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A new value stream mapping approach for healthcare environments

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Hospitals worldwide are giving a growing emphasis to the application of lean concepts in the healthcare sector, commonly known as 'lean healthcare'. A fundamental tool that allows such implementations is the value stream mapping (VSM). The problem is that VSM models used in implementations of lean healthcare are simple adaptations of the original VSM model, which was initially directed towards manufacturing and may not always represent important support activities for the patient flow that directly impact treatment time. Within this context, this paper presents a new VSM approach for healthcare environments. This new VSM model, specifically designed for healthcare environments, contemplates all activities that directly affect the treatment time. In addition, the present paper also presents an action research in a Brazilian hospital where the proposed VSM model is compared to other VSM models found in the literature. The results shown that the proposed VSM model was able to identify some operational bottlenecks and wastes that interfere in the patient's treatment that could not be identified by other mapping models studied.

Keywords: lean healthcare; value stream mapping; quality improvement

1. Introduction

Hospitals have increasingly sought to improve their operations to remain competitive. The growth of demand for healthcare services, emergence of new technologies, increased competition and requirement for higher quality standards have forced hospitals to adapt to a new reality in which the survival of the business is directly connected to the efficiency of its processes (Porter and Lee 2013).

Baker and Taylor (2009) state that hospital medical services are generally of good quality. The greatest problem that hospitals face is associated with a lack of operational capacity, which generates long waiting lines for hospitalisations and consultations, among other problems. Squire Jr. (2008) adds that the greatest cause of these problems is that many hospitals do not emphasise the business as a whole and instead operate as individual departments with their own objectives, information systems and separate internal processes. Haraden and Resar (2004) state that hospitals have responded to this problem for years by increasing their resources, investing in hiring and adding beds. To the authors, this is not a solution, as the problem at hand is not a resource problem but rather a flow problem.

To address this challenge, various hospitals have co-opted techniques adopted in manufacturing to solve their problems and manage their processes (Dickson et al. 2009). Growing emphasis is being given to the application of lean concepts in the healthcare sector, commonly known as 'lean healthcare'. The literature shows various cases of hospitals that have initiated their lean journey and have already achieved excellent results.

Womack (2005) defends the application of lean thinking in the hospital environment. Gill (2012) reports that, in an organisation, the need to 'see the whole' to rethink systemic functioning is the basis for process improvement. In hospital environments, there is an enormity of disconnections, and it is necessary to recognise these disconnections and work carefully with them to ensure that the performance of the whole is better. A fundamental tool for approaching this problem is value stream mapping (VSM).

VSM, broadly used in manufacturing by Rother and Shook (2003), comprises the material and information flows to transform a raw material into a final product. In the case of hospitals, Slack, Chambers, and Johnston (1999) state that the primary purpose is to transform sick patients into healthy patients.

Although VSM is considered an essential tool in the search for continuous improvement, a bibliographic survey performed in the period from 2000 to 2013 demonstrated that the VSM models used in implementations of lean healthcare (see, e.g. Baker and Taylor 2009; Tapping et al. 2009; Jimmerson 2010) are adaptations of

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the Rother and Shook (2003) model, which was initially directed towards manufacturing and may not always represent important support activities for the patient flow that directly impact treatment time. The VSM from Rother and Shook (2003) handles only the information and product processing and its adaptation to the hospital environment; thus, because it does not consider a third dimension, it does not represent the processing of materials, such as medications and laboratory exams, showing only the patient flow (product) and related information.

In this context, the objective of this study was to propose a new VSM approach that considers on a single map all of the flows that directly affect the duration of patient treatment and serves as a standard model for lean applications in hospitals. Additionally, this study also shows a practical example of its use in a Brazilian hospital. The results from the application of the VSM proposed in the studied hospital showed that the patient performed activities that really transformed them from being 'sick' to 'healthy' in only 0.04% of the total treatment time. It was also possible to identify operational bottlenecks and innumerable wastes that affect patient treatment and could not be identified by other mapping models existing in the literature.

This article is organised in the following manner: the methodology used in this study, which considers the primary stages developed, is shown in Section 2. Section 3 contains a literature review that provides the basis for the proposal of the new VSM, which is detailed in Section 4. Section 5 shows the application of the model in a Brazilian hospital and Section 6 presents the conclusions and proposals for future work.

2. Research methodology

This study can be divided into six primary stages, schematically represented in Figure 1.

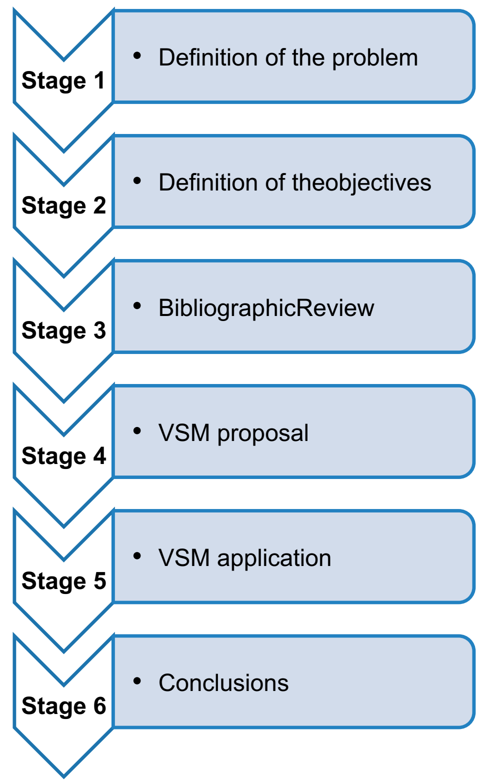

Figure 1. Development stages of the study.

The study reported in this article was primarily motivated by the difficulty of representing on a single map all of the flows involved during the transformation of a sick patient into a healthy patient, in one lean implementation in a Brazilian hospital (Stage 1). Although VSM is a commonly used tool in lean healthcare applications, there is not a single model or standard that supplies all of the information necessary to understand all of the variables that can affect the duration of medical treatment. The most used model to map the patient flow is the simple adaptation of VSM by Rother and Shook (2003), in which the patient flow substitutes the product flow. For the information flow, a hospital does not function in an analogous manner to a factory, where there is a production control and planning department. In hospitals, the processing of information moves together with the patient flow, and many times, the information processing may be the bottleneck for treatment. In the VSMs proposed specifically for hospitals (such as those by Baker and Taylor 2009; Tapping et al. 2009; Jimmerson 2010), the information flow is represented in a simplified manner, and it is not possible to determine its impact on the patient treatment time. Additionally, material processing also occurs in a hospital, such as in the medication and laboratory exams flow, which is only represented in the VSM from Baker and Taylor (2009), albeit in a superficial manner, as it is not possible to observe the impact of the material flow on patient treatment time.

To circumvent this problem, this article proposes a new VSM model for hospital environments. It is expected that this model will be able to take into account all of the flows that directly affect the duration of treatment of the patient on a single map and serve as a standard model for lean applications in hospitals (Stage 2).

Following the establishment of the problem and the research objectives, a bibliographic review was performed that sought to identify the VSM models currently used in lean healthcare implementations and their main characteristics (Stage 3), in the period from 2000 to 2013. The following databases were searched: Google Academics, ISI Web of Knowledge, IEEE Explore, Scielo and Google Scholar.

The keywords 'lean healthcare' and 'lean hospital' were used for a primary search separately and the redundancies were eliminated; 702 articles were selected. Based on the objective of this paper, the primary list of results were crossed to the secondary keywords 'value stream mapping', 'patient flow' and 'hospital process mapping'. These secondary keywords were used as filters to the primary searches. The redundancies were eliminated off this list and the remaining articles and books selected composed the final list of works considered in the bibliographic review in this paper.

A new VSM model was then proposed for hospital environments unifying the positive points of each studied model and is able to portray the vision of the whole, reuniting the patient, information and material flows that occur during the transformation of the patient from sick to healthy (Stage 4).

In Stage 5, the proposed VSM was applied in a Brazilian hospital through action research. Action research requires that the research team participates in the implementation process and engages with the practitioners to observe the process. Therefore, action research has been selected as an appropriate research methodology (see, e.g. Westbrook 1995; Coughlan and Coghlan 2002; Hendry, Huang, and Stevenson 2013). Action research is a grounded, iterative and interventionist research approach which is considered to have great potential for theory building (Westbrook 1995). So, it is appropriate when the focus of the research is on learning about changes and making improvements over time (Coughlan and Coghlan 2002).

Action research has been used in a series of recent studies related with the implementation of change. This includes Westbrook's (1995) development of an order book model, Karlsson and Ahlstrom's (1996) study on the implementation of lean product development, Nonthaleerak and Hendry's (2007) study on the implementation of new six sigma execution tools in service processes and Hendry, Huang, and Stevenson's (2013) study on the implementation of a new production planning and control concept.

Basically, action research is based on a nested set of plan-do-check-act cycles specified by authors such as Coughlan and Coghlan (2002) as: diagnosis, planning, action and evaluation. Following Hendry, Huang, and Stevenson (2013), there are two main issues to avoid the pitfalls associated with action research and ensure rigorous, high-quality outcomes: (i) effective roles and relationships; and (ii) appropriate data collection methods.

Regarding (i), in this action research project, the team relied on a strong support from the hospital Superintendent Director. Since he was also the project sponsor, his presence ensured commitment from both external (consultants) and internal (hospital staff) teams. Concerning (ii), structured interview guides and structured data collection methods were used by the research team.

In Stage 6, the discussion and final conclusions about the study and the proposed model will be presented. A proposal for future research is also presented.

3. Literature review

3.1. *Lean healthcare*

Lean manufacturing aims to embody both process improvement and enhanced customer service (Radnor and Johnston 2013). According to Lindgaard Laursen, Gertsen, and Johansen (2003), companies from diverse sectors around the world have applied lean production concepts and techniques to manage their operations in an efficient manner. Initially used in the automotive industry, lean philosophy spread to the manufacturing industry as a whole and later to other areas of these companies, such as the administrative and product development sectors. After the success achieved with the results obtained, lean thinking was broadly spread to service companies. More recently, and specifically associated with this study, lean applications in hospital environments have rapidly moved into use in hospitals around the world due to the excellent results that have been observed. Figure 2 shows this evolution.

The application of lean production concepts in hospitals seeks to increase the quality of assistance to patients, supporting the collaborators and doctors to eliminate wastes and allow them to focus on providing care, according to Graban (2012). Today, operations and supply chain management researchers are giving a great emphasis to healthcare field. One such example of modern technology applied to hospital is collaborative planning, forecasting and replenishment (CPFR), as can be seen in the paper of Lin and Ho (2014). Other example is simulation, as can be seen in the paper of Wang et al. (2009). Despite becoming extensive, research on improvement in healthcare focuses on distinct characteristics of the system rather the system as a whole (Rich and Piercy 2013).

Brandao de Souza (2009) emphasises that the USA is the country with the most publications related to lean healthcare with 57% of the publications and the UK is in second place with 29%. Only two studies were found in Brazil, which represents an enormous opportunity for future studies. According to Mazzocato et al. (2010), some of the main results observed in lean implementations are wait time reduction, reduction in the time of stay, capacity increase/liberation and cost reduction. The same authors report that the VSM, Kaizen events and work standardisation are among the most used lean tools in hospital environments. For issues about implementations of lean healthcare, see for example Chiarini and Bracci (2013).

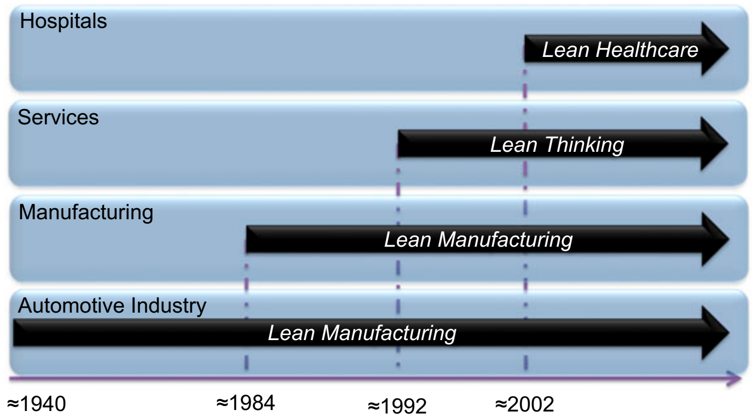

Figure 2. Evolution of lean philosophy.
Source: Adapted from Lindgaard Laursen et al. (2003).

3.2. *VSM for healthcare environments*

According to Parthanadee and Buddhakulsomsiri (2014), VSM is a tool for portraying the system to identify areas for improvement. Seth and Gupta (2005) define VSM as the process of mapping the material and information flows of all components and sub-assemblies in a value stream that include manufacturing, suppliers and distribution to the customers. Hall et al. (2006) state that various flows are present in a hospital environment, including the patient, sample, employee, information, materials and pharmaceutical product flows. According to the authors, the largest delays are often related to flows that are invisible to the patient. Therefore, the authors state that the patient lead time will depend, in part, on how they physically move through the hospital and, in part, the manner in which the information, equipment and other materials flow and meet their needs. Graban (2012) states that the bottleneck in the patient flow is frequently the material or the information flow involved in transforming the sick patient into a healthy patient. For example, in this study, some of the main causes of the patient staying in the hospital are the waiting time for exam results and treatment approval.

The literature review conducted in this study showed that the largest concentration of studies in lean healthcare, where the VSM was applied, is related exclusively to the patient flow. Some authors such as Baker and Taylor (2009), Jimmerson (2010) and Tapping et al. (2009) proposed adaptations to the Rother and Shook model (2003), seeking to meet the needs of the hospitals. To complement this study, two other VSM models, which specialise in administrative flows and were found in studies related to lean healthcare, were also studied: the information stream map (ISM) proposed by Tapping and Shuker (2002) and the ISM known as Makigami cited by Chiarini (2013). Figure 3 demonstrates which flows (patients, materials and information) are considered for each studied model.

Among the studied models, the only one that represents the three mentioned flows is the Baker and Taylor model (2009). The largest critique of this model, however, is related to the representation of the information and material flows that directly affect the patient flow. In this model, these flows are represented in a simplified manner, with all of the information centralised at a single point of the value stream. It is impossible to discern how the processing of some information and materials can affect the patient lead time (LT). In other words, it is not known whether the processing of exams, for example, can affect long wait times or contribute to a longer time for the treatment duration.

The VSM model proposed by Jimmerson (2010) also represents the information flow, in addition to the patient flow. However, the material flow that directly affects the patient LT is completely neglected; that is, it is not possible to clearly visualise the interfaces between the activities performed by the patient and some support activities that are cited as being vital for the global understanding of the patient flow by Hall et al. (2006) and Graban (2012) through the application of this model.

In the same manner, in the model proposed by Tapping et al. (2009), the patient flow is mapped in detail. However, the information flow is represented in an extremely simplified manner and materials flows, such as possible medication and exam processing, are not cited in their study.

The ISM proposed by Tapping and Shuker (2002) is a model aimed at the exclusive mapping of information flows. What then occurs, in many cases, is the separation of the patient stream map from the ISM into two distinct maps. Therefore, it is still not possible to observe the interfaces between the information and the patient flow

Flows considered in the model	VSM (Baker and Taylor)	VSM (Jimmerson)	VSM (Tapping et al.)	VSM (Tapping and Shuker)	*Makigami*
• Patient flow	✓	✓	✓		✓
• Material flow	✓				
• Information flow	✓	✓	✓	✓	✓

Figure 3. Flows considered for each studied model.

and the impact of one on the other. Two studies that use ISM in practical applications are those of Casey (2007) and Radnor et al. (2006). Casey (2007) cites the application of lean concepts in the administrative environments of hospitals like the Kaiser Permanente Facility in California, the Cancer Treatment Centers of America, the Clearview Cancer Institute and a medical clinic in Iowa, a US state. Radnor et al. (2006) cite some results from the application of ISM in the public hospital sector of Edinburgh, Scotland, emphasising the 48% reduction in patient LT. It is important to emphasise that the ISM by Tapping and Shuker (2002) has an exclusive characteristic among the studied models, to list the inputs and outputs for each activity represented at the map. Tapping and Shuker (2002) suggest that every activity must have information that feeds it and, after being processed, must produce results in the form of new information. According to the authors, this makes the value stream clearer and easier to understand. Another important suggestion that is only found in this model is to differentiate each activity by colour, according to the department that performs it. This facilitates the visualisation of transitions and refluxes during information processing.

Makigami, an ISM model, is more recent, but it brings a new perspective for value stream visualisation through 'swimlanes'. These 'swimlanes' are utilised by many process modelling methodologies and perform as a mechanism to organise activities into separate visual categories in order to illustrate different departments or areas (White 2010). This model was also adapted to map a patient flow and was successfully applied in the St. Elizabeth hospital in the USA in 2006. An important characteristic of Makigami, that is not present in the other studied models, is the identification of activities that add value and do not add value to the map itself through red and green labels that make it possible to clearly distinguish waste. Additionally, Makigami was the only mapping model among those surveyed in this bibliographic review that showed the patient travelling to and from home. However, it too does not work with the material flow and its relationships with patient total LT.

In general, all authors of the studied models emphasised the importance of the involvement and participation of people during the mapping. For these, the VSM must be capable of elucidating problems and wastes along the value stream to identify possible bottlenecks and contribute to basing the improvements propositions.

With the surveying of the characteristics of the studied models shown in this bibliographic review, some of the main positive points addressed can be identified so that the VSM represents the whole in the clearest manner possible in hospital environments. These characteristics will serve as requirements for the new proposed model and form the basis of its construction. The experience of the authors in lean implementations in hospital environments also contributed to the selection of these requirements. Table 1 brings some characteristics used for the elaboration of the proposed model, identifying the authors that cite them in their studies.

4. The proposed VSM

The largest challenge of the proposed model is to represent the information, material and patient flow involved in the transformation of a sick patient into a healthy patient on a single map.

Adapting the 'swimlanes' concept used in Makigami, in which each activity moves on the map according to the department in which it is performed, it is proposed that this model has three sections dedicated to each one of the three flows. Thus, depending on the flow that is being processed, the activity will move between one section and another.

Regarding the layout, it is also proposed that the model have a section dedicated to the timeline in the same manner as that found in the models by Jimmerson (2010), Baker and Taylor (2009) and in the ISM by Tapping and Shuker (2002). Additionally, the proposed model will have a section dedicated to the identification of the problems and wastes by process as used in Makigami.

The construction of the map is divided into two phases:

- Pre-mapping
- Mapping

Each one of them is more fully detailed in the following sections.

4.1. *Pre-mapping phase*

The preparation for mapping must involve the following steps:

Table 1. Characteristics used as requirements for the new proposed model.

VSM characteristics	Authors
Be able to see, on a single map, all flows that directly impacts on the patient´s lead time, showing how the support activities, including laboratories, pharmacies and information services could influence the treatment´s duration	Hall et al. (2006), Graban (2012)
When creating a current state VSM, identify the main problems and wastes across the value stream	Baker and Taylor (2009), Jimmerson (2010), Tapping et al. (2009), Tapping and Shuker (2002), Chiarni (2013), Graban (2012), Gill (2012)
Identify the problems and wastes in the interactions or handoffs between departments	Tapping and Shuker (2002), Chiarni (2013)
Identify all the value-added and non value-added steps across department boundaries (the value stream) from a patient's perspective	Baker and Taylor (2009), Jimmerson (2010), Tapping et al. (2009), Tapping and Shuker (2002), Chiarni (2013), Porter (2013)
Identify all the inputs and outputs of each activity that is necessary for understanding the value stream	Tapping and Shuker (2002)
The steps and times captured on a value stream map must be enough to identify the bottleneck processes	Baker and Taylor (2009), Jimmerson (2010), Tapping et al. (2009), Tapping and Shuker (2002), Chiarni (2013)
When mapping a end-to-end patient processes, it is important to have representatives from all departments and functions that work in that value stream	Baker and Taylor (2009), Jimmerson (2010), Tapping et al. (2009), Tapping and Shuker (2002), Chiarni (2013)

(1) Identify the value stream that will be mapped;
(2) Identify the departments and personnel involved;
(3) Detail all of the value stream activities on paper;
(4) Prepare the material to be used; and
(5) Invite the involved personnel.

4.1.1. *Identify the value stream that will be mapped*

The central focus of the improvement process is the patient value stream, considering groups of patients with similar needs for the delivery of services. The patient families are defined by the similarity of processes that are performed to transform a sick patient into a healthy patient. These groups are broader than the classifications based on diseases. They are defined by the grouping of patients with similar value streams, such as patients that visit the emergency room and later return home or patients with rapid procedures. The creation of these patient families simplifies the redesigning process. The value stream for a specific patient family must be designed to meet their needs and the needs of the operators (McGrath et al. 2008). Sim and Rogers (2009) address the problem of resistance to change and why implementing lean systems can be difficult at times. King, Ben-Tovim, and Bassham (2006), Ben-Tovim (2008), Trilling et al. (2010) and Graban (2012) share the vision that the initial direction of lean projects in hospitals must seek rapid and simple gains, as this facilitates employee involvement and minimises the barriers to change.

4.1.2. *Identify the departments and personnel involved*

Tapping and Shuker (2002) emphasise the importance of involving each individual that contributes to perform any activity within the value stream. To know which departments affect the value stream, it helps to identify which key people must be present in the mapping.

4.1.3. *Detail all of the value stream activities on paper*

To conduct the mapping process, the leaders must keep all of the points that are important to the analysis of the current situation in mind (Jimmerson 2010). For this, prior to performing a mapping, the leaders must detail all of the value stream activities on paper.

4.1.4. *Prepare the material to be used*

Mapping will be performed using a roll of paper and post-it notes, as proposed by Tapping et al. (2009). For the mapping to be performed with the required professionalism and organisation, some materials and accessories must also be prepared previously. In general, the following can be highlighted: a roll of paper; post-it notes of different colours; red and green round labels; rulers; pencils; erasers; and stickers representative of the houses of the patients. Another important action on this phase is to communicate the mapping meeting that will happen and the lean project as a whole for the organisation. Worley and Doolen (2006) define communication as an essential variable to reduce resistance to change on a lean implementation.

4.1.5. *Invite the involved personnel*

Womack (2005), Dickson et al. (2006), Graban (2012) and Egolf et al. (2007) emphasise the importance of involving the employees that act on the operation for the success of the implementations. Graban (2012) and

McGrath et al. (2008) emphasise that the involvement of employees from other areas contributes to breaking paradigms. Despite being cited by Langabeer et al. (2009) as being the most resistant portion to changes, only Ben-Tovim (2008) and McGrath et al. (2008) specifically cite the involvement of doctors in developing improvements. Womack (2005), McGrath et al. (2008) and Trilling et al. (2010) show the involvement of upper management as an essential factor for the success of lean healthcare projects. Worley and Doolen (2006) also emphasise that management support does play a role in driving a lean implementation.

4.2. *Mapping*

After preparing everything in the pre-mapping phase, the stages performed during the mapping meeting with those involved may occur as follows:

(1) Divide the map into five lines (material flow, information flow, patient flow, time line and problems identification);
(2) Insert demand data;
(3) Place a post-it note for each activity on the value stream line to which it belongs;
(4) Trace connection lines between the activities according to the nature of the process;
(5) Place the necessary inputs and outputs;
(6) Place the waiting times between the processes;
(7) Identify the activities that add and do not add value using green and red labels, respectively;
(8) Identify the main problems and wastes; and
(9) Calculate the total LT of the value stream and the time for adding and not adding value.

Figure 4 illustrates the final format of the proposed VSM.

5. Practical application

5.1. *The hospital studied*

The hospital in the action research described here was named the 'Arnaldo Vieira de Carvalho Cancer Institute' (ICAVC). The ICAVC is one of the most important philanthropic hospitals in São Paulo, the largest city in Brazil. The hospital has 77 beds and the clinical staff includes over 100 doctors from different specialties. The ICAVC's focus is the treatment of cancer, involving chemotherapy, radiotherapy and surgery. The ICAVC has a structure composed of two buildings, called the Outpatient Clinic and Hospital. The first building houses the administrative body and outpatient operations, such as consultations. In the second building, for the most part, procedures defined by the outpatient service, such as surgeries, chemotherapy, radiation therapy and exams, are performed.

The Outpatient building has 10 floors, of which 5 are reserved for outpatient services. The Hospital structure is composed primarily of the following:

- Hospitalisation Ward: 77 beds;
- Intensive Care Unit (ICU): seven beds;
- Operating room: four rooms for small-, medium- or large-scale surgeries;
- Diagnostics Centre;

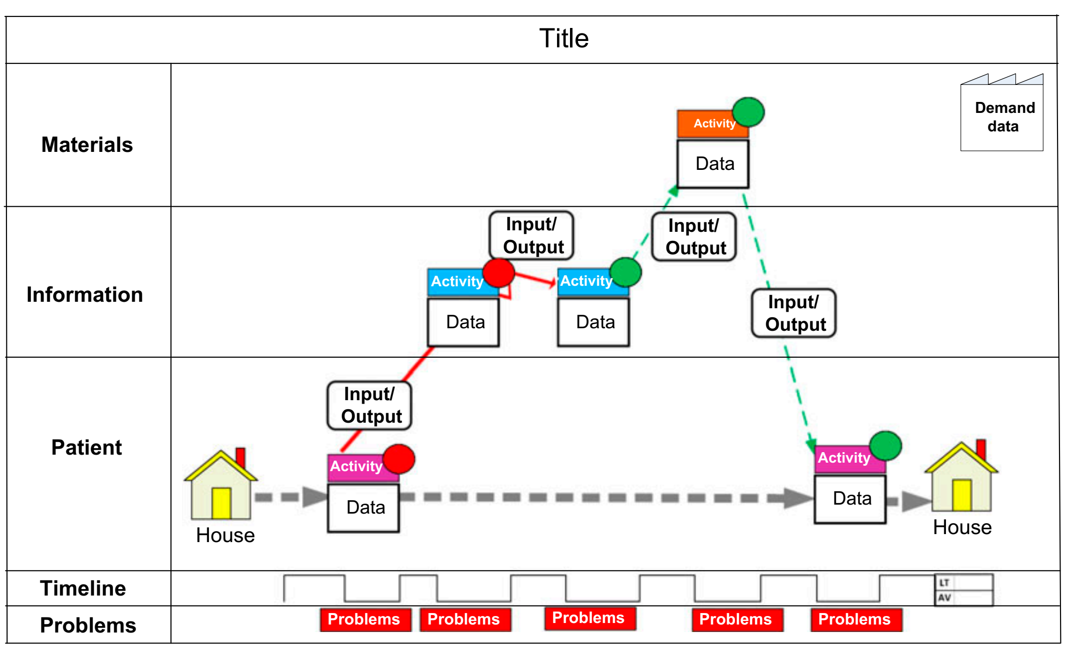

Figure 4. Final format of the proposed VSM.

- Radiation therapy Centre;
- Chemotherapy Centre; and
- Pharmacy and Storage Area.

5.2. *Application*

5.2.1. *Pre-mapping*

In the pre-mapping stage, as suggested in the development of the new VSM model proposed in Section 4, the following steps were conducted:

5.2.1.1. *Identify the value stream that will be mapped.* The ICAVC has the objective of treating cancer using radiation and other physical agents, specialised surgery, chemotherapy and other means. Figure 5 shows the macro value stream of the main treatments performed by the Institute.

It is possible, through Figure 5, to observe the three main value streams: surgical, chemotherapy and radiation therapy.

In agreement with King, Ben-Tovim, and Bassham (2006), Ben-Tovim (2008), Trilling et al. (2010) and Graban (2012) which defend that initial direction of lean projects in hospitals must seek rapid and simple gains to minimise possible barriers to change, the surgical value stream was chosen. An enormous gap between the current state of this area when compared with the world-class level was identified. The surgical value stream is also extremely strategic for the hospital. For this article, the surgical value stream is also the most interesting, as it is a value stream found in almost all Brazilian hospitals, which is not the case for the chemotherapy and radiation therapy value streams. The surgical value stream was therefore defined as the scope of the project.

5.2.1.2. *Identify the departments and personnel involved.* In the case of the ICAVC, Figure 6 illustrates the departments found in the surgical value stream. One colour was defined for each department, so that it is easier to observe the number of transitions and refluxes between the departments on the map.

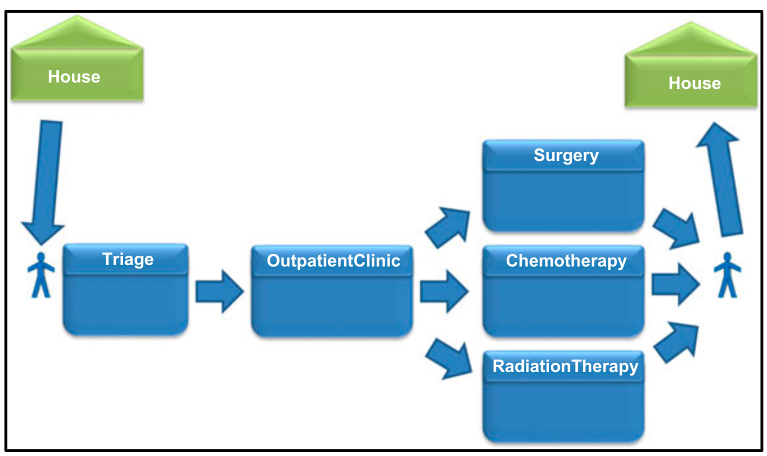

Figure 5. Value streams of the ICAVC.

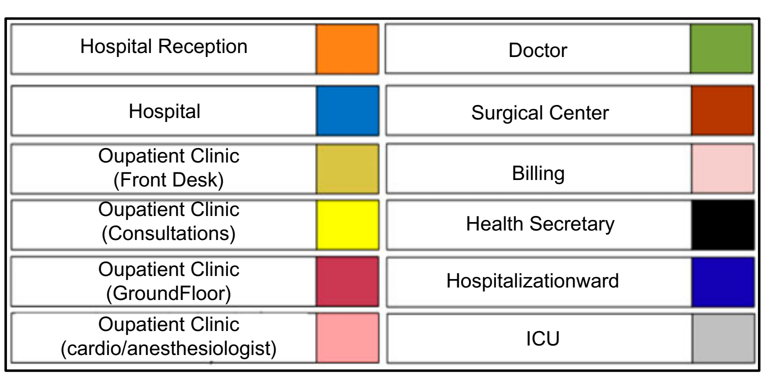

Figure 6. Departments involved in the surgical patient stream.

The chosen patient flow represents the entire trajectory of a surgical patient in the hospital. This means that the mapping is not limited to the operating room. The mapping was more comprehensive, comprising all of the processes performed in the hospital that 'transform' the patient, from Triage to post-surgery, including the material and information flows that affect the patient LT.

5.2.1.3. *Detail all of the value stream activities on paper.* To perform the mapping, Baker and Taylor (2009) suggest that all of the processes must be viewed from the perspective of the patient. For this reason, all of the stages must be physically monitored with a stopwatch, including observing the lines between the processes. The proposed model follows this recommendation, and data collection for the map was performed from this perspective. For two weeks, the internal hospital team dedicated to this project, along with the consulting team, passed through all of the stages followed by a surgical patient, timing activities and surveying problems observed during the Gemba walk.

5.2.1.4. *Prepare the material to be used.* The preparation stage of the material used in the mapping meeting lasted only one day, with the participation of the team that was dedicated full-time to the project. During this stage, the map layout with the swimlanes was drawn on the map, and its title was added to the roll of paper, which was placed on a wall. Post-it notes of various colours, red and green round labels, rulers, pencils and erasers were purchased and made available for use. The team also communicates to the organisation the mapping meeting and the project as a whole in agreement with Worley and Doolen (2006) to reduce a possible resistance to change.

5.2.1.5. *Invite the involved personnel.* To conduct the mapping, the ICAVC had a consulting team that developed a lean healthcare project in conjunction with an improvement team from the hospital itself, known as the internal team. This interaction permitted the development of the internal team and made greater access to client information by the consulting team possible.

In addition to the consulting team and the improvement team of the ICAVC, the following were invited to perform the mapping, among other involved parties:

- The technical director of the hospital, who is a doctor;
- Two nurses from the operating room;
- The individual responsible for the approval and billing of surgeries;
- The individual responsible for the administrative sector of the hospital that controls scheduling consultations, exams and surgeries;
- The individual responsible for the IT department;
- The individual responsible for the financial department;
- Two people involved in the operational processes of scheduling; and
- The individual responsible for the quality department of the hospital.

The technical director of the hospital was involved to play a role in driving this lean implementation. Ben-Tovim (2008) and McGrath et al. (2008) specifically cite the involvement of doctors in developing improvements. Worley and Doolen (2006), Womack (2005), McGrath et al. (2008) and Trilling et al. (2010) also define management support as an essential factor for the success of a lean project. Other professionals involved were also chosen taking into account Womack (2005), Dickson et al. (2006), Graban (2012) and Egolf et al. (2007) which emphasise the importance of involving the employees that act on the operation for the success of the implementations.

5.2.2. *Mapping using the proposed VSM*

After preparing everything in the pre-mapping phase, all of the stages that were listed in Section 4.2 were performed during the mapping process with those involved. As a result, the VSM of the current state of a surgical patient was generated. Figure 7 illustrates the surgical value stream in a macro manner. For ease of visualising the presentation in this study, this complete mapping was divided into five figures (Figures 8–12).

The first process of the surgical value stream in the ICAVC is Triage, where a doctor analyses whether the case is a patient with cancer and the possible treatment options for the patient (chemotherapy, radiation therapy, surgery or a combination of these). After Triage a patient who will be treated by surgery is directed to a consultation with an oncologist. In this consultation, the doctor analyses the exams of the patient and, if there is a need, requests the pending exams (Figure 8). If necessary, the patient undergoes the exams and after the results from the exams are available, they return for another consultation with the oncologist specialised in their disease. All of the blood exams performed in the hospital are processed in an external laboratory. In this consultation, the specialist doctor determines whether the patient is a surgical case and what exams and consultations he/she needs to have for surgery. The surgical patient then passes through a battery of tests composed primarily of blood and cardiological exams; they then consult with the cardiologist (Figure 9). The patient consults with the anaesthesiologist and then return to the specialist with all of the necessary exam results. In this return consultation, the specialist doctor evaluates the patient condition, and

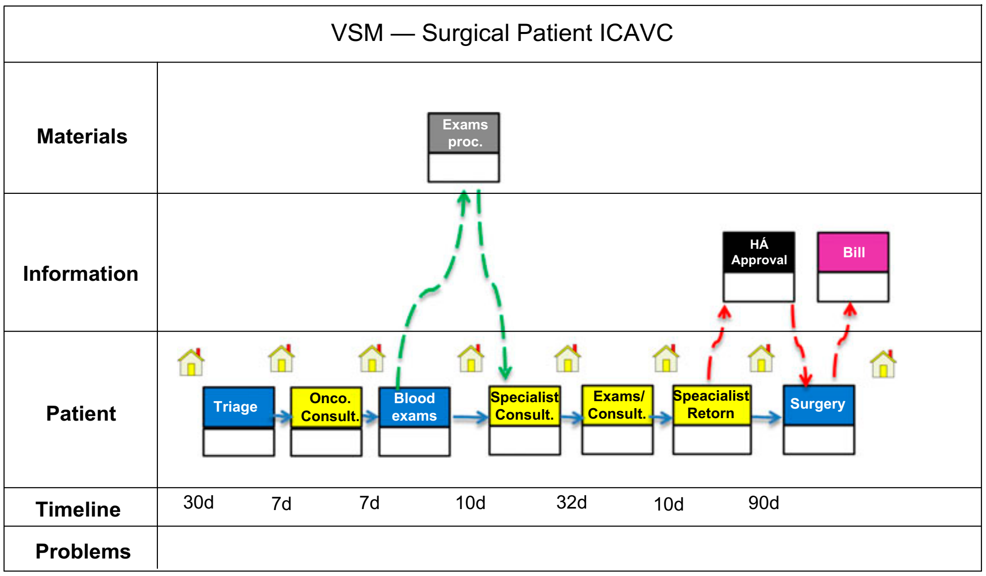

Figure 7. Macro VSM.

if he/she is in an acceptable condition on which to be operated, a date for the surgery is set. Also in this consultation, a surgery authorisation known as a Hospitalisation Authorisation (HA) is printed and sent (Figure 10) for authorisation to the Secretary of Health of the State of São Paulo (Figure 11). Generally, on the day prior to the surgery, the patient is hospitalised and prepared for the surgical procedure. After the surgery, the HA returns to the billing department, where it will be billed to the Secretary of Health of the State of São Paulo (Figure 12).

It is also possible to observe some problems that were identified over the VSM in each one of these figures. Some problems are general and are not necessarily positioned at the point at which they occur. For example, the patient moves between eight different departments during the treatment, represented in Figure 10, which is the sum of all of the different departments through which he/she passes over the entire VSM. This also occurs with the identification of 11 necessary trips to and from home to complete the treatment. This problem is identified in Figure 9 but occurs over the entire VSM.

In general, eight activities are emphasised in the generated VSM that do not add value and directly impact the treatment time. They are listed as follows:

- Waiting for the Triage process (Figure 8);
- Waiting for doctor visits (Figure 9);
- Waiting for test results (Figure 9);
- The surgical patient has to go 11 times from the hospital to his/her home during the treatment;
- Unnecessary movement between eight different departments;
- Hospitalisation approval (Figure 10);
- Bed preparation and cleaning (Figure 12);
- Surgical set-up (Figure 12).

5.3. *Current state analysis*

The mapping of the surgical value stream in the ICAVC made it possible for the Institute to discern the inefficiencies of their processes from the point of view of the patient. The surgical patient performs activities that add value in only 0.04% of the treatment time. The patient travels a path of 187 days until the surgery.

From the application of the proposed VSM, it was possible to identify operational bottlenecks of the surgical value stream. Triage, the consultations and the line for scheduling a surgery are the main bottlenecks. In the Triage process, for example, it was identified that only one doctor was available for this activity for two hours per week to see 150 patients per month. It was also identified that this first Triage was not necessary, once the oncological doctor could realise this activity. Table 2 shows some activities that do not add value identified by the proposed VSM, their impact on the duration of patient treatment and which of the studied VSM models would also diagnose it.

All of the VSM models presented in this article would identify the wait for the patient to perform Triage, the wait for the patient to pass through the various medical consultations, the preparation time to make a bed available and the set-up time for the surgery room. Other wastes would be identified by only more than one VSM found in the literature.

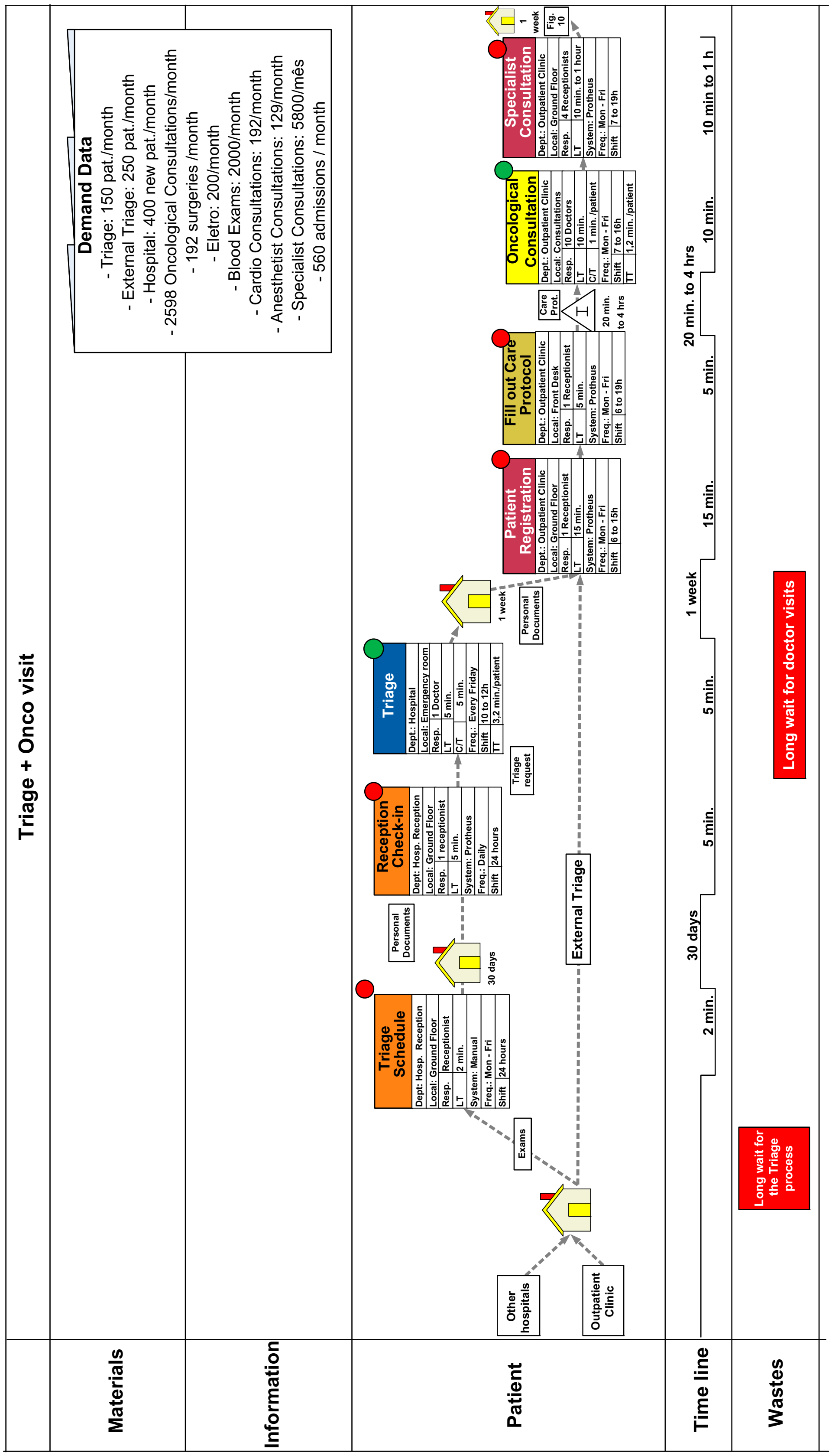

Figure 8. Triage and Onco visit.

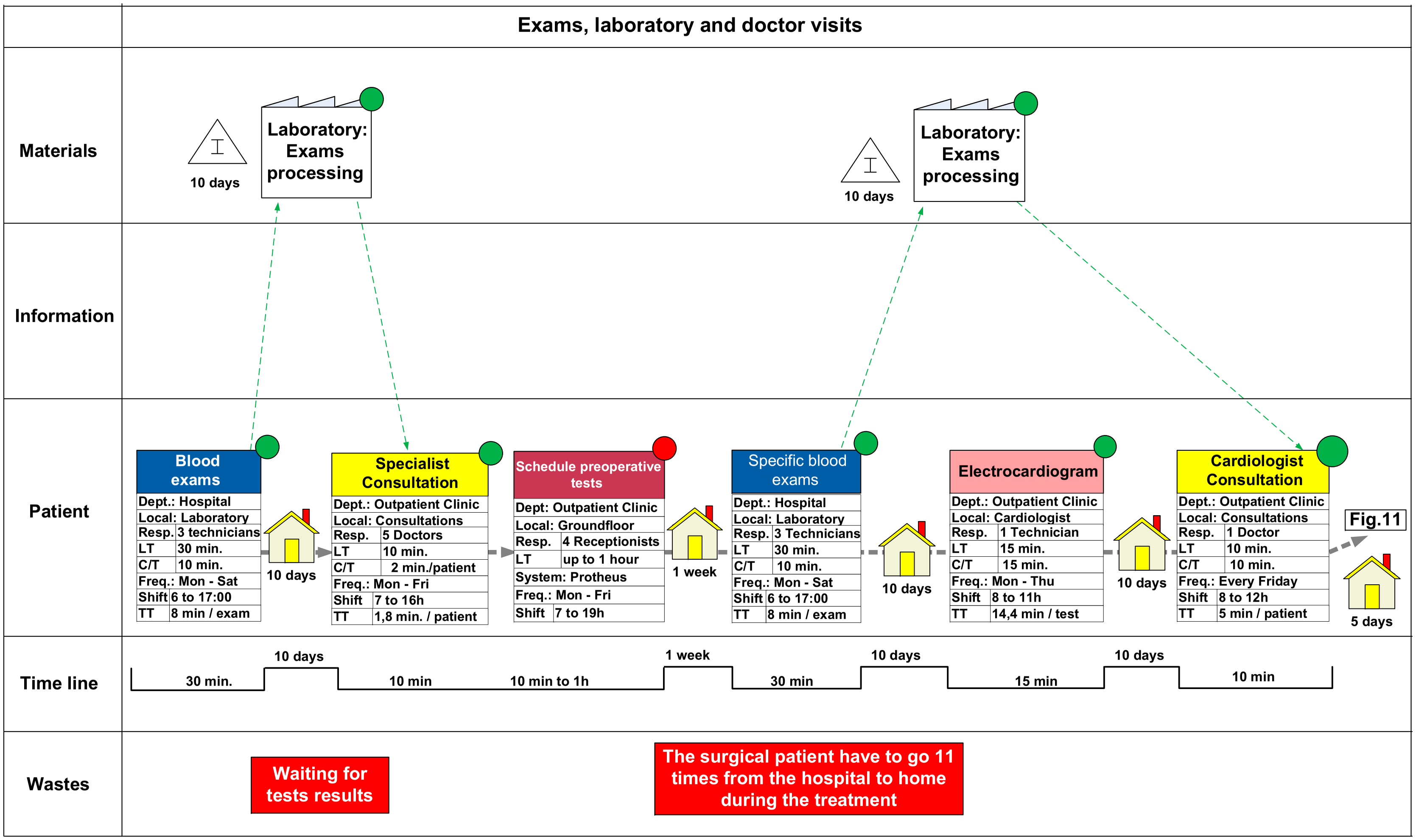

Figure 9. Exams and laboratory and doctor visits.

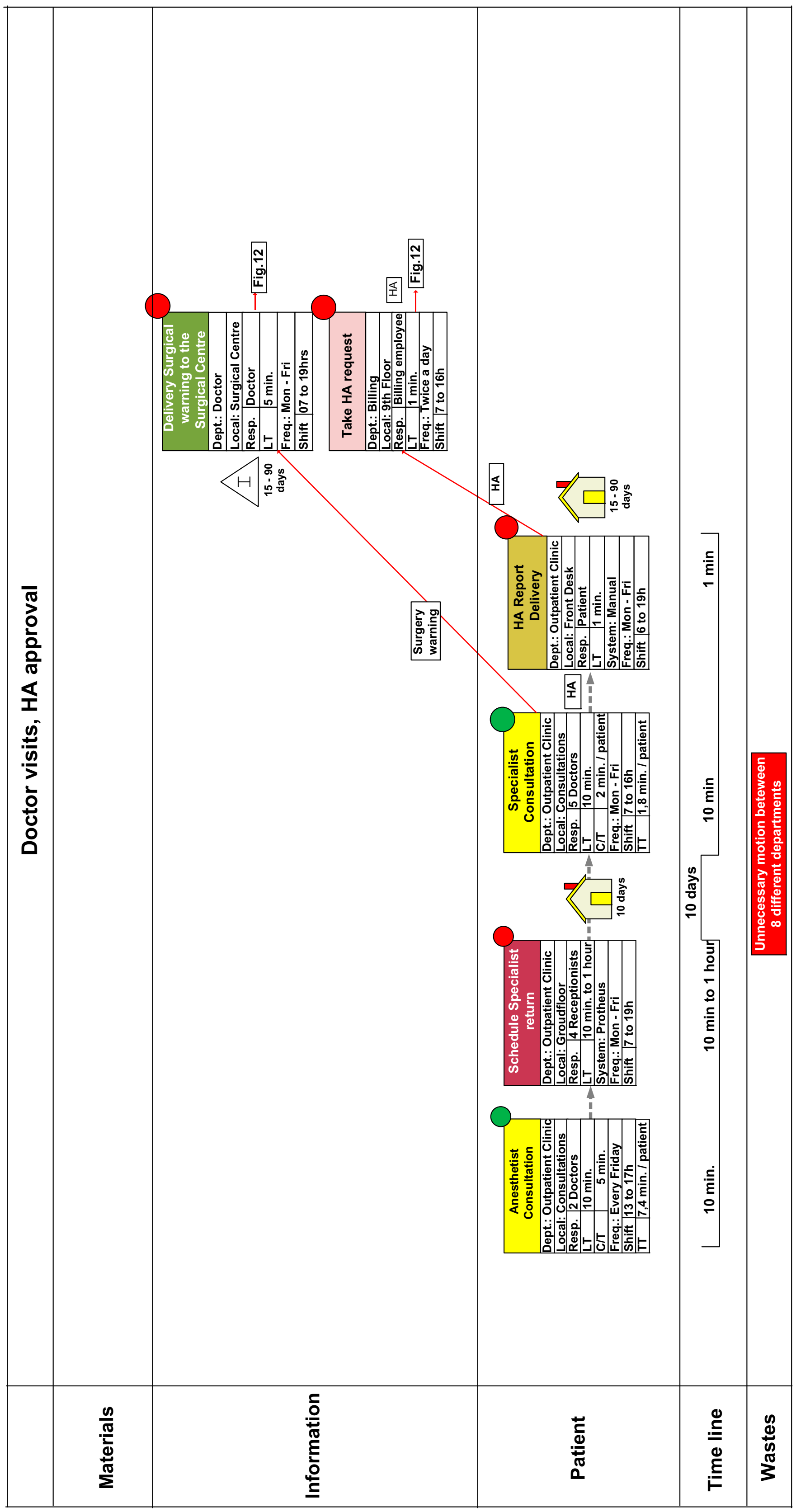

Figure 10. Doctor visits and HA approval.

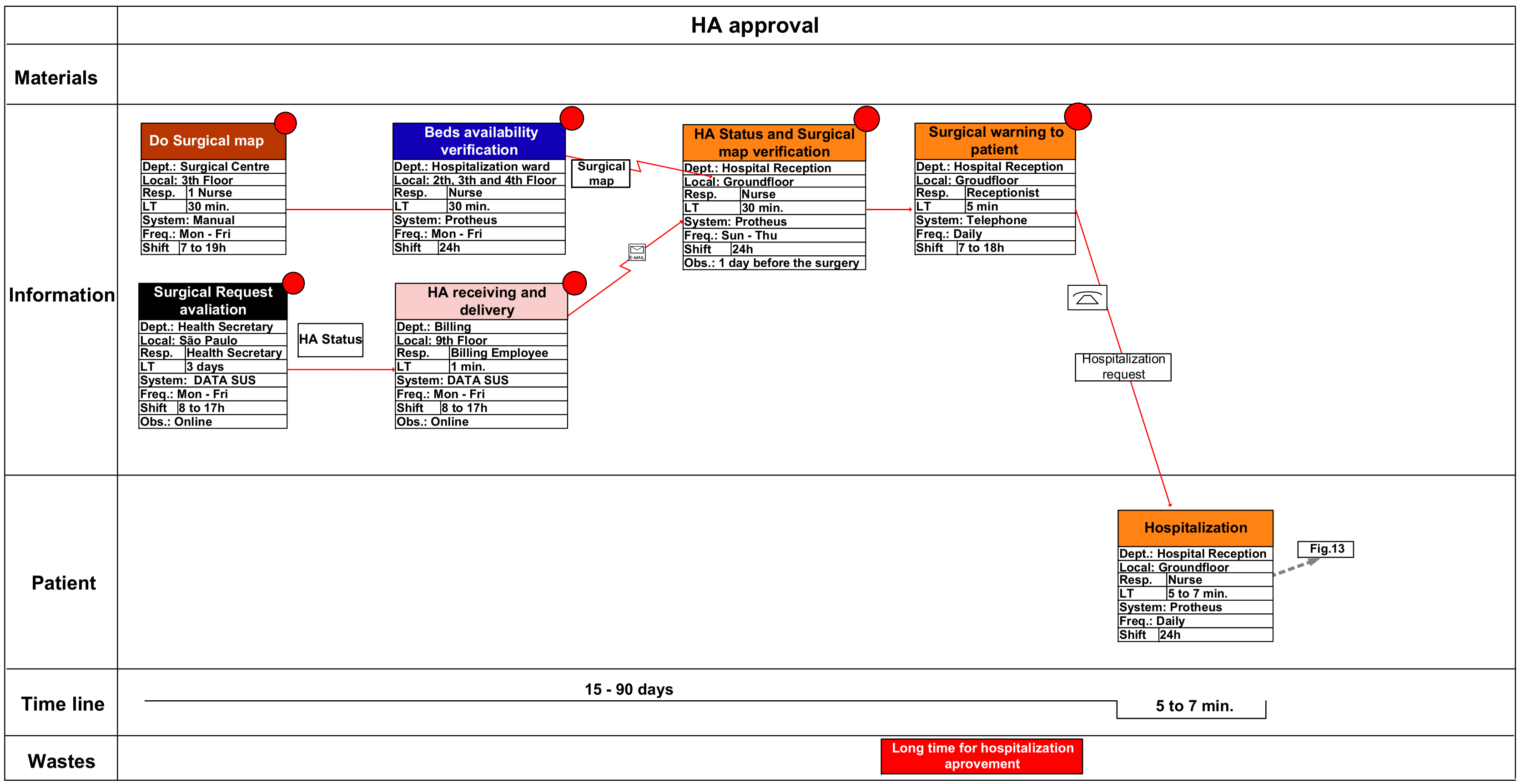

Figure 11. HA approval.

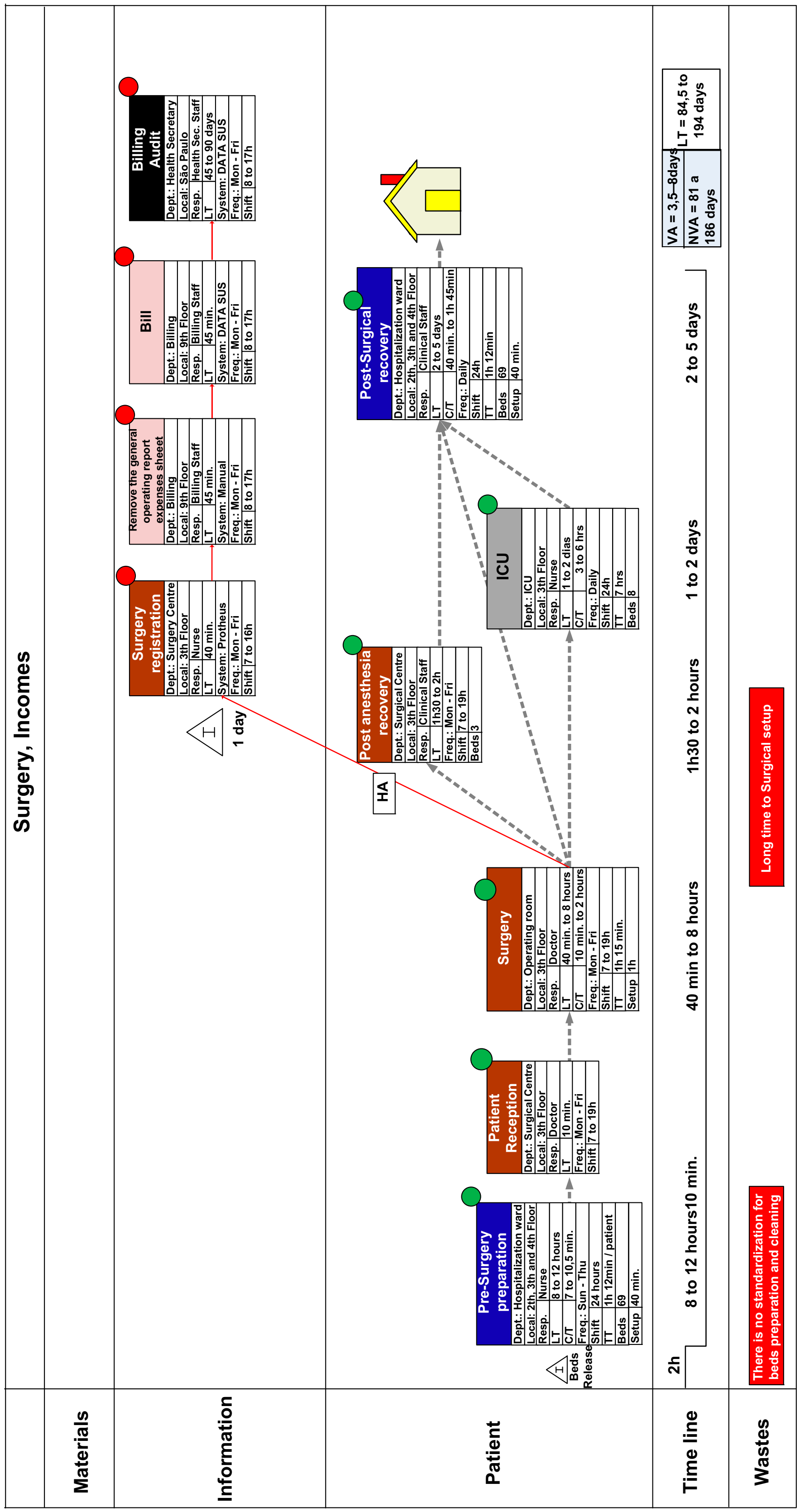

Figure 12. Surgery and incomes.

Table 2. NVA Activity × Impact × VSMs.

NVA activity identifyed	Time spent	% of the total LT	Department/local	Identifiesd by the follow VSMs
Waiting for the Triage process	30 days	15	Triage centre	Baker and Taylor (2009), Jimmerson (2010), Tapping et al. (2009), Tapping and Shuker (2002), Makigami
Hospitalization aprovement	90 days	46	São Paulo secretary of health	–
Waiting for doctor visits	20 days	10	Hospital clinics	Baker and Taylor (2009), Jimmerson (2010), Tapping et al. (2009), Tapping and Shuker (2002), *Makigami*
Waiting for tests results	20 days	10	Laboratory	–
The surgical patient have to go 11 times from the hospital to home during the treatment	11 h	1	Hospital	*Makigami*
Unnecessary motion between eight different departments	40 min	0.1	Hospital	Tapping and Shuker (2002), Makigami
Beds preparation and cleaning	1 h	0.1	Hospital	Baker and Taylor (2009), Jimmerson (2010), Tapping et al. (2009), Tapping and Shuker (2002), *Makigami*
Surgical setup	2 h	0.2	Operating room	Baker and Taylor (2009), Jimmerson (2010), Tapping et al. (2009), Tapping and Shuker (2002), *Makigami*

Makigami, for example, as the proposal VSM, would also be capable of identifying the 11 times that the patient needs to interrupt their treatment and return home. For the calculation, it was considered that each trip from the hospital to home is performed in 1 h. This time was estimated considering the long distances and the traffic of the city of São Paulo, where the studied hospital is based. It should also be considered that, in this case, time is not the only nuisance for the patient. The cost of transport, the repeated interruption of treatment and the delay between the treatment stages are even more serious factors.

Makigami method itself, together with the Tapping and Shuker (2002) model, would also identify the unnecessary and excessive movement of the patient through eight different departments over the treatment. To calculate the time, it was also considered that each transition between the departments would last 5 min on average. This time was estimated based on the distances between the sectors of the hospital in question.

However, some of the main problems identified in this practical application could not be diagnosed by other models found in the researched literature. Such is the case of the following situations:

- The approval process for hospitalisation by the Secretary of Health could take up to 90 days and represented 46% of the total treatment time of the surgical patient. This long approval time occurs due to the large waiting list for surgery in the Brazilian health system and the enormous bureaucracy involved in this activity.
- The processing of blood exams and the consequent wait for the results, which could take 20 days to be ready, represented 10% of the total treatment time for the surgical patient. The long delay in this case occurs due to the line to get a schedule in a laboratory through the Brazilian health system.

It is important to note that these activities, which would not be identified by any other studied model except for the proposed model, would have a combined impact of up to 110 days of waiting for the patient, representing 56% of the total LT of the patient. Thus, the importance of discern all of the necessary activities to transform a sick patient into a healthy patient on a single map is clear, whether or not these are performed directly by the patients.

5.4. *Future state proposition*

From the current state analysis, the future state of the surgical patient was proposed. The steps taken to propose the future situation are the following:

- Eliminate activities that do not add value and are not required;
- Propose improvements to activities that do not add value, but are required;
- Eliminate, where possible, comings and goings of patient from hospital to home;
- Eliminate, where possible, transitions between departments;
- Propose continuous flow where possible; and
- Compare the takt time with the cycle time and establish the necessary capacity of each process to absorb the demand.

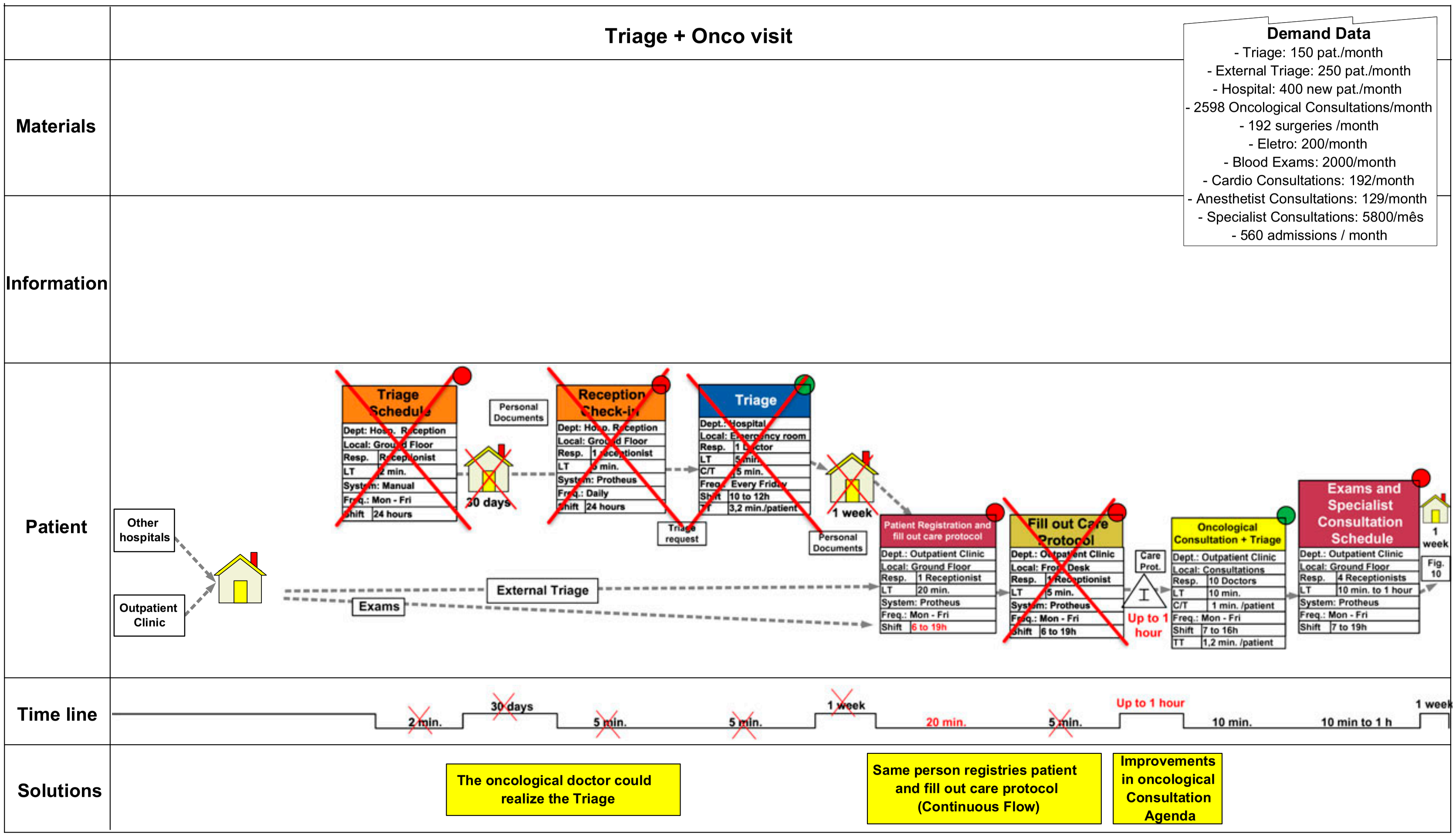

Figure 13. Triage and Onco visit (future state).

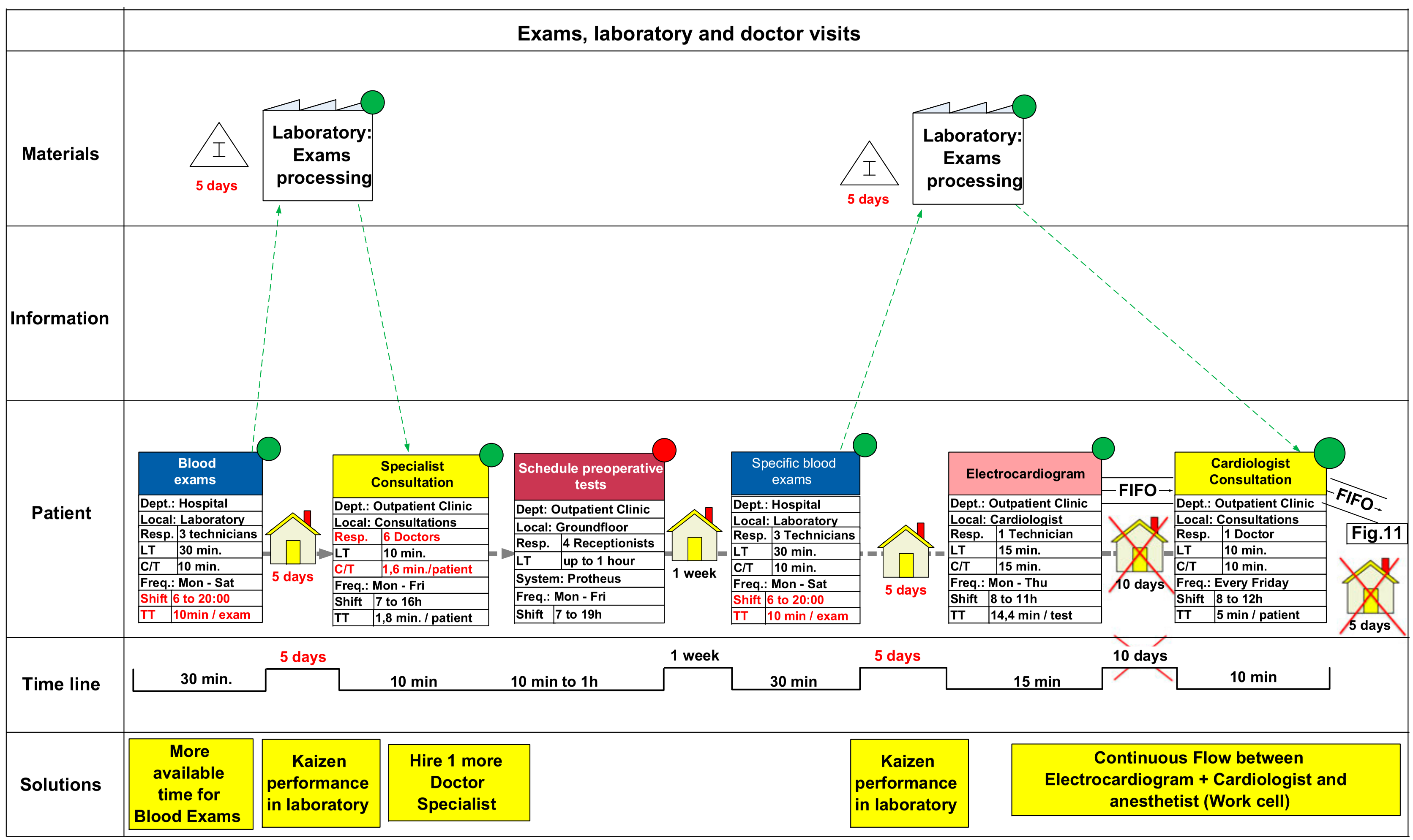

Figure 14. Exams and laboratory and doctor visits (future state).

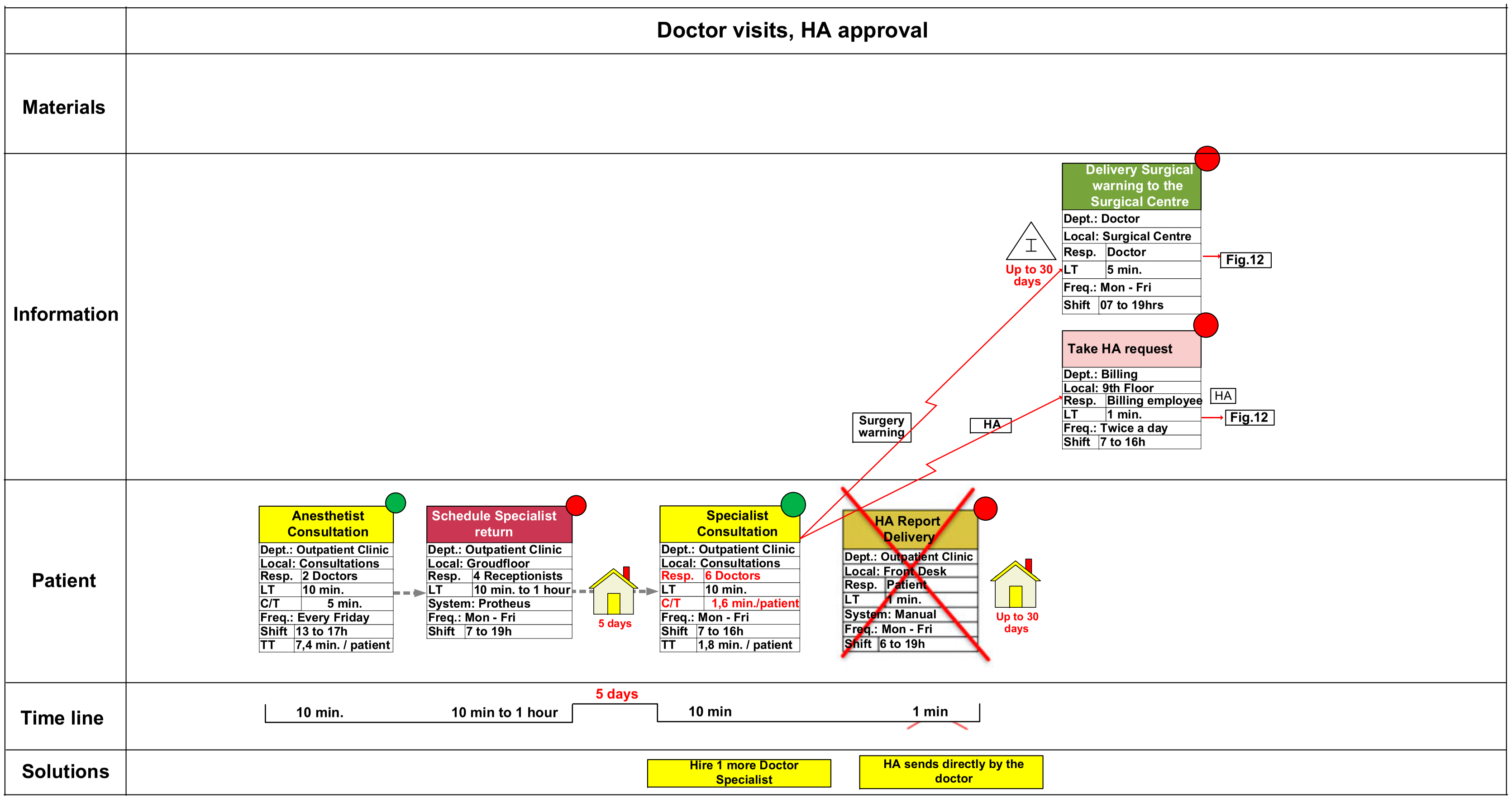

Figure 15. Doctor visits and HA approval (future state).

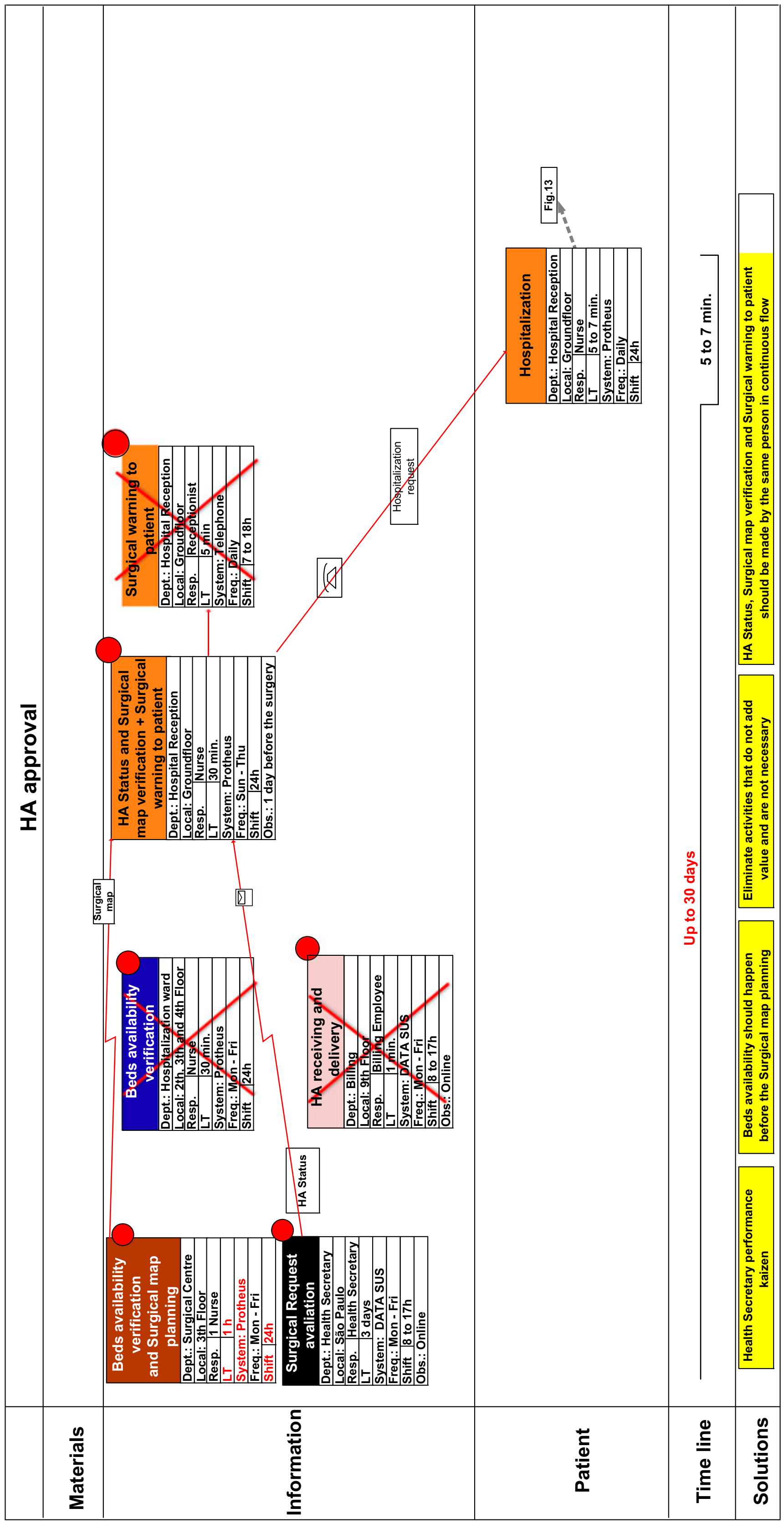

Figure 16. HA approval (future state).

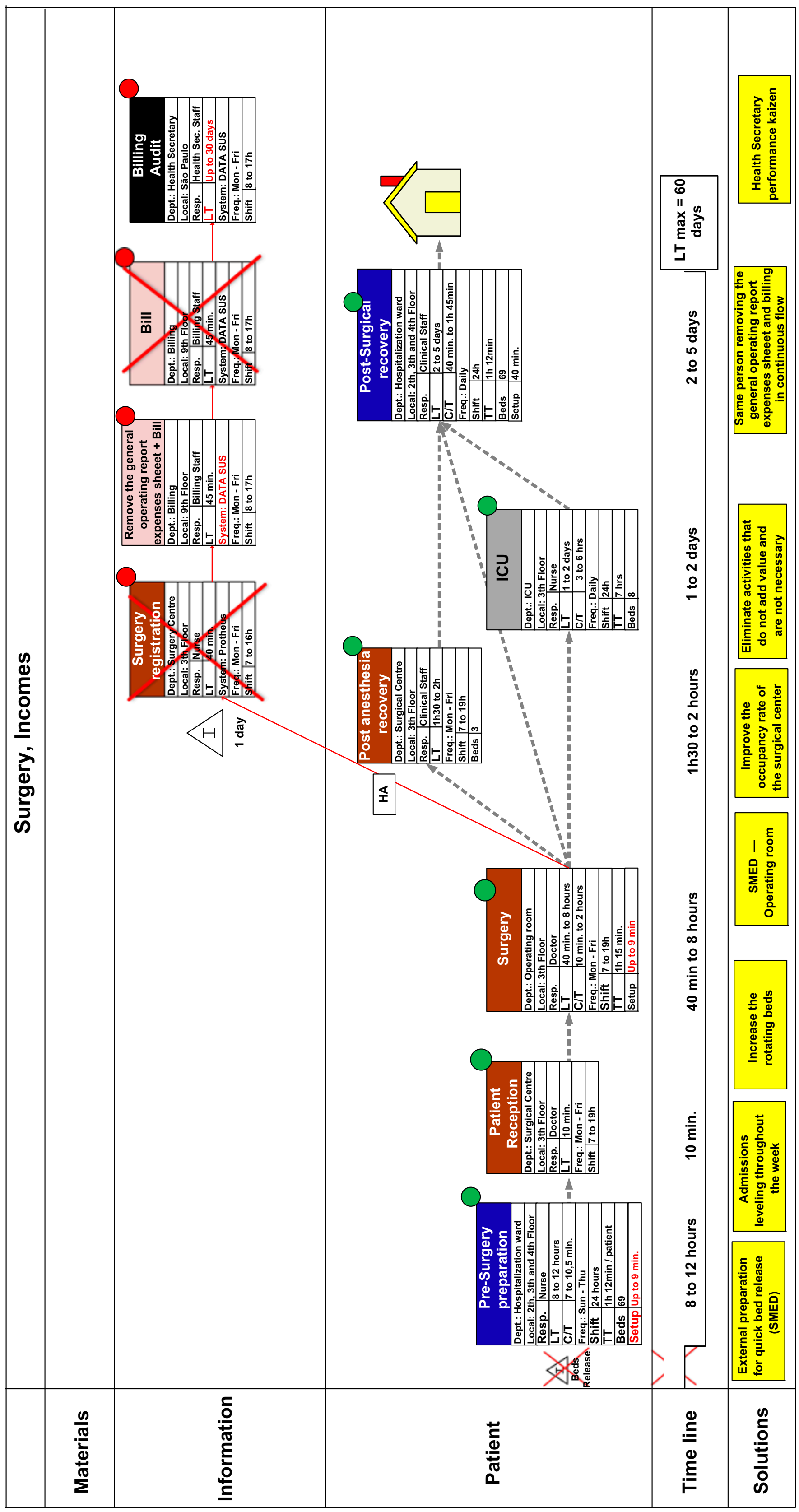

Figure 17. Surgery and incomes (future state).

Table 3. Future state gains.

	Motion between departments		Times from hospital to home		Total lead time	
	current state	Future state	current state	Future state	current state (days)	Future state
Triage + Onco visit	5	2	2	0	37	2.5 h
Exams, laboratory and doctor visits	5	5	5	3	42	17 days
Doctor visists, HÁ approval	5	4	2	2	10	5 days
HÁ approval	3	1	0	0	90	30 days
Surgery, Incomes	5	5	0	0	8	8 days
Total	23	17	9	5	187	60 days

After preparing everything in the pre-mapping phase, all of the stages that were listed in Section 4.2 were performed again during the future mapping process with those involved. As a result, the VSM of the future state was generated. For ease of visualising the presentation in this study, the future VSM was divided into five figures (Figures 13–17) as done to the current state.

To evaluate the future state gains, the Table 3 was built. It is possible to observe a large reduction in the treatment time, from the Triage to discharge, coming from 187 days to 60 days. Similarly, there was a reduction of 23–17 transitions between departments and 9–5 goings from hospital to home.

The actions proposed have not been implemented yet. They were only presented and approved by the leadership of the hospital. It is an opportunity for future work to discuss these implementations, as well as new applications of the new VSM developed in other hospitals.

The main solutions proposed during the future state mapping meeting are the following:

- Triage and Onco visit:
  - The oncological doctor could realise the Triage;
  - Same person registers the patient and fills out care protocol (continuous flow); and
  - Improvements in oncological Consultation Agenda.
- Exams, laboratory and doctor visits:
  - Increase the available time for blood exams;
  - Kaizen performance in laboratory;
  - Hire one more doctor specialist; and
  - Continuous flow between electrocardiogram, cardiologist and anaesthetist (Work cell).
- Doctor visits and HA approval:
  - Hire one more doctor specialist; and
  - HA is sent directly by the doctor;
- HA approval:
  - Health Secretary performance Kaizen;Please check the clarity of the sentence “Health ... Kaizen” and amend if necessary.
  - Beds availability verification should happen before the surgical map planning; and
  - HA status, surgical map verification and surgical warning to patient should be made by the same person in continuous flow.
- Surgery and Incomes:
  - External preparation for quick bed release (single minute exchange of die – SMED);
  - Admissions levelling throughout the week;
  - Increase the rotating beds;
  - SMED in Operating room;
  - Improve the occupancy rate of the surgical centre; and
  - Same person should remove the general operating report expenses sheet and billing in continuous flow.

To obtain the gains projected, these actions must be implemented and sustained by all personal involved. King, Ben-Tovim, and Bassham (2006), Ben-Tovim (2008), Trilling et al. (2010) and Graban (2012) share the vision that the initial direction of lean projects in hospitals must seek rapid and simple gains. For this reason, the hospital must plan the initial actions carefully and determine the right prioritisation. In addition, cross-training will be also very important since several different activities will be performed by the same worker or group of workers (an example of gains reported using cross-functional teams in healthcare is shown in Larsson et al. (2012)). Finally, Womack (2005), Dickson et al. (2006), Graban (2012) and Egolf et al. (2007) emphasise the importance of involving the employees that act on the operation for the success of the implementations. In this action research, all personnel involved were part of the team to construct the current situation and also to propose the future state. It is very important to involve these persons in the same way to implement the actions proposed.

6. Conclusions

This study had the main objective of proposing a new approach for VSM in hospital environments.

In this study, it was possible to identify some VSM models currently employed in lean healthcare projects and analyse them to observe their main characteristics and the positive points of each one, when the objective is having a vision of the whole. Based on the research performed in the literature and on the action research performed, the authors conclude that the VSM concepts in hospital environments are highly relevant in the day-to-day experiences of hospitals; however, there is no single, standard model for their application. This study sought to unite the positive points of the mapping models found in studies related to lean healthcare in a single model and contribute to the development of the area.

The results showed that the proposed VSM model was able to identify some operational bottlenecks and wastes that interfere in the patient's treatment that could not be identified by other mapping models studied. It is important to note that these wastes and operational bottlenecks, which would not be identified by any other studied model except for the proposed model, would have a combined impact of up to 110 days of waiting for the patient, representing 56% of the total LT of the patient. Thus, the importance of discern all of the necessary activities to transform a sick patient into a healthy patient on a single map is clear, whether or not these are performed directly by the patients.

The paper also proposed a future state free of these wastes. With the solutions proposed, it is possible to observe a large reduction in the treatment time, from the Triage to discharge, coming from 187 days to 60 days. Similarly, there was a reduction of 23–17 transitions between departments and 9–5 goings from hospital to home, which causes a significant improvement in the treatment's quality.

The practical application of the proposed VSM model for hospital environments could also exemplify and make the proposed mapping process more didactic. This study demonstrated, therefore, that it is possible to consider all of the flows that impact patient LT on a single map and be able to clearly visualise the interfaces between the activities performed by the patient and the support activities as information and materials flows.

This study also demonstrates a method that other healthcare institutions can use as a simple and efficient tool to discern some problems that are often hidden in their day-to-day operations through the inclusion of a new VSM model for lean applications in hospitals.

The proposed model can be adapted for mapping streams that involve more than one dimension, as occurring with the majority of value streams involving providing services. Future studies may analyse what adaptations would be needed to apply a model in these environments and to prove its applicability.

Disclosure statement

No potential conflict of interest was reported by the authors.

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