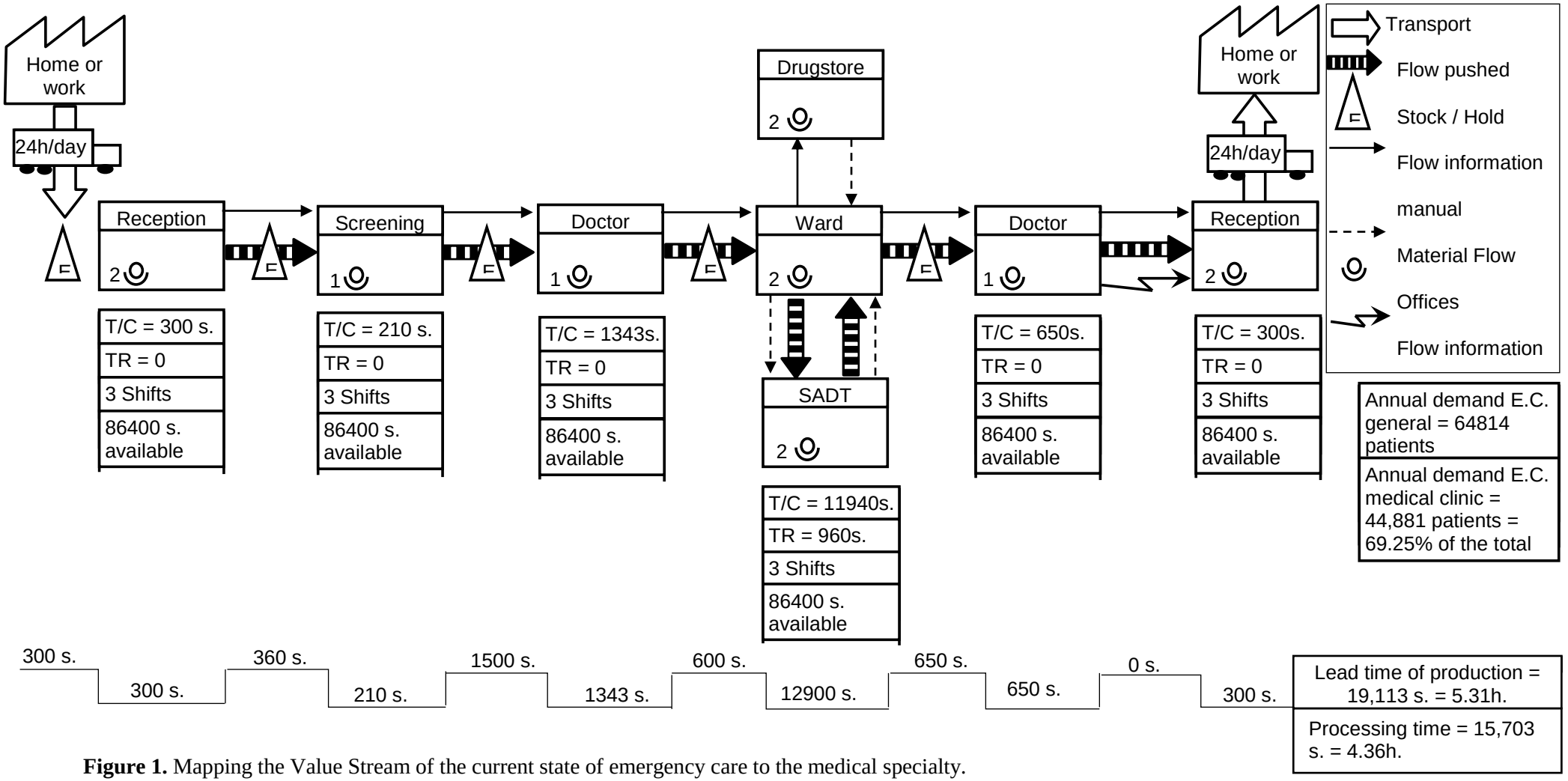

Figure 1. Mapping the Value Stream of the current state of emergency care to the medical specialty.
Source: Own author. (2017).

As can be seen in the mapping of Figure 1, there are no large wastes between the service process steps, but even though they are small, the waste is there. In the form of waiting, patient waiting to be attended by the doctor, the nurse or to do tests. In addition, the current flow of information is mostly based on manual information through tokens, medical records and so on.

In addition, the Manchester Classification, or risk classification, has not been implemented in this service. This classification may not reduce the overall lead time, but it improves the quality of care by giving priority to the care that needs it, as well as creating an important database for future decision making aimed at reducing the patient's emergency care.

4.2. Map of the future state value stream

Passing the construction of the value stream mapping of the future state value in emergency care, in the specialty of medical clinic, we start by reducing the waiting times of patients between the stages of care. The first action suggested is to invest in receptionist training so that filling in the register and collecting basic information is streamlined, thus reducing the size of the reception queue and consequently the screening. In addition to this training, it is suggested to computerize the entire flow of information, from reception, through the sorting, through the doctor's office, through the ward and SADT, to the doctor and the reception. In this way, the information previously circulated manually will circulate in a computerized way, through the hospital's computer system, reducing errors and deviations of information and slow and wasted time in filling out paperwork that could simply be computerized and secure.

As already mentioned, the real and effective implementation of the Manchester Classification is also suggested. It is also suggested to educate physicians to speed up as much as possible, taking care to ensure that the quality of the service is not lost, in order to reduce the patient's stay in the emergency room. This would reduce the total lead time, reduce costs, and increase resource availability for new calls. In the ward and SADT it is suggested a technical kaizen with the employees of these sectors with focus on reducing wastes and time of permanence of the patient in the enclosure.

With these suggestions it is expected to reduce the lead time of total production from 5.31h to 5.12h, that is, a reduction of 3.7%. Recalling that technical kaizen in the

infirmary and SADT is vital to reduce the lead time at this point which is the big bottleneck of the emergency care. Any reduction of time made in the bottleneck will represent gain for the whole emergency care system. Task forces should be created focused on reducing patients' time spent in the ward and SADT. With the reduction, the availability of resources will be improved and the attendance capacity and, consequently, the billing capacity will be increased.

Figure 2 below shows the value stream mapping in its future state, as expected, before the kaizen improvement that should be done in the ward and SADT sector.

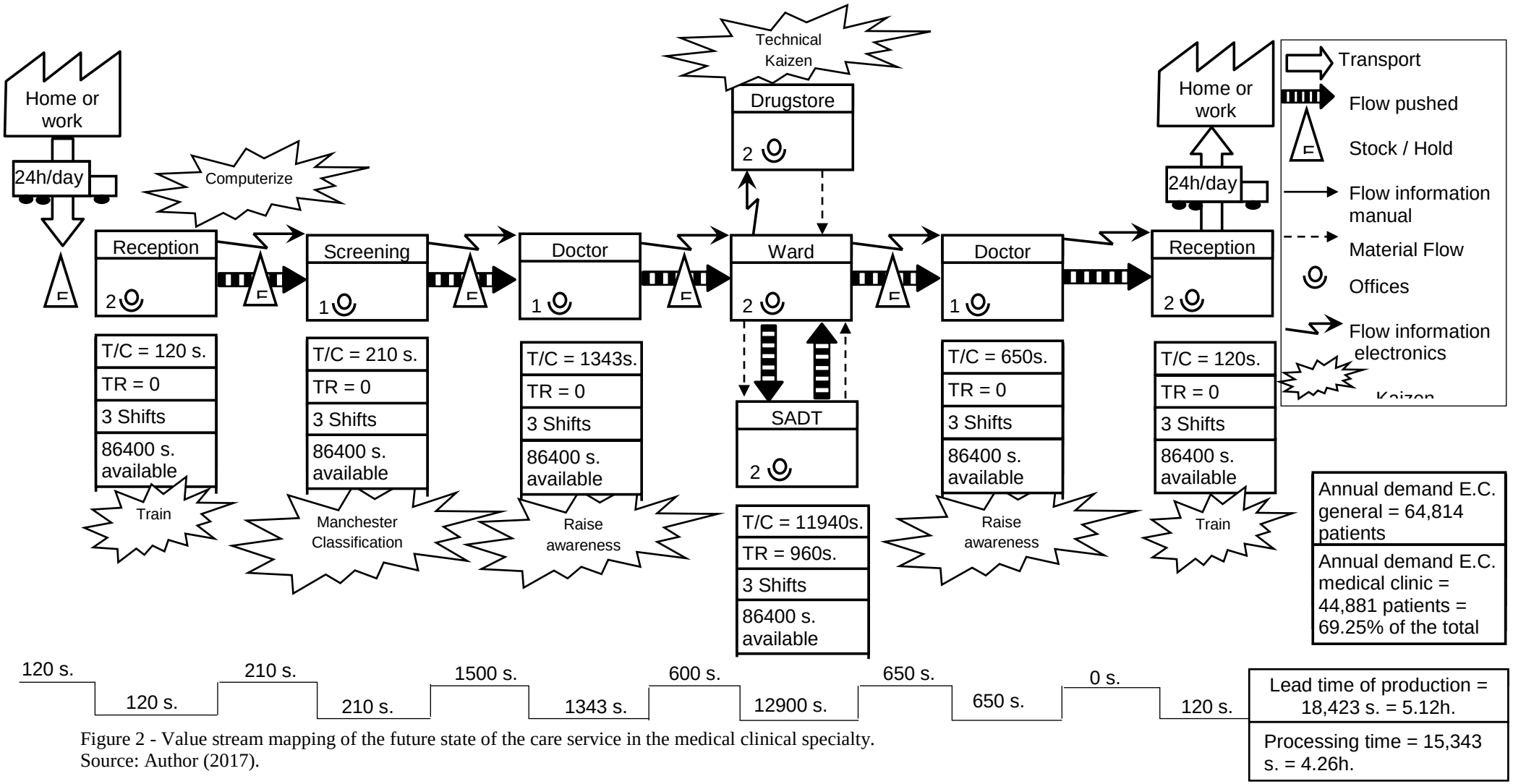

Figure 2 - Value stream mapping of the future state of the care service in the medical clinical specialty.
Source: Author (2017).

5. FINAL CONSIDERATIONS

This article has as main objective to demonstrate that Value Stream Mapping is a Lean Manufacturing tool of great importance to see wastes and points of improvement, thus supporting in a strategic way the diagnosis of the current situation of the process under analysis. In addition, the article aims to prove that the VSM can be applied in any productive environment, be it manufacturing or services, as it was in this case in a hospital.

In the case of the target hospital of this case study, more specifically in the emergency care where the VSM was performed, this tool, which in hospital and health care environments is approached within the Lean Healthcare philosophy, was of great importance to identify bottlenecks and faulty points in the patient care process. If the proposals suggested in this article are implemented, it is initially expected that there will be a 3.7% gain in the total lead time of the patient care process, from its entry to its release or discharge. And after technical kaizens in the ward and SADT this index can soar.

Finally, it is suggested that, before beginning the process of cultural change to implement the philosophy Lean Healthcare, begin by implementing the VSM, mapping and diagnosing the bottlenecks that deserve attention even before the implementation of the Lean. In this way, the Lean deployment process will be started in a mapped environment with less uncertainties.

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